FIELD MANUAL
NO 34-40-9

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, DC, 29 August 1991

DIRECTION FINDING OPERATIONS

Table of Contents

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PREFACE

Direction finding (DF) involves determining the direction of arrival of a radio wave. Since the conception of signals intelligence (SIGINT) gathering, direction finding has been an important part of the intelligence cycle. Direction finding is used to support other intelligence information. It is normally integrated with other sources of intelligence such as communications and noncommunications intercept to determine the approximate location, movement, and relocation of threat emitters. Direction finding bearings and locations are used in developing threat order of battle (OB) information to support national and tactical intelligence information.

This field manual provides direction finding doctrine, procedures, techniques, and theory for personnel conducting strategic and tactical operations. It is written for military intelligence (MI) organizations; supported commanders and their staffs; echelons above corps (EAC) conducting direction finding operations; strategic joint operations personnel needing direction finding information; intelligence analysts; and direction finding supervisors, operators, and analysts.

The subject area of *strategic systems* refers to DF systems at a permanently fixed or semifixed site that have long-range DF capability. The area of *tactical systems* refers to semipermanent or mobile DF systems on the battlefield. These systems have a short- to medium-range DF capability.

The words *target* or *target area* are used for the purpose of brevity. These terms are synonymous with *target transmitting antenna.* The transmitting antenna may be far removed from the actual location of the transmitter.

The proponent of this publication is Headquarters, United States Army Training and Doctrine Command (TRADOC). Send comments and recommendations on DA Form 2028 directly to the Commander, United States Army Intelligence School, Fort Devens (USAISD), ATTN: ATSI-ETD-PD, Fort Devens, Massachusetts 01433-6301.

Unless this publication states otherwise, masculine nouns and pronouns do not refer exclusively to men.

CHAPTER 1

ELEMENTS

Direction finding involves determining the direction of arrival of a radio wave. Direction finding equipment will indicate the approximate direction along an imaginary line on which a transmitting antenna lies. This is commonly referred to as a line of bearing (LOB). The information obtained by a single direction finding site is seldom accurate enough to pinpoint a location. However, the direction of a distant transmitter's antenna can be determined (depending on the training and expertise of the DF personnel and the DF equipment used) to an accuracy of plus or minus 2 degrees. With the exception of the single station locator (SSL), one DF site can only indicate the approximate direction of a transmitter's antenna (Figure 1-l).

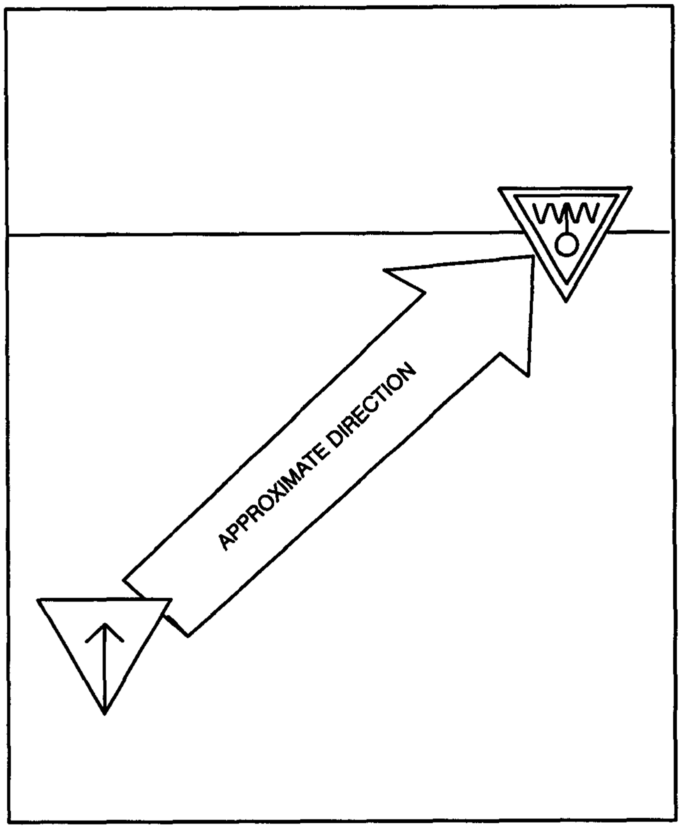


Figure 1-1. LOB of a distant transmitter's antenna.

Two DF sites, however, can indicate the general location of a transmitter's antenna by providing a *cut* (Figure 1-2).

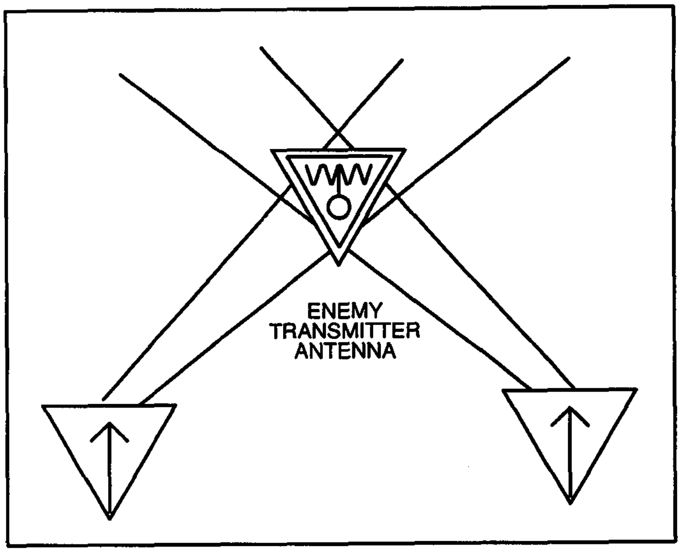


Figure 1-2. General location of a distant transmitter's antenna (cut).

Three or more DF sites can provide the fix location of a desired transmitter's antenna (Figure 1-3).

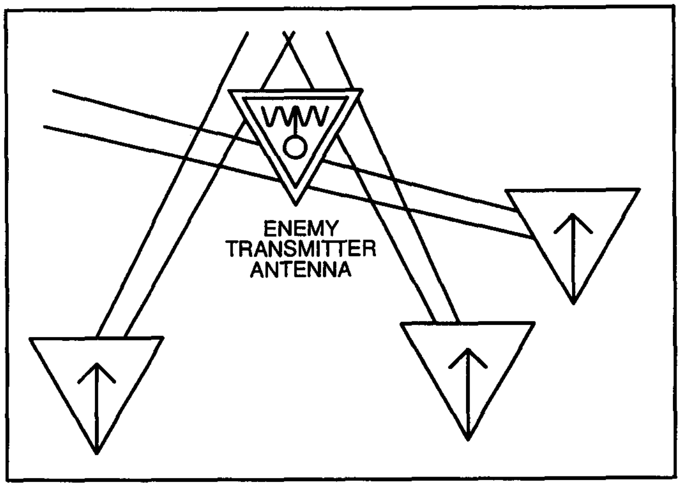


Figure 1-3. Fix location of a distant transmitter's antenna.

The theory of direction finding has remained reasonably static since the early history of the study of electromagnetic (EM) wave phenomena. Early radio communications were directional in nature. This was because the radio transmitters were relatively low powered. They were inefficient in their output, and the receivers were relatively insensitive. Efforts were undertaken to *direct* the transmitted wave toward the receiving device. This was done to ensure communications rather than to determine location. Therefore, the useful applications of DF were obtained almost simultaneously with the effort to direct the radio transmissions.

Direction finding has many uses. It can be used as a navigational aid. In this capacity, the DF equipment is either used alone or in combination with other DF systems. This depends on the service which is to be provided. Such service includes positioning, controlling, and homing of ground, sea, and air forces. DF equipment is also used by rescue personnel as an essential part of air-sea rescue. Also, crash beacons on downed aircraft or disabled ships provide a signal which can be located (or *homed-in* on) by DF equipment.

The extensive use of military radio communications has increased the value of DF in the production of SIGINT. Even if a military force is extremely careful, radio and radar transmissions can be intercepted and the locations of the transmitter's antennas determined. Direction finding can provide enemy transmitter antenna locations to intelligence personnel for the construction of enemy order of battle and fusion into other intelligence activities. Specifically, direction finding can also be used to assist in determining—

- Enemy troops or equipment movements which may indicate a possible attack.
- Locations of transmitting antennas associated with various weapon systems (to help determine enemy capabilities).
- New, and confirming known, transmitter antenna locations.
- Possible targets for jamming or intercept.

CHAPTER 2

RADIO WAVE PROPAGATION

Radio direction finding (RDF) deals with the direction of arrival of radio waves. Therefore, it is necessary to understand the basic principles involved in the propagation of radio waves from the transmitting station to the DF equipment.

CHARACTERISTICS

The distance between two points of corresponding phase in consecutive cycles is known as a wavelength. A wavelength can be expressed in any unit of measure. However, it is normally expressed in meters. The number of complete waves that move past a given point in one second is called frequency. A unit of frequency is called Hertz (Hz). One unit is equal to one cycle per second (Figure 2-1). The radio wave's strength or intensity is called its amplitude. The radio wave, which is electromagnetic in nature. consists of an electrical field (E field) and a magnetic field (H field). Each field supports the other, and neither can be propagated by itself. Table 2-1, page 2-2, lists frequency bands. their designators. and the commonly accepted limits of each band.

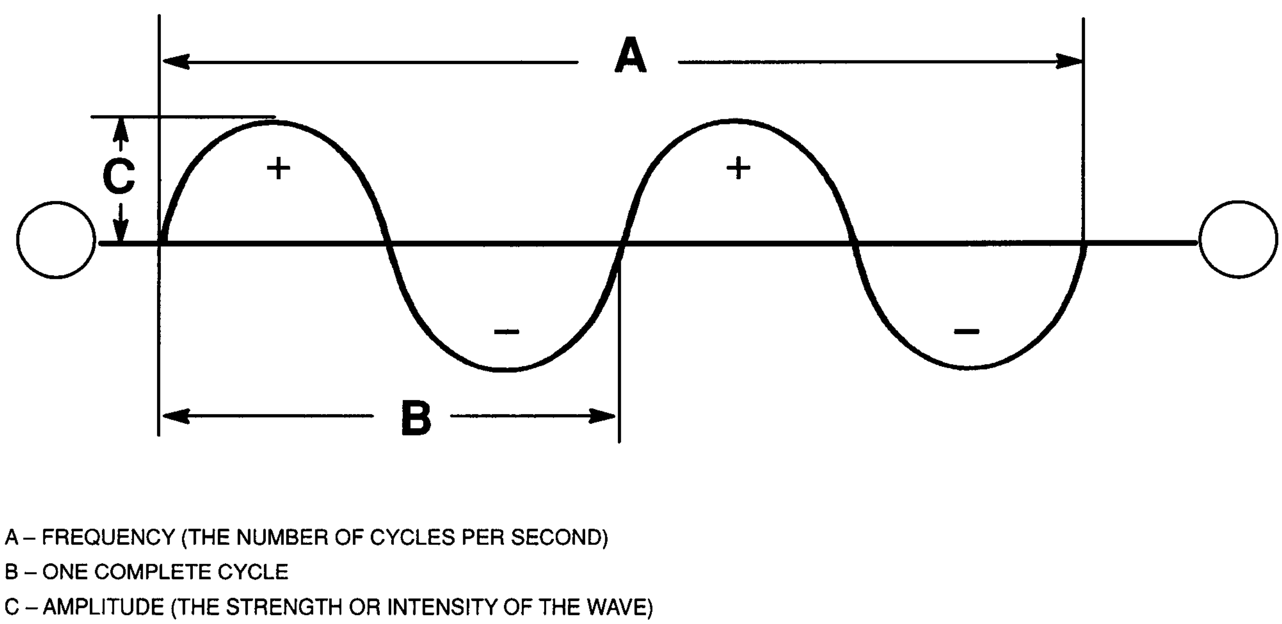


Figure 2-1. Wavelength characteristics.

Table 2-1. Frequency range and band designator.

FREQUENCY RANGE		BAND DESIGNATOR
3-30	kilohertz (kHz)	very low frequency (VLF)
30-300	kHz	low frequency (LF)
300-3000	kHz	medium frequency (MF)
3-30	megahertz (MHz)	high frequency (HF)
30-300	MHz	very high frequency (VHF)
300-3000	MHz	ultra high frequency (UHF)
3-30	gigahertz (GHz)	super high frequency (SHF)
30-300	GHz	extremely high frequency (EHF)

POLARIZATION

The direction of the E field of a radio wave, relative to the ground, determines the polarization of the wave. Polarization can either be horizontal, vertical, or a mutation which adopts portions of vertical and horizontal. The latter results in a circular or a hybrid form of a wave. If a whip or other vertical type transmitting antenna is used to propagate radio waves, the transmitted wave is considered to be vertically polarized. If the transmitting antenna is horizontal, relative to the earth's surface, the transmitted wave is horizontally polarized.

To illustrate vertical wave polarization, imagine a rope lying reasonably straight on the ground. One end is attached to a tree or other support (Figure 2-2). If the loose end of the rope is raised, tightened, and given a violent up and down motion, a series of undulating *waves* will travel along the rope. The movement of the waves will be vertical to the earth and clearly visible.

If the same rope had a similar movement applied in a horizontal manner, the waves would be in a horizontal plane. These waves would be called horizontally polarized (Figure 2-3).

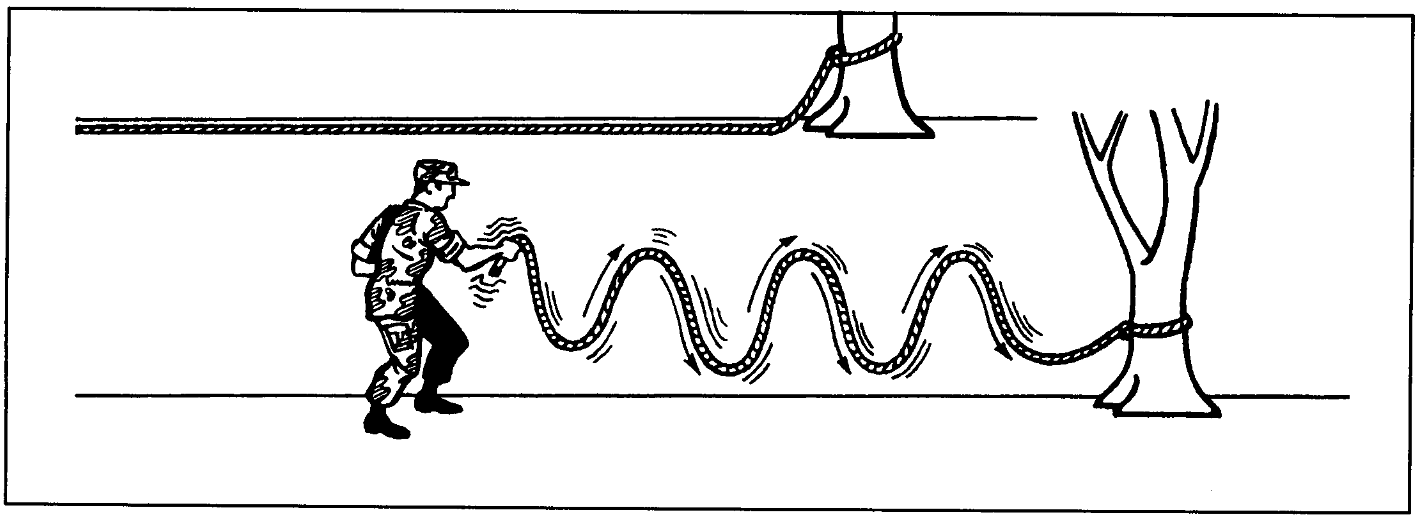


Figure 2-2. Vertical wave polarization.

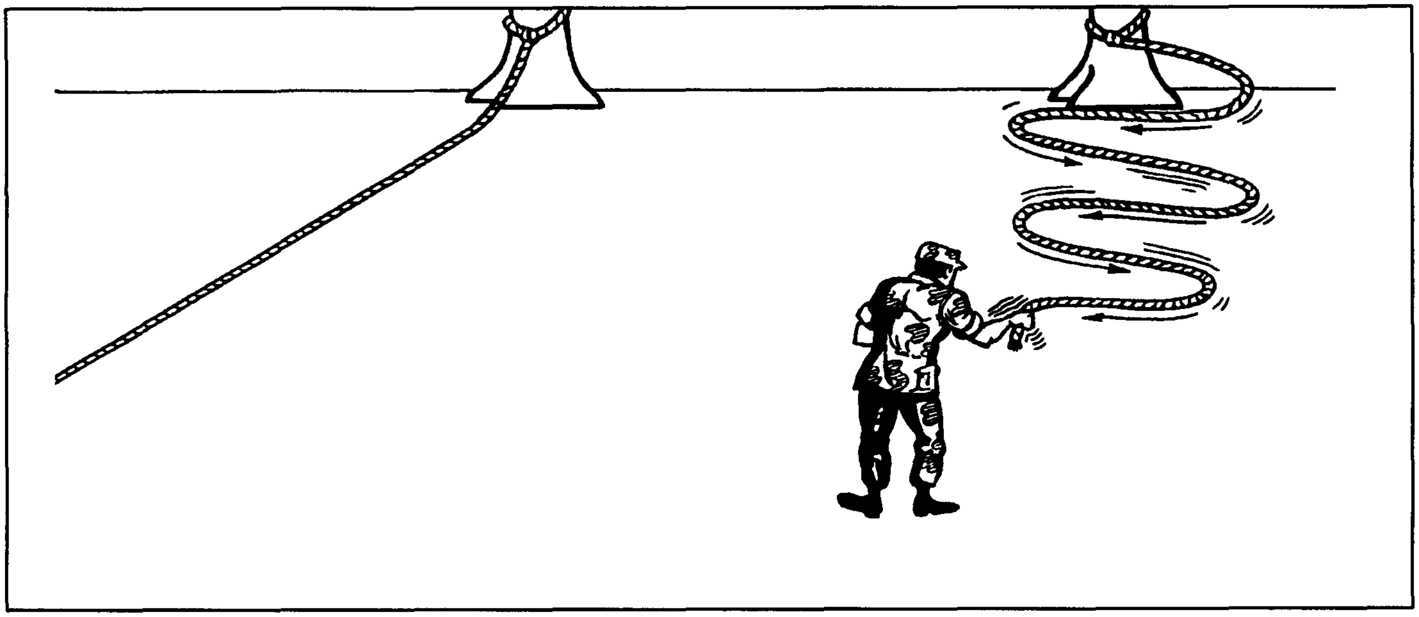


Figure 2-3. Horizontal wave polarization.

PROPAGATION FACTORS

Radio waves are electromagnetic waves which travel through space at the same speed as light. They travel approximately 186,000 miles per second or 300,000,000 meters per second. A conversion formula for wavelength and frequency is shown below. If the measurement in Hertz is known and a conversion to wavelength is desired, apply—

$$\textbf{Wavelength (meters)} = \frac{300{,}000{,}000}{\textbf{Frequency (Hz)}}$$

If wavelength (in meters) is known and a conversion to frequency (Hz) is desired, apply—

$$\textbf{Frequency (Hz)} = \frac{300{,}000{,}000}{\textbf{Wavelength (meters)}}$$

Radio wave propagation is defined as extending or transmitting electromagnetic energy through space. Wavelength, frequency, and polarization are all essential elements of the actual wave and are factors which affect the radio wave propagation. The simplest form of propagation is through the space wave. The wave is radiated from the transmitter and continues through space in a line of sight (LOS) fashion until it reaches the receiver. Over a flat surface there are few problems in interception or direction finding. However, we do not live on a flat surface. The curved surface of the earth, while appearing to be flat over a short distance, limits the effective LOS range.

Radio waves tend to travel in straight lines unless they are acted on by some force. They can be reflected off the surface of any sharply defined object such as the earth's surface. The radio waves can also meet other obstructions or objects that will scatter or reflect the signal. They can be reflected, refracted, or diffracted. Factors which affect radio wave propagation include—

- Wavelength.
- Polarization.
- Space (or the medium through which waves travel).
- Physical obstructions.

All of the above factors contribute to or create additional considerations. Personnel engaged in or using direction finding results must understand these factors.

Reflection

When observing oneself in a mirror, the light beams or waves reflected directly off the mirror's silver finish give the identical or mirror image, barring an optical distortion. Radio waves are reflected similar to light waves traveling at the same speed. Although light waves can be seen, radio waves must be detected by electronic equipment. Figure 2-4 illustrates how radio waves are reflected off the ionosphere. The reflective components of light beams are further illustrated in Figure 2-5.

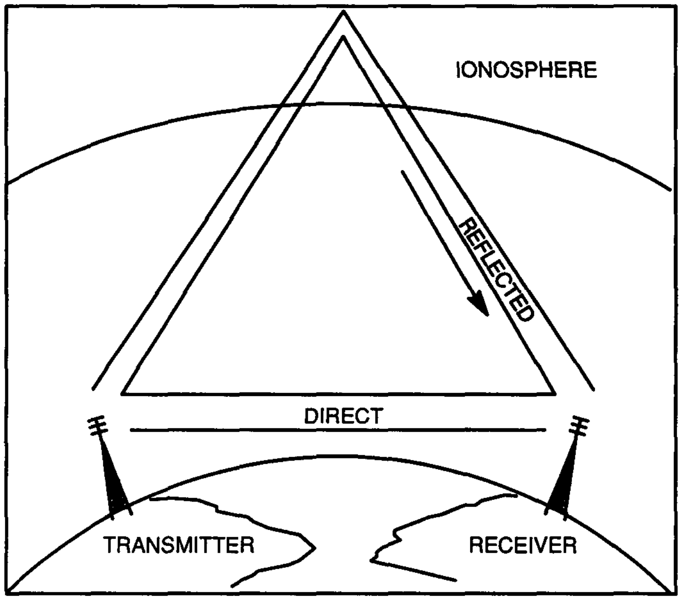


Figure 2-4. Reflected radio waves.

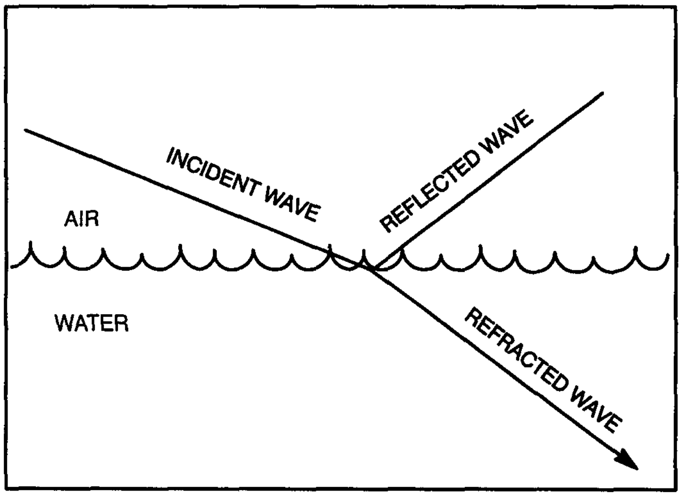


Figure 2-5. Reflection of a light beam.

Refraction

Refraction can best be illustrated by a pencil held obliquely so that a portion of it is beneath the surface of some water (Figure 2-6). From most viewpoints, the pencil will have the appearance of being bent at the point where it enters the water. This effect is because light waves travel more slowly in water than in air. This causes a change in direction of travel of the refracted light. Also, radio waves travel at a different speed over water than land. Therefore, when passing from land to water or vice versa, the radio wave is refracted or bent. Note, refraction occurs only when the wave or light beam approaches the new medium at an oblique angle. If the whole wave front arrives at the new medium at the same moment (perpendicularly), it is slowed uniformly and no bending occurs.

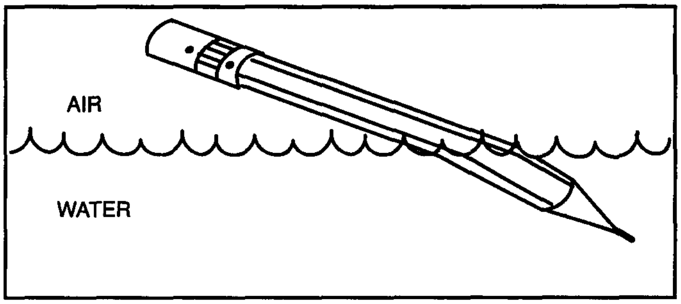


Figure 2-6. Refraction of a pencil.

Diffraction

Diffraction of a radio wave is the phenomena of bending the wave around a solid object. The lower the frequency or the longer the wavelength, the greater the bending of the wave. Therefore, radio waves are more readily diffracted than light waves. Sound waves are more readily diffracted than radio waves. Figure 2-7 illustrates why radio waves of the proper frequency can be received on the far side of a hill or other natural obstruction. It also illustrates why sound waves can be heard readily around the corner of a large building. Diffraction is an important consideration in the propagation of radio waves over long distances. The largest object to contend with is the curvature of the earth. It prevents the direct passage of the waves from the transmitter to the DF receiver.

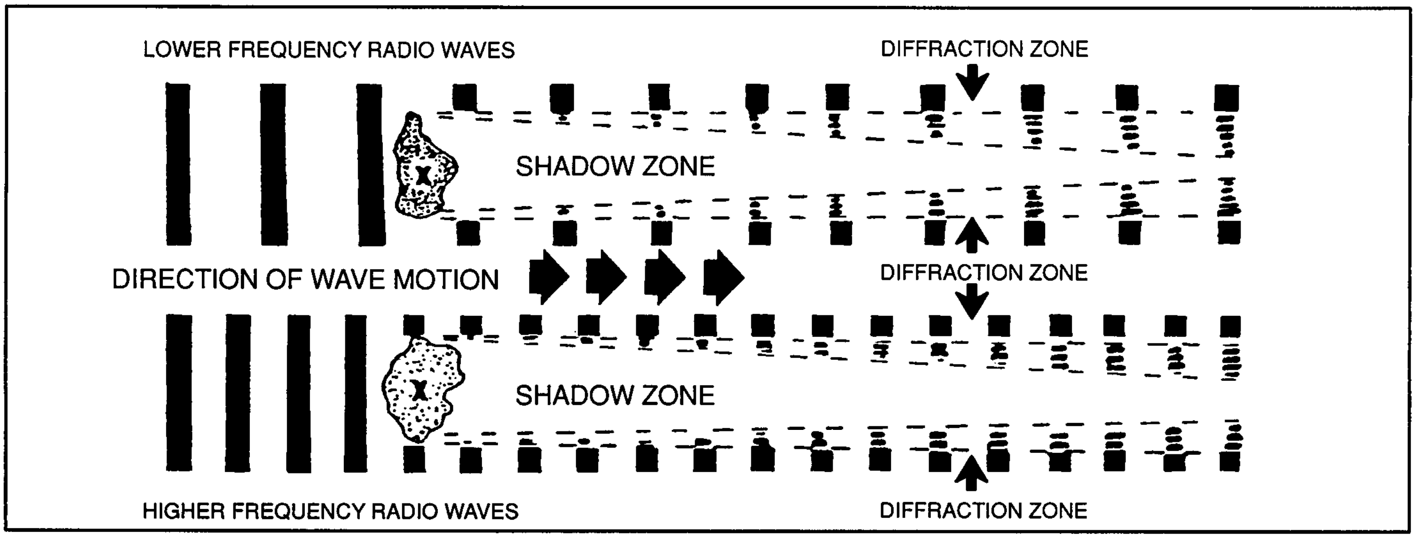


Figure 2-7. Diffraction of radio waves around a solid object.

ATMOSPHERE

The earth's atmosphere plays a crucial role in long distance radio communications. Radio waves may be reflected in the atmosphere and returned to earth. This technique is discussed later in this chapter. As shown in Table 2-2, the atmosphere consists of multiple layers, of which only a few have any discernible effect on radio waves. The ionosphere is the primary layer that is used to return a radio wave back to earth.

Table 2-2. Characteristics of the atmosphere.

ATMOSPHERIC REGION	LOCATION (Km)	FEATURES	EFFECT ON COMMUNICATIONS (Radio Frequency)
Ionosphere	Extending 50-600 km from the earth's surface.	Electrically charged set of layers, with large amounts of free electrons.	Excellent reflection/refraction of MF and HF signals. Some VHF may be propagated as well. Primary medium for sky wave communications.
Stratosphere	Extending 15-50 km from the earth's surface.	The only isothermal region of the atmosphere.	No effect.
Troposphere	From earth's surface to 10-15 km.	Lowest region of the atmosphere. Sustains life. Temperature decreases with increasing altitude.	Negligible effect. Allows direct, surface, and ground wave communications of all frequencies.

Ionosphere

The ionosphere is a region of ionized (electrically charged) gasses located approximately 50-600 kilometers (km) above the earth's surface. As illustrated in Table 2-3, there are essentially four layers (D, E, F1, and F2) of the ionosphere which affect communications and DF. These layers vary in ionization and height above the earth's surface, depending on the amount of exposure to the sun.

The ionosphere is formed when extreme ultraviolet light from the sun strips the electrons from neutral atoms in the ionosphere. Thus, the electrons become *free* (unbound), and the remaining atom becomes positively ionized. The free electrons reflect/refract radio waves of a certain frequency. Due to this process, the E and F layers become positively ionized.

However, the free electrons may attach to neutral atoms. When such attachments occur, the atoms become negatively ionized. This process is common in the D layer, making the region of the ionosphere negatively ionized.

Factors which influence the ionosphere and its effect on radio waves include—

- The time of day.
- The seasons of the year.
- Solar flares.
- Magnetic storms.
- Certain man-made disturbances such as nuclear detonations.

An important relationship between radio waves and the ionosphere is that the higher the frequency, the less its tendency to bend. Depending upon ionospheric conditions and the angle of the signal's arrival at the ionosphere, the bending may be slight. The radio waves may not be sent back to earth (Figure 2-8).

Table 2-3. Characteristics of the ionosphere.

IONOSPHERIC LAYERS	LOCATION (Km)	FEATURES	EFFECT ON COMMUNICATIONS (Radio Frequency)
D	50-100 km	Layer closest to earth. Negatively ionized layer, with relatively little free electrons. Exists during the day.	Primarily acts to absorb radio waves. Small amounts of refraction are possible, but unpredictable.
E	100-200 km	Positively ionized with varying amounts of free electrons. State changes with temperature, angle of the sun, magnetic fields, and time of day. Exists during the day.	Erratic behavior. Sometimes reflects/refracts radio waves in MF, HF, and lower VHF bands.
F	145-400 km (F1–145-200 km) (F2–240-400 km)	Very positively ionized with large amounts of free electrons. During the day, this region separates into the F1 and F2 layers. The F region decreases in ionization and increases in altitude at night.	Primary means of reflecting/refracting MF and HF signals in sky wave propagation. At night, behavior becomes slightly erratic, but communications distances are much greater.

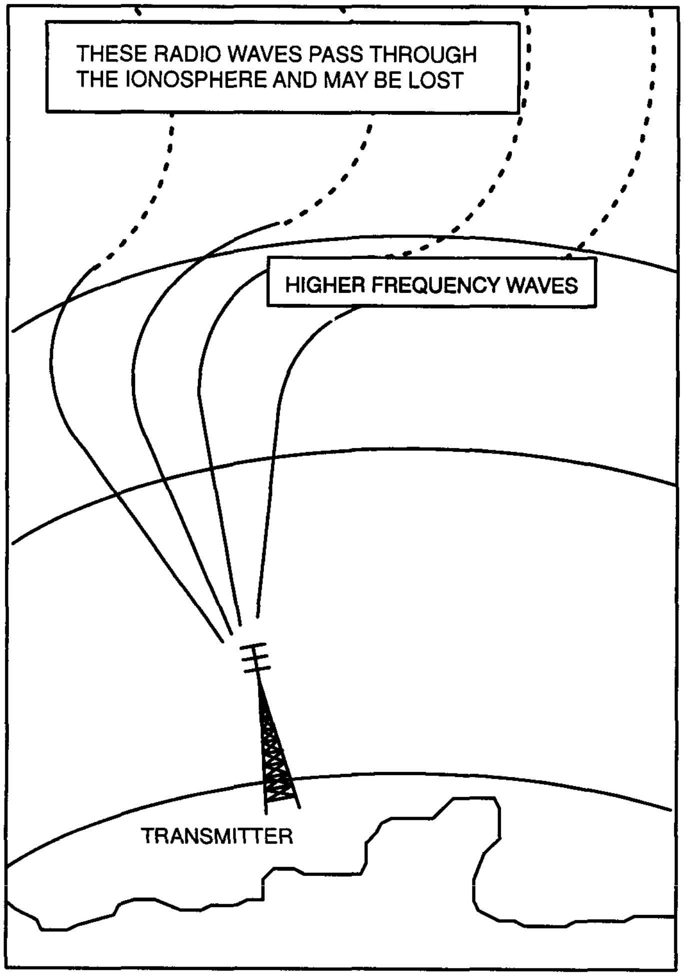


Figure 2-8. High frequency wave penetration.

During daylight hours, the ionosphere is subject to full ultraviolet output from the sun. Therefore, the D, E, F1, and F2 layers reach their full potential. At night, the composition of the layers of the ionosphere changes as the F layers combine. Therefore, higher radio frequencies are more likely to penetrate the ionosphere and be lost. As a general rule, lower communication frequencies are used during the night.

Conversely, during the day when ionization of the atmosphere is more intense, higher communications frequencies can be used without undue loss of the signal. This is because penetration of the ionized layer is at a minimum. Changes in the relative proximity of the sun to the earth will also cause gradual changes in the ionosphere. The longer exposure of the ionosphere to the sun in the summer causes a greater degree of ionization during the night and day. Therefore, higher frequencies may be used for summer operations. Figure 2-9 illustrates the approximate heights of the various layers of the ionosphere.

Remember, however, that the actual number of layers, their heights above the earth, and the relative intensity of ionization present will vary. They vary from hour to hour, from day to day, from month to month, and from year to year.

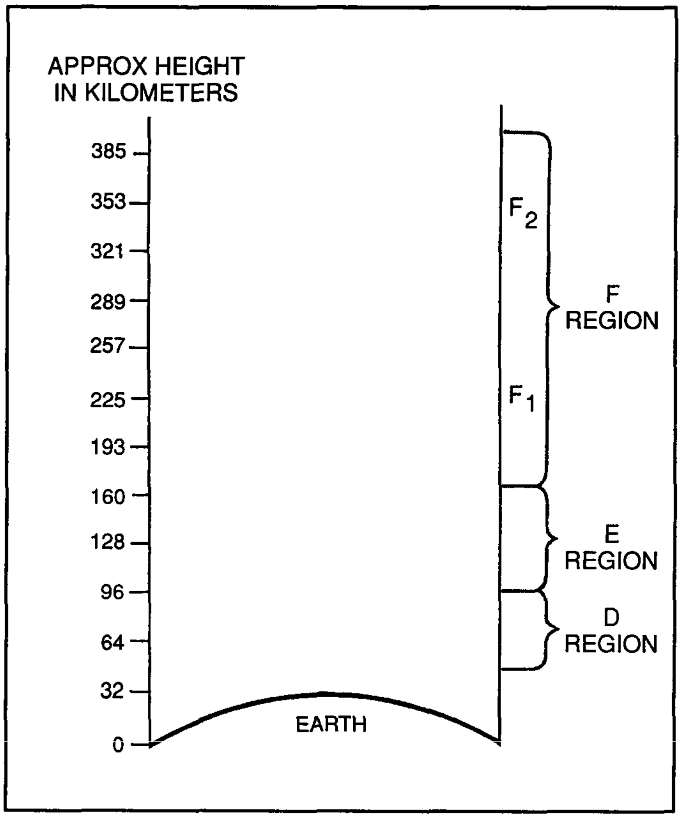


Figure 2-9. Approximate heights of ionospheric layers.

Stratosphere

The stratosphere is that portion of the earth's atmosphere between the ionosphere and the troposphere. Since the temperature in this region is considered to be almost constant, it is also known as the isothermal region. The stratosphere has little, if any, effect on radio waves which are transmitted through it. It is mentioned only to differentiate the three major regions of the earth's atmosphere.

Troposphere

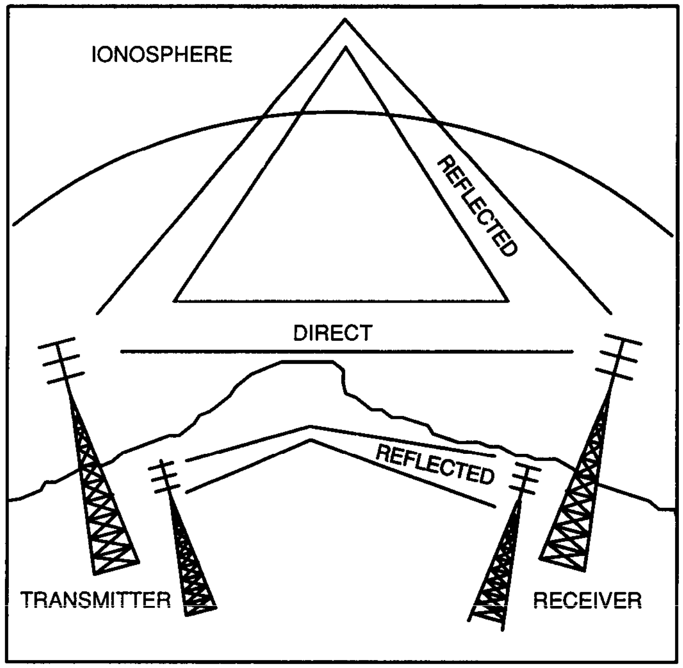
The troposphere greatly influences electromagnetic emissions. It is that portion of the earth's atmosphere extending from the surface of the earth to heights of approximately 10 to 15 kilometers. This region contains the mixture of gasses we depend on for life. Additionally, most weather activity occurs in the troposphere.

WAVE PATHS

There are three distinct paths that a radio wave may take to reach the receiving antenna. They are—

- Direct.
- Reflected.
- Refracted.

The direct and reflected paths are shown in Figure 2-10. They are purposely exaggerated to enable the reader to clearly grasp the differences.



The direct path goes directly from the transmitting to the receiving antenna. The reflected path bounces off the ionosphere or the surface of the earth at the same angle at which it arrives and continues to the receiving antenna (angle of incidence = angle of arrival). The refracted path is the path caused by the bending of the waves in the same manner light waves are bent when seen through water.

If the waves are refracted by the earth, the distance they travel is severely limited due to large losses of energy in the form of heat dissipated into the earth's crust.

WAVE TYPES

Radio waves may be classified as either ground waves or sky waves (Figure 2-11).

Ground waves are continually in contact with the earth's surface. They do not make use of reflection from the ionosphere. They have a tendency to be refracted and, in some cases, reflected into the lower atmosphere. At frequencies above 1500 kilohertz, a ground wave is affected very little by the time of day or season. The ground wave loses much of its strength and dissipates energy as it travels over the earth's surface. However, less strength is lost when it travels over water.

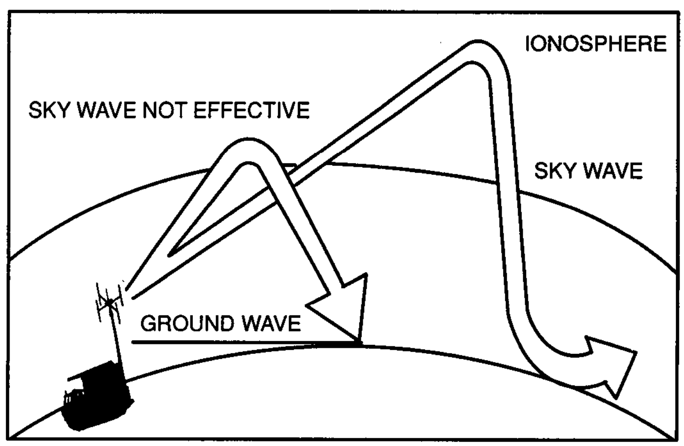


Figure 2-11. Ground waves and sky waves.

Sky waves are transmitted upward with respect to the earth's surface. Sky waves would not be useful for communications were it not for the ionosphere. Radio waves approaching the ionosphere at an angle are refracted back to earth. They may be detected and used for communications purposes or for DF exploitation. Figure 2-12 depicts the waves that penetrate the ionosphere and are lost for all practical purposes. It also illustrates those waves that return to earth for communication use.

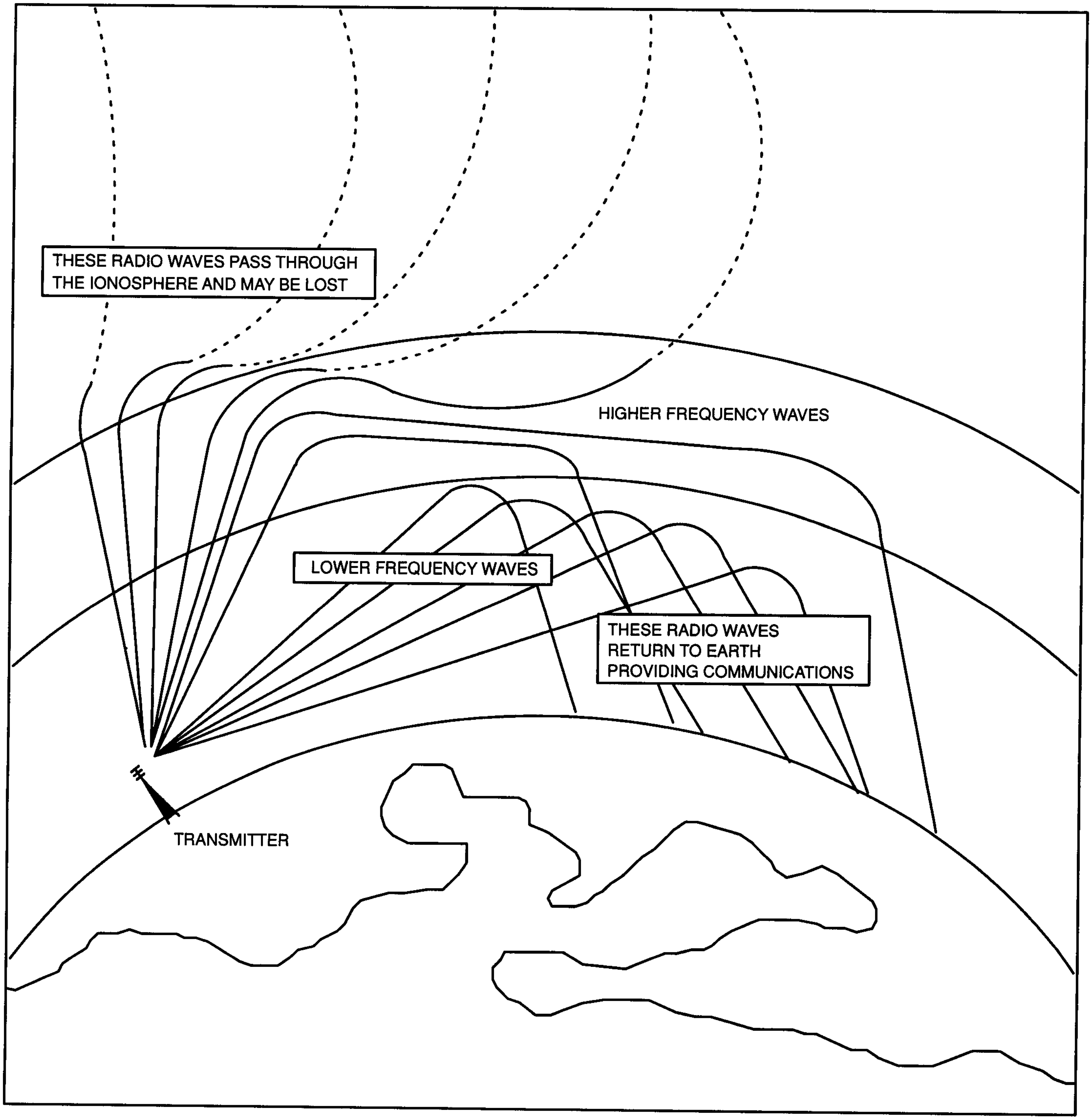


Figure 2-12. Sky waves.

SKIP ZONE AND DISTANCE

The skip zone is the area where the ground wave can no longer be detected (Figure 2- 13) and the sky wave has not yet returned to earth after being reflected or refracted off the ionosphere or troposphere. The skip distance is that area where no sky wave reception will be possible. This is because the wave has not returned to earth after its first or subsequent bounce off the reflecting layer.

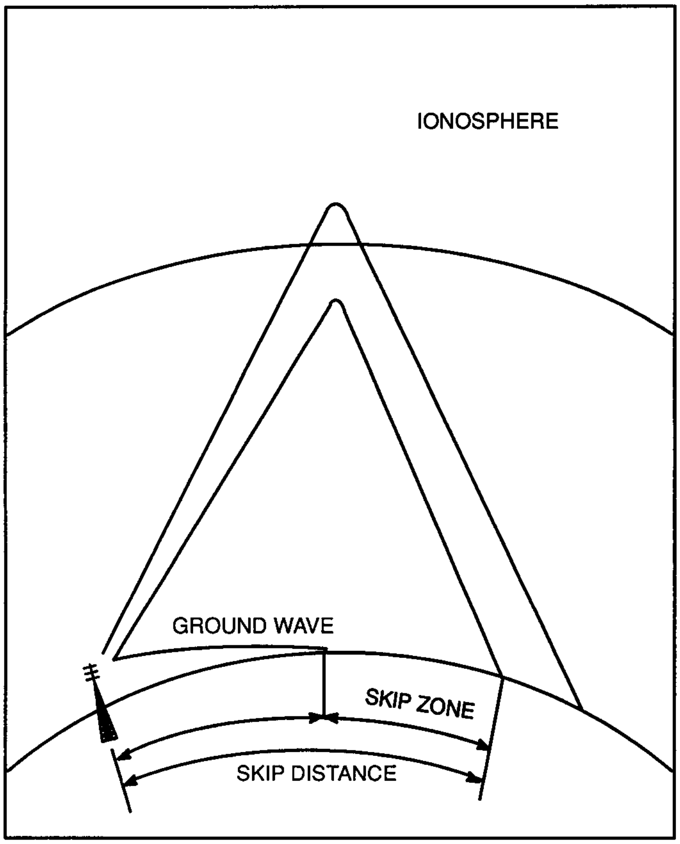


Figure 2-13. Skip zone and distance.

Depending upon the frequency and the transmitter power, multihop transmissions are routinely used for communications. Figure 2-14 illustrates multihop transmissions. There will be, however, skip zones between the points of the wave's return at each hop. Note, however, skip zones are not static or stable.

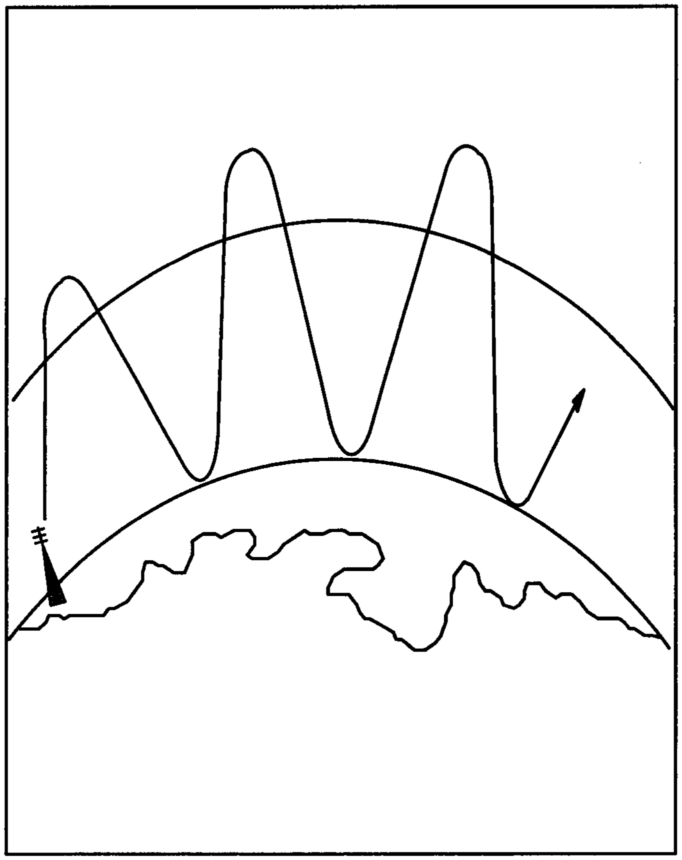


Figure 2-14. Multihop transmissions.

CHAPTER 3

TECHNOLOGY

The Army has several DF systems that target varying types of threat signals, frequencies, and ranges. The DF systems are also characterized by their mobility and their assigned military echelon. These systems are outlined in Table 3-1.

This chapter relates some of the historical and technological developments in acquiring a signal azimuth. It explains some of the antennas, systems, and bearing indicators used to obtain DF information. All direction finding systems serve one primary purpose-to measure the angle of arrival of an EM wave in reference to a known reference (true, magnetic, or grid north).

Table 3-1. Army direction finding systems.

EQUIPMENT	ECHELON	MOBILITY	SIGNALS	MOS (Op/Maint)	FREQ (DF)
AN/PRD-10 MRDFS	Div, ACR MI Co (SF)	Ground Vehicle Manpack	CW, AM, FM, SSB	98G/33T	VHF
AN/PRD-11 MANPACK	Div, ACR MI Co (SF)	Ground Vehicle Manpack	CW, AM, FM, SSB	98G/33T	VHF, UHF
AN/TRQ-32 TEAMMATE	Corps, Div ACR	Ground Vehicle	CW, AM, FM, SSB	98G, 98H, 33T	VHF
AN/TRQ-37 TACFIX	Div	Ground Vehicle	CW, AM, FM, SSB	98G, 98H, 33T	VHF
AN/TSQ-138 TRAILBLAZER	Div	Ground Vehicle	CW, AM, FM, SSB	98G/33T	VHF
AN/TRD-15/23	EAC	Ground Vehicle Semi-Fixed	CW, AM, FM, SSB	98D/33T	HF
AN/TSQ-152 TRACKWOLF	EAC	Ground Vehicle Semi-Fixed	CW, AM, FM, SSB	98D, 98H, 98G/33T	HF
AN/FLR1-9	EAC	Fixed	CW, AM, FM, SSB	98D/33P	HF
DF-6	EAC	Fixed	CW, AM, FM, SSB	98D/33P	HF
AN/ALQ-151 QUICKFIX	Div, ACR	Airborne	CW, AM, FM, SSB	98G/33R	HF, VHF
AN/USD-9 GUARDRAIL V	Corps	Airborne	CW, AM, FM, SSB	98D, 98C, 98G/33R	HF, VHF, UHF
AN/ALQ-133 QUICKLOOK II	Classified	Airborne	CW, Pulse	98J, 33T	UHF
AN/TSQ-164 DRAGONFIX	Corps	Ground Vehicle	CW, AM, FM, SSB	98G, 98H, 33T	HF

HISTORY OF MAJOR DIRECTION FINDING SYSTEMS

Loop Antenna

Early direction finding technology required a movable directional loop antenna and a receiver. The arrival angle is measured by moving the antenna until a maximum or minimum signal strength is achieved. The simple loop antenna (Figure 3-1), or some derivative of it, can still be found today. One of the disadvantages of using this method is that the signal being measured is reduced, while noise from other directions is not. To overcome this problem, wave amplitude comparison (using two directional antennas with different orientations) was introduced.

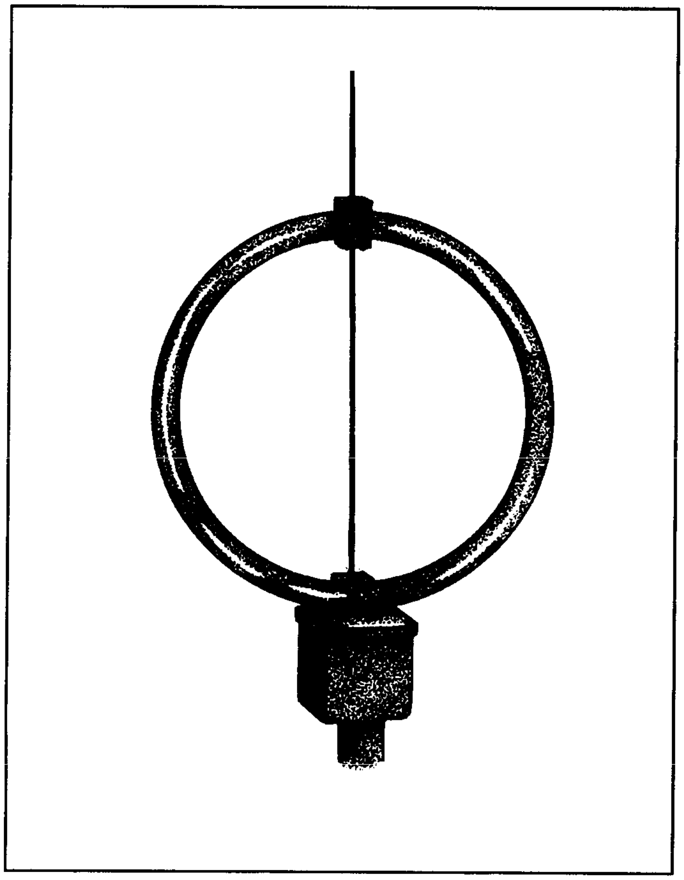


Figure 3-1. Loop antenna.

Rotating Loop

It was not always feasible or desirable to physically move the antenna. As a result, some RDF technology used a fixed antenna that measured signal strength to provide an azimuth. One of the earliest of these systems used fixed crossed loops to feed a small orthogonal loop arrangement with a rotating loop inside of it. This was called a goniometer. Today, the term goniometer may refer to any type of mechanical or electrical cyclic sampling equipment.

Cathode Ray Tube

The first cathode ray tube (CRT) direction finder used cross loops (Figure 3-2). Instead of using a goniometer, each loop was fed to a channel of a dual-channel receiver. The outputs from the receiver were applied to pairs of deflection plates within a special CRT.

A clear signal produced a straight line, the angle of which gives the azimuth of the signal.

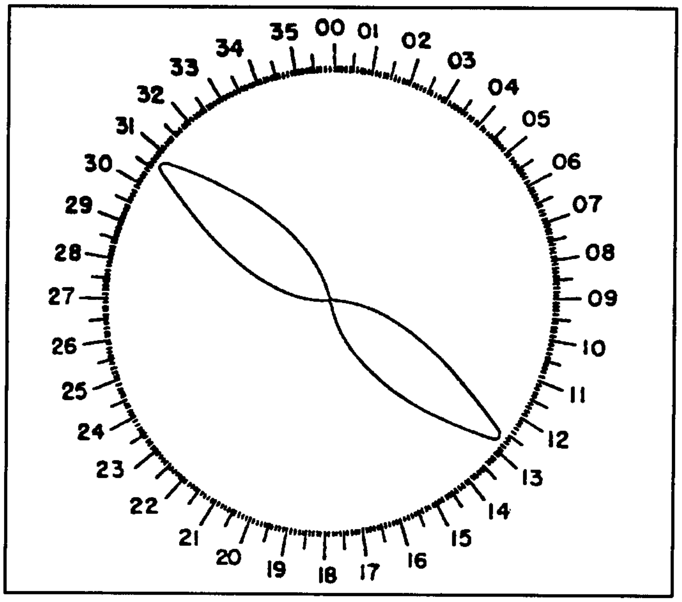


Figure 3-2. Cathode ray tube.

Adcock Antenna

Until the end of World War II (WWII), the most common type of DF system was the crossed loop or Adcock antenna (Figure 3-3). This antenna system is still used in modified form for short-distance direction finding systems. The Adcock antenna used top horizontal members that were well shielded, to reduce polarization errors. These systems were small in relation to the wavelength of the received signals. They were therefore classified as narrow aperture direction finding (NADF) systems.

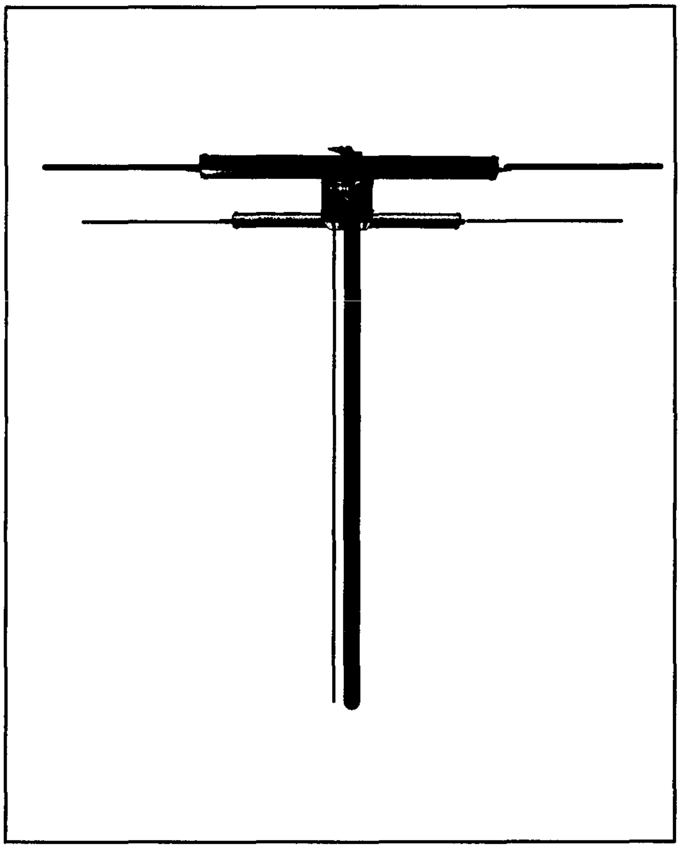


Figure 3-3. Adcock antenna.

Wullenweber System

During WWII, the Wullenweber system heralded the era of wide aperture direction finding (WADF) systems (Figure 3-4). The Wullenweber has a circularly disposed antenna array (CDAA) up to 1,000 meters in diameter with a large number of elements. About a third of the elements are combined to form sum/difference beams. The beams are effectively rotated in azimuth by a rotating switch (goniometer) which connects and combines elements around the ring.

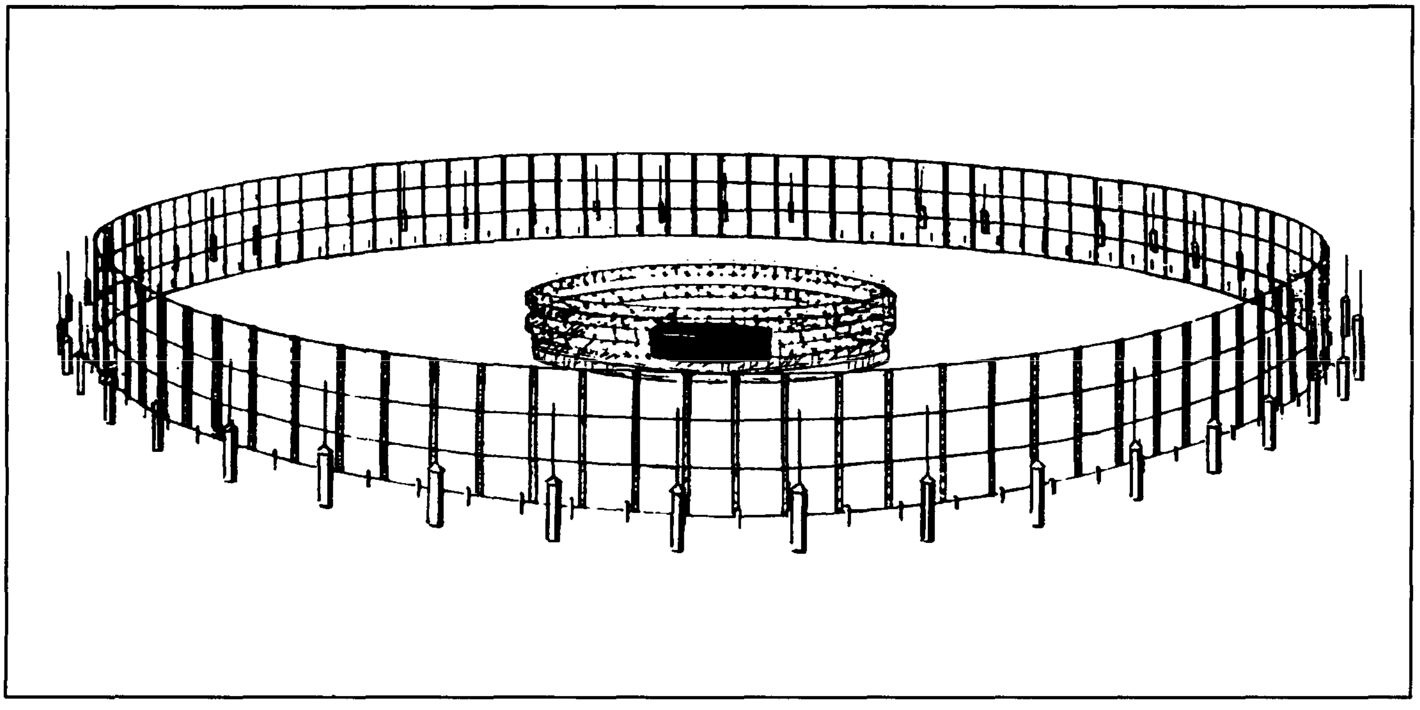


Figure 3-4. Wullenweber system.

Quasi-Doppler System

A further variation of the Wullenweber system is called the Quasi-Doppler or Pseudo-Doppler system (Figure 3-5). This variation has also been called a commutated-antenna direction finder (CADF). Most of the older groundbased EAC tactical direction finding systems are of this type. In theory, the Doppler systems impose a phase modulation on the received signal by moving the antenna in a circle. The phase of the modulated signal is a function of its direction. In actual practice, a fixed CDAA is used. The receiver rapidly samples each antenna around the ring by using a goniometer switch.

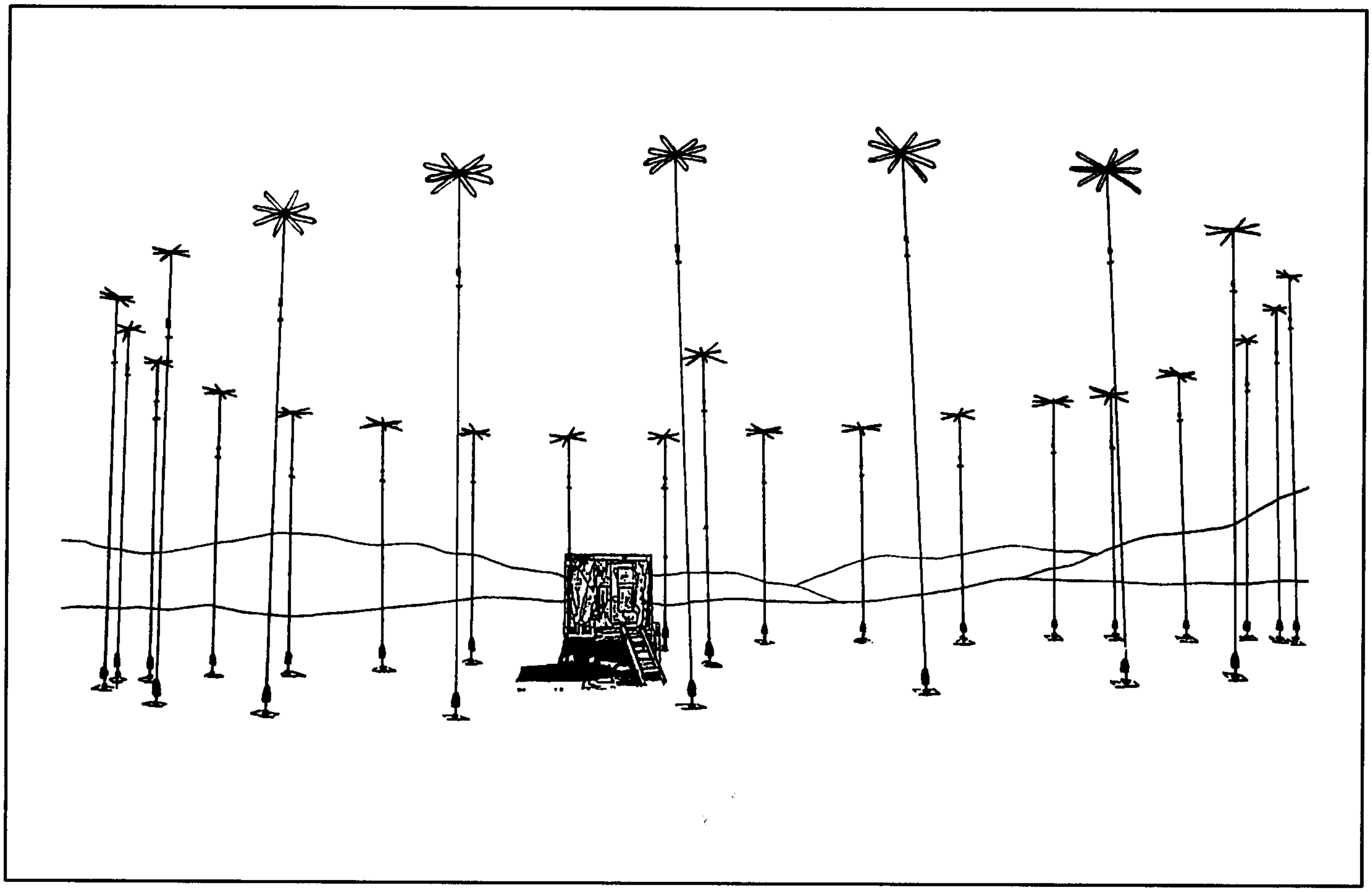


Figure 3-5. Quasi-Doppler system.

Interferometric System

Interferometric systems area completely different class of direction finding systems (as illustrated in Figure 3-6). The azimuth of an incoming wave is not deduced by rotating beams. It is taken from the phase measurements of signals, made on a number of spaced antennas. Unlike the beam-forming type of WADFs, interferometers accept all signals on the array. Two different approaches are used to process the results. Depending on the type of system, one or both of the following may be used:

- Wavefront analysis (WFA).
- Wavefront testing (WFT).

Wavefront analysis accepts all signals but attempts to recover the major ones. It attempts this by analyzing the complex voltages measured on the elements of the antenna array under wave interference conditions.

Wavefront testing accepts only signals arriving from one direction or quasi uni-modal propagation (QUMP). QUMP is achieved by detecting a linear phase shift across the array with near equal amplitudes on all the elements. (This process is also called coincidence interferometry.) For further information on linear phase shift and measuring wave amplitude, see TM 11-666.

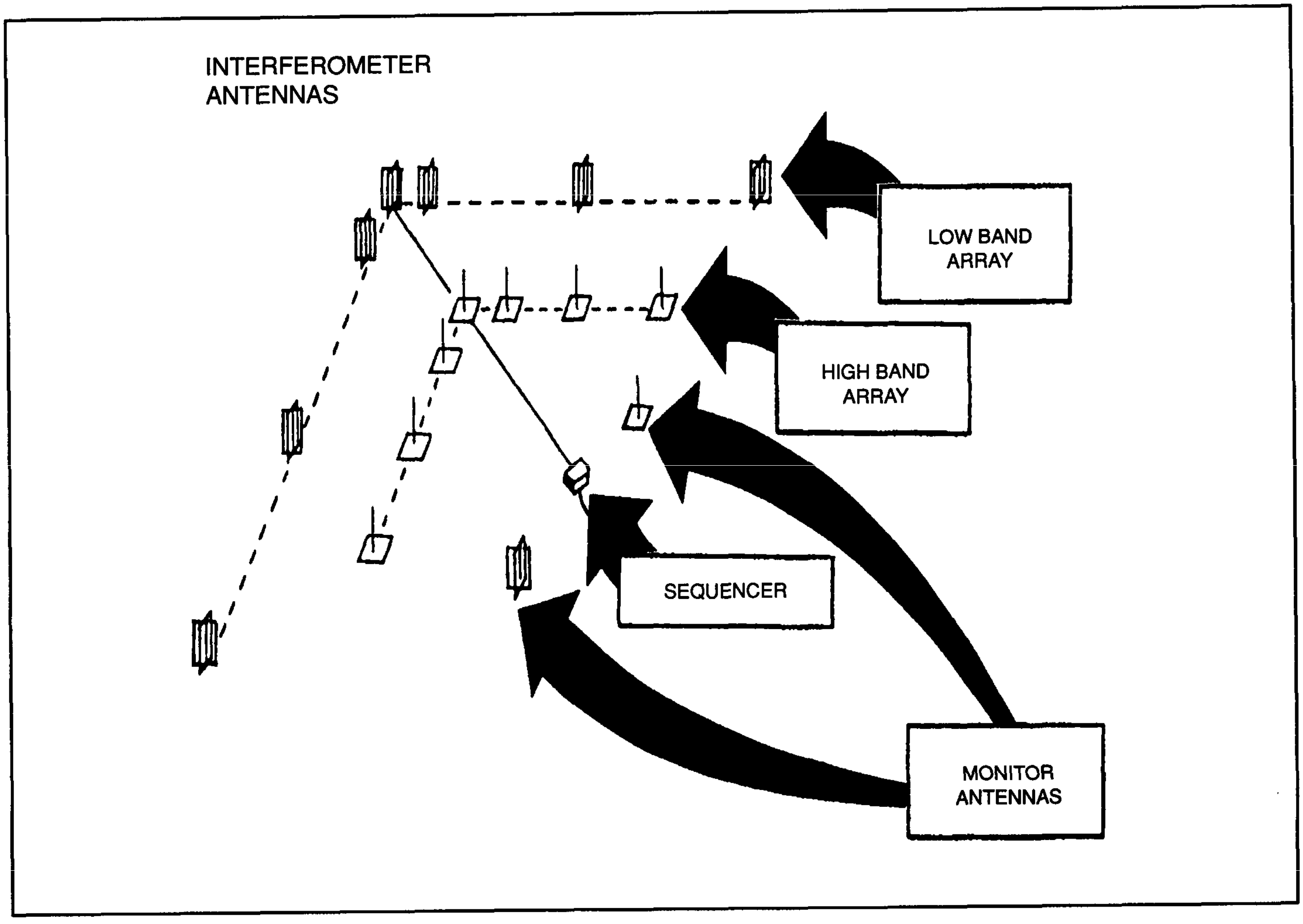


Figure 3-6. Interferometric system.

Time-Difference System

There are time-difference direction finders (TDDF) which measure the difference between the times of arrival of the radio wave at a number of receiving sites. A hyperbolic position line is obtained from the time difference between each pair of sites.

Single Station Locator System

As demonstrated earlier, there are many types of direction finding systems. In some, only the horizontal component (or azimuth) of the arrival angle can be measured. In others, the azimuth and the vertical component (elevation angle) can be obtained. When only an azimuth is resolved, two or more independent DF stations are needed to determine the position of the transmitting antenna. Systems that measure both azimuth and elevation angles are called single station locator systems because, in the case of signals propagated in the ionosphere, two components from just one DF station are sufficient to define the location of the transmitting antenna (assuming a knowledge of the ionosphere along the wave path). The SSL was developed because of the problems of audibility with the traditional DF network. Sometimes the signal could only be heard at one DF site.

The SSL system direction finder is a phase measuring interferometer. Location data include an azimuth measurement on the target signal and a range estimate based on the measured parameters at the DF site. The combination of azimuth and great circle range to the target produces the location output from the system's computer.

DIRECTION FINDING THEORY

Quasi-Doppler Theory

The Doppler DF system is based on Christian Johann Doppler's principle for wave motion, commonly called the *Doppler effect*. The Doppler effect is the perceived change in the frequency of waves from a given source by the observer, when the source and observer are in rapid motion with respect to each other. The frequency of the wave increases or decreases according to the speed at which the distance is increasing or decreasing between the observer and source. An example of the Doppler effect is a train approaching an observer and blowing its whistle. As the train approaches at a high rate of speed, the frequency of the sound waves emitted from the whistle increase. The train passes by and leaves the observer, and the frequency of the whistle decreases.

In an idealized Doppler DF system, the motion of the receiver could be obtained by moving one antenna in a circular path as shown in Figure 3-7. With this system, the frequency of the received wave would be lower than the transmitted frequency during the time the antenna moves with the wavefront. It would be higher than the transmitted frequency when it moves against the wavefront. No change occurs when the antenna is moving perpendicular to the direction of arrival of the EM wave. This activity produces a sinusoidal waveform across the array, such as illustrated in Figure 3-8.

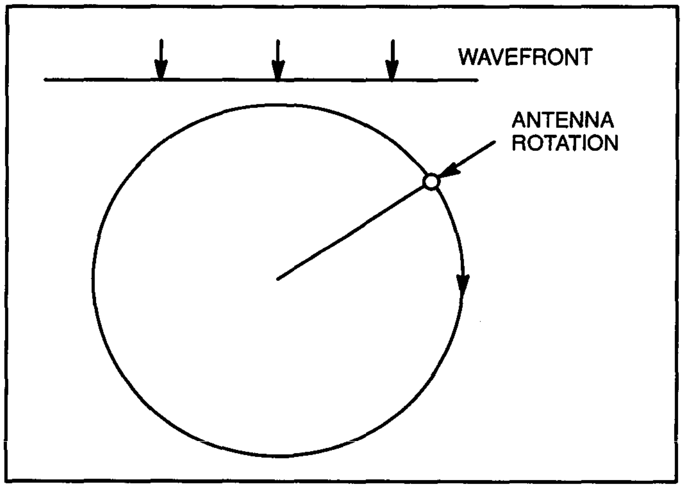


Figure 3-7. Theoretical Doppler DF.

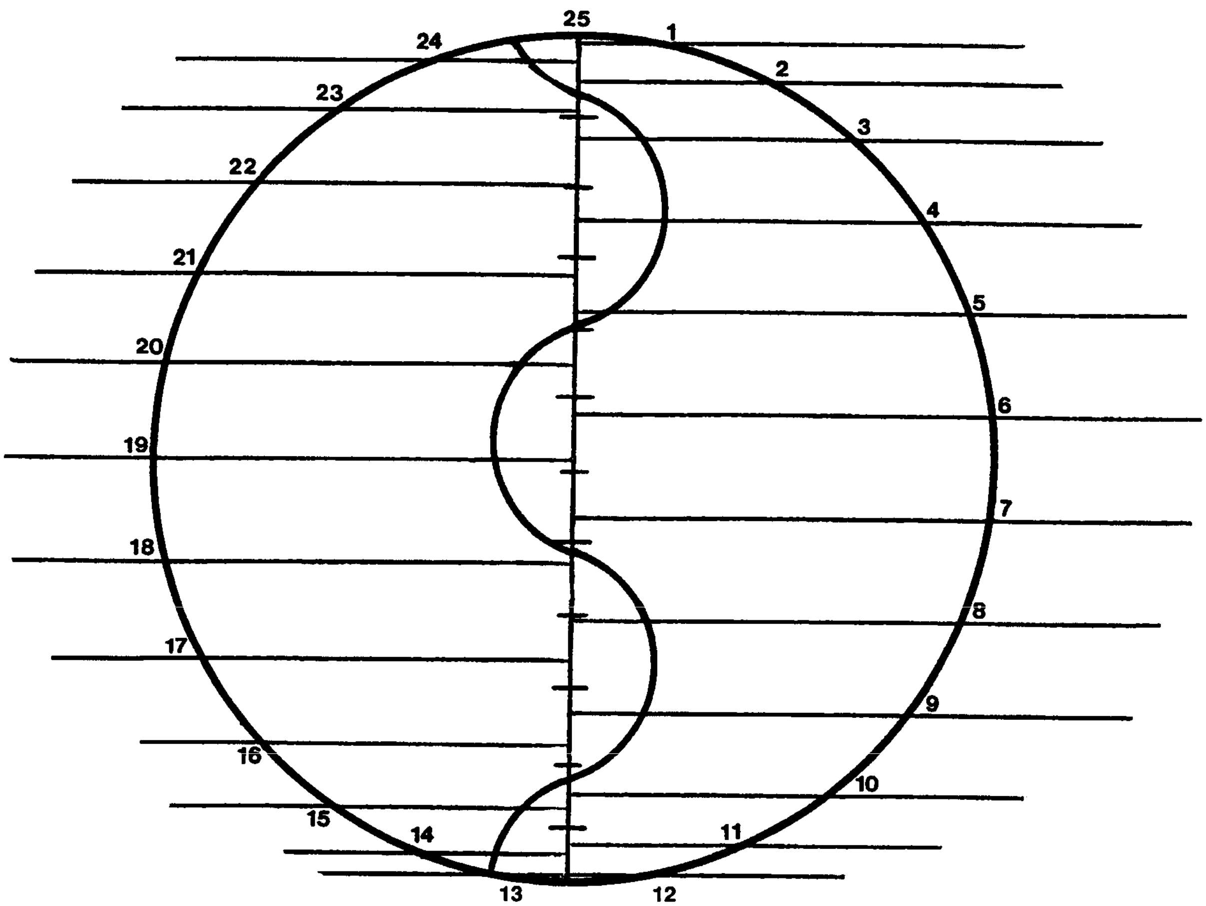


Figure 3-8. Sinusoidal waveform across the array.

The direction of arrival of the signal can be determined if the phase of the frequency modulation signal produced by the antenna motion is compared to a reference phase. The antenna peripheral speed is required to produce an adequate degree of frequency modulation. This speed is impractical to attain in a single rotating antenna system.

To create the required peripheral speed, a simulated Doppler motion is made by placing a number of fixed antennas in a circular array and scanning the signals from the antennas. This is done by sequential sampling using a rotary coupler and drive unit motor (Figure 3-9, page 3-8).

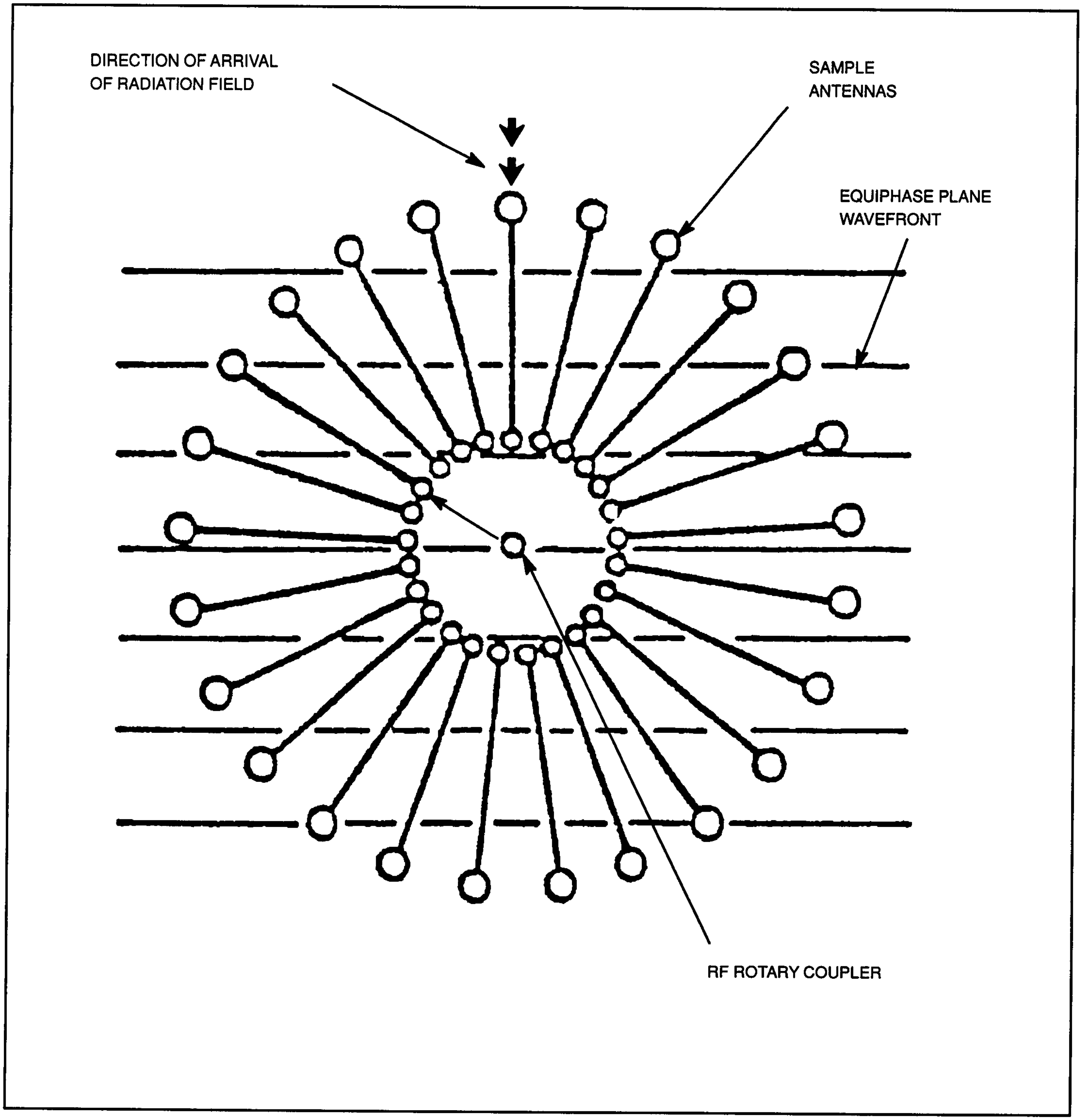


Figure 3-9. Quasi-Doppler DF.

A signal from a distant transmitter induces voltages of equal amplitude in all antennas of the array. The phase difference between the signals in adjacent antennas is a function of the frequency and direction of arrival as shown in Figure 3-10.

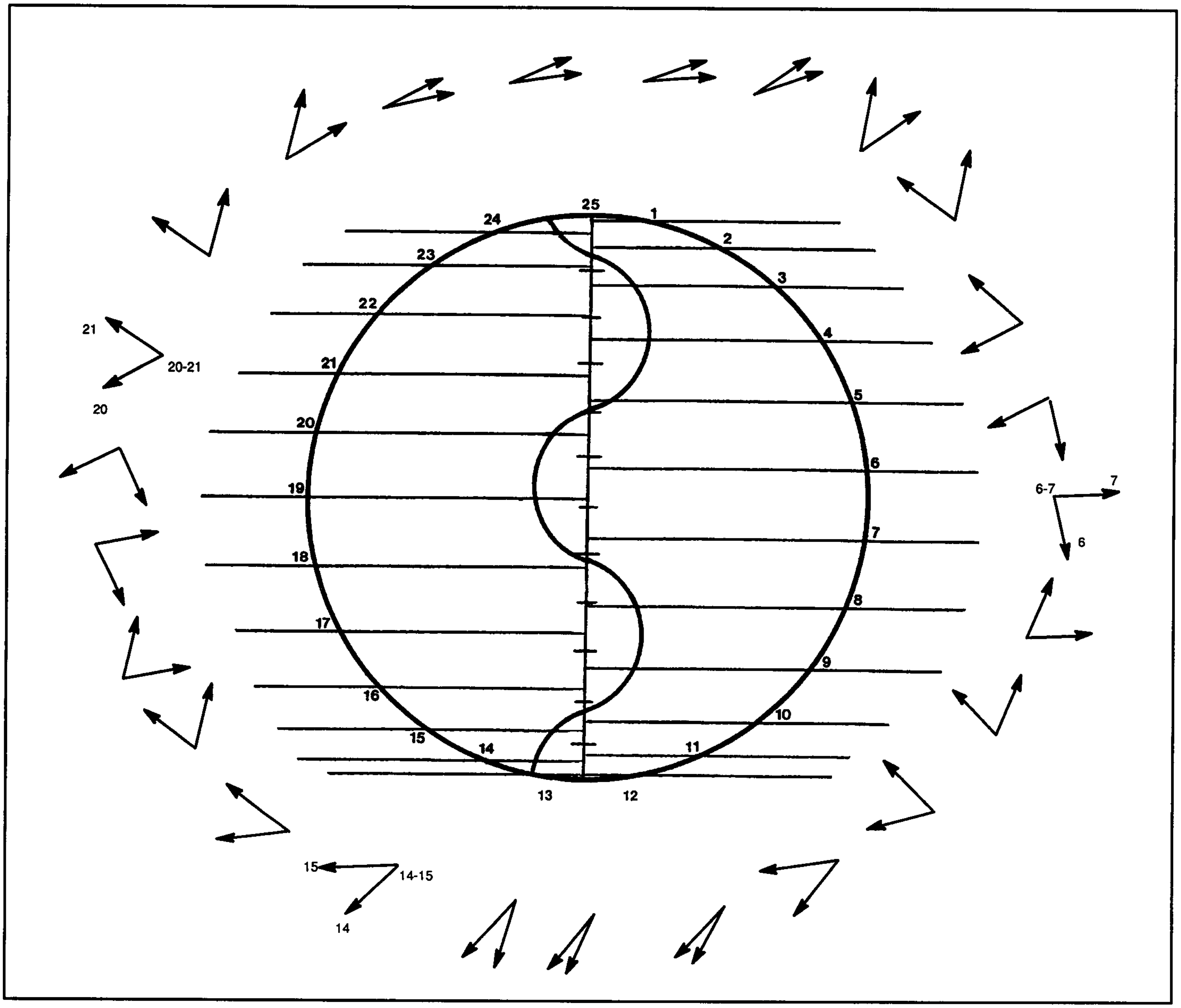


Figure 3-10. Phase difference at the antenna array.

The maximum phase step between adjacent antennas is found between those which fall on a line most nearly parallel with the direction of the wave travel. The minimum phase step occurs between antennas falling on a line most nearly perpendicular to the direction of wave travel.

The antennas of the array are scanned in sequence by a rotating coupling coil unit. The vectors revolve quickly in relation to the motion of the rotor unit. However, at any single moment, the relative phase relationships between antennas do not change with the time of viewing or motion of the coupler. The relationship only changes with the measured frequency.

Signals from adjacent antennas are combined during the scan to produce a frequency modulated (FM) signal. The frequency deviation at every instant is proportional to the size of the phase step between adjacent antennas. The phase of the envelope of the FM depends only on the direction of arrival of the signal. A bearing indicator compares the phase of the FM envelope with a reference phase and presents the bearing indication on a CRT.

Single Station Locator System Theory

Determining a transmitting antenna's location with the SSL system requires an azimuth measurement on the target signal and a range estimate based on measured ionospheric parameters. These requirements automatically infer certain limitations on the system.

Because the SSL system depends on ionospheric propagations, it is designed for use against the high frequency (HF) spectrum sky wave transmissions. As shown in Figure 3-11, the combination of an azimuth and great circle range to the target produces a location from the system that is expressed in geographic coordinates. An HF radio wave transmitted from a target transmitter is reflected from one or more reflecting regions in the ionosphere and arrives at the SSL site with a given bearing and angle of elevation. All SSL systems today use interferometric antenna systems to measure these azimuth and elevation angles.

The SSL system includes an ionospheric sounder which measures the height of the ionospheric reflecting region. There are two types of sounders used in SSL systems. The oldest type is the vertical incidence sounder (VIS) as shown in Figure 3-12. This sounder measures ionospheric reflection heights straight up from the sounder site (usually collocated with the SSL site). A more recent and accurate sounder is the oblique incidence sounder (0IS) as shown in Figure 3-13. The sounder, usually located along the anticipated target ray path, transmits at an oblique angle to the ionosphere and is received at another location (usually the SSL site).

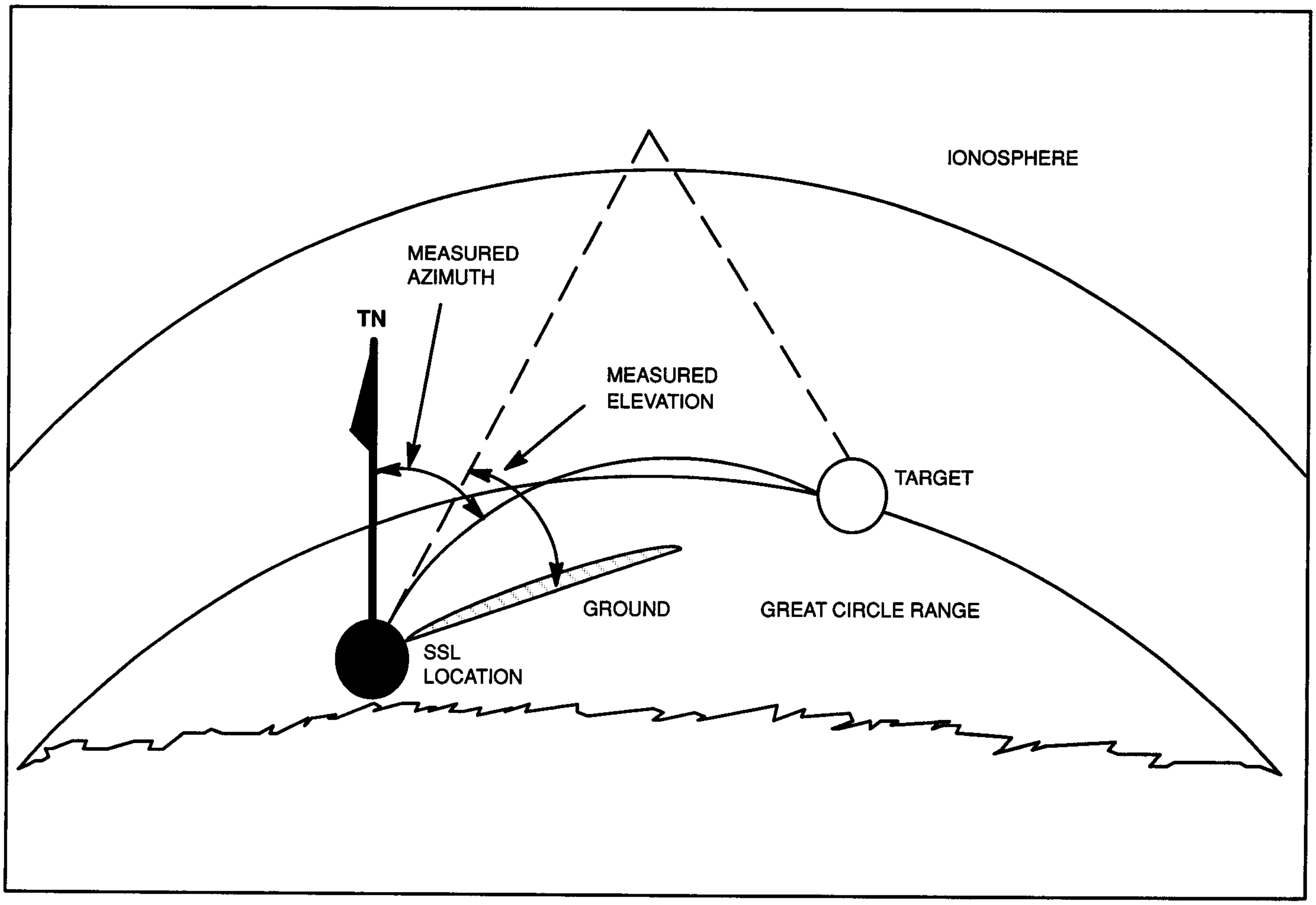


Figure 3-11. Single station locator DF.

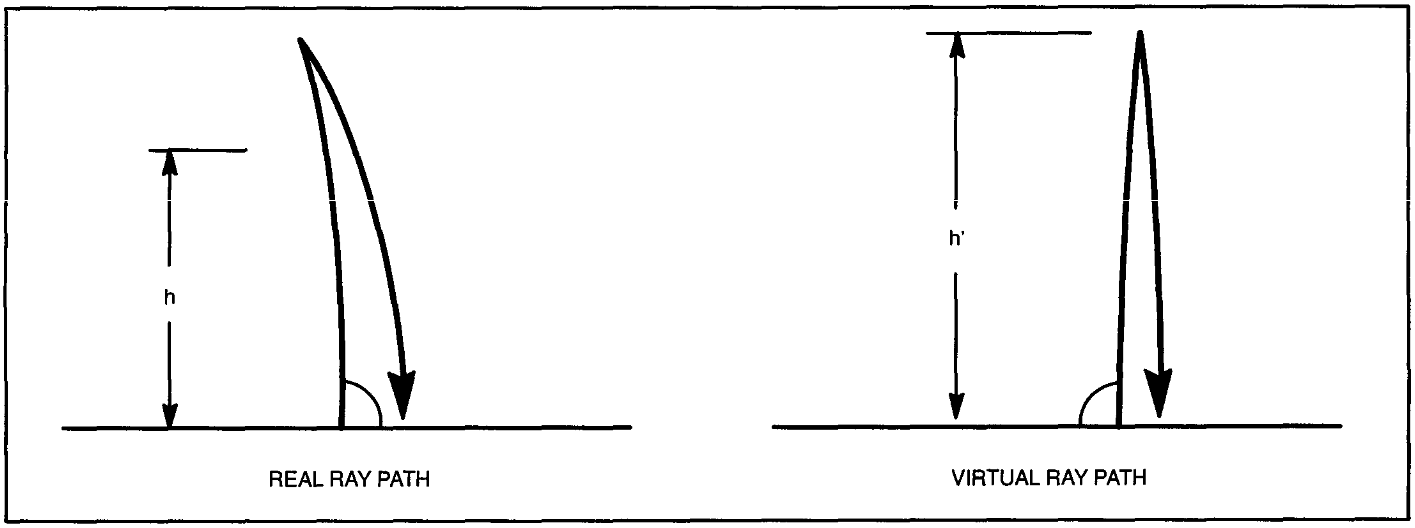


Figure 3-12. Vertical incidence sounder.

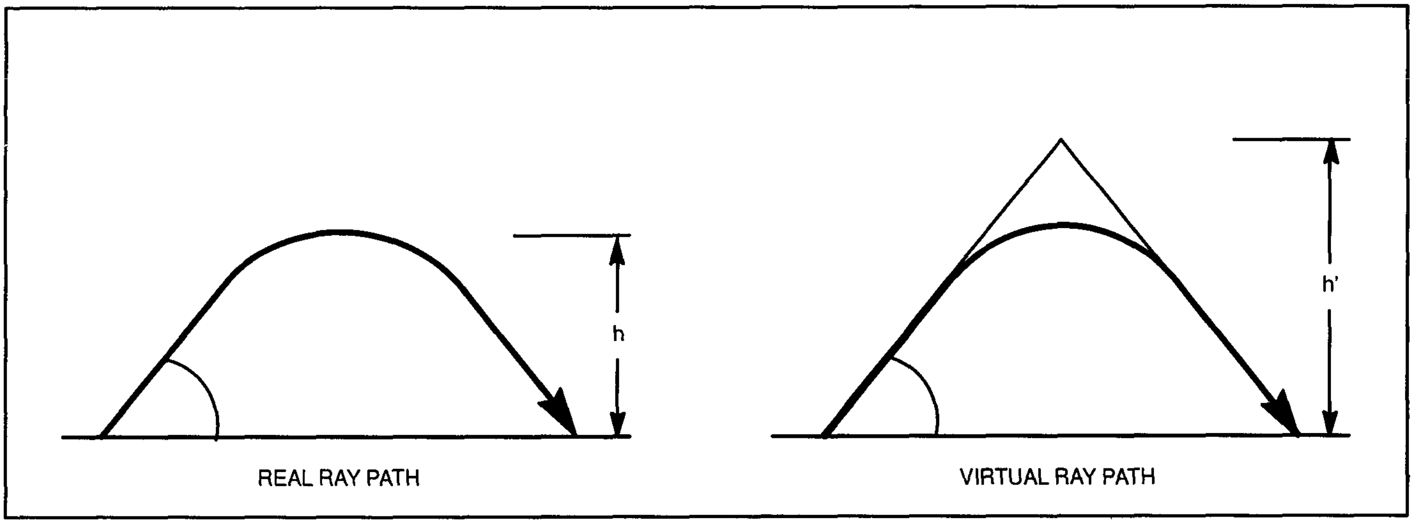


Figure 3-13. Oblique incidence sounder.

After the height of the ionosphere is measured, the SSL then assumes that the reflection height measured by the sounder applies at the midpoint of the radio wave path. Figure 3-14, page 3-12, shows the triangle from the SSL site through the ionospheric midpoint and down to the target transmitter antenna may be solved. This calculation generates a range estimate which, when combined with the observed bearing, is used to calculate the coordinates of the target location.

Each SSL system has a unique way of calculating range. The most commonly found range calculation uses the measured elevation and virtual height with the law of cosines to determine the angle at the center of the earth from the midpoint (half range) to the SSL system. This angle, when multiplied by twice the earth's radius, gives the great circle range from the SSL site to the target. Other systems attempt to also provide traveling ionospheric disturbances, magnetic dip angle, and electron density data in the calculations for a more accurate product.

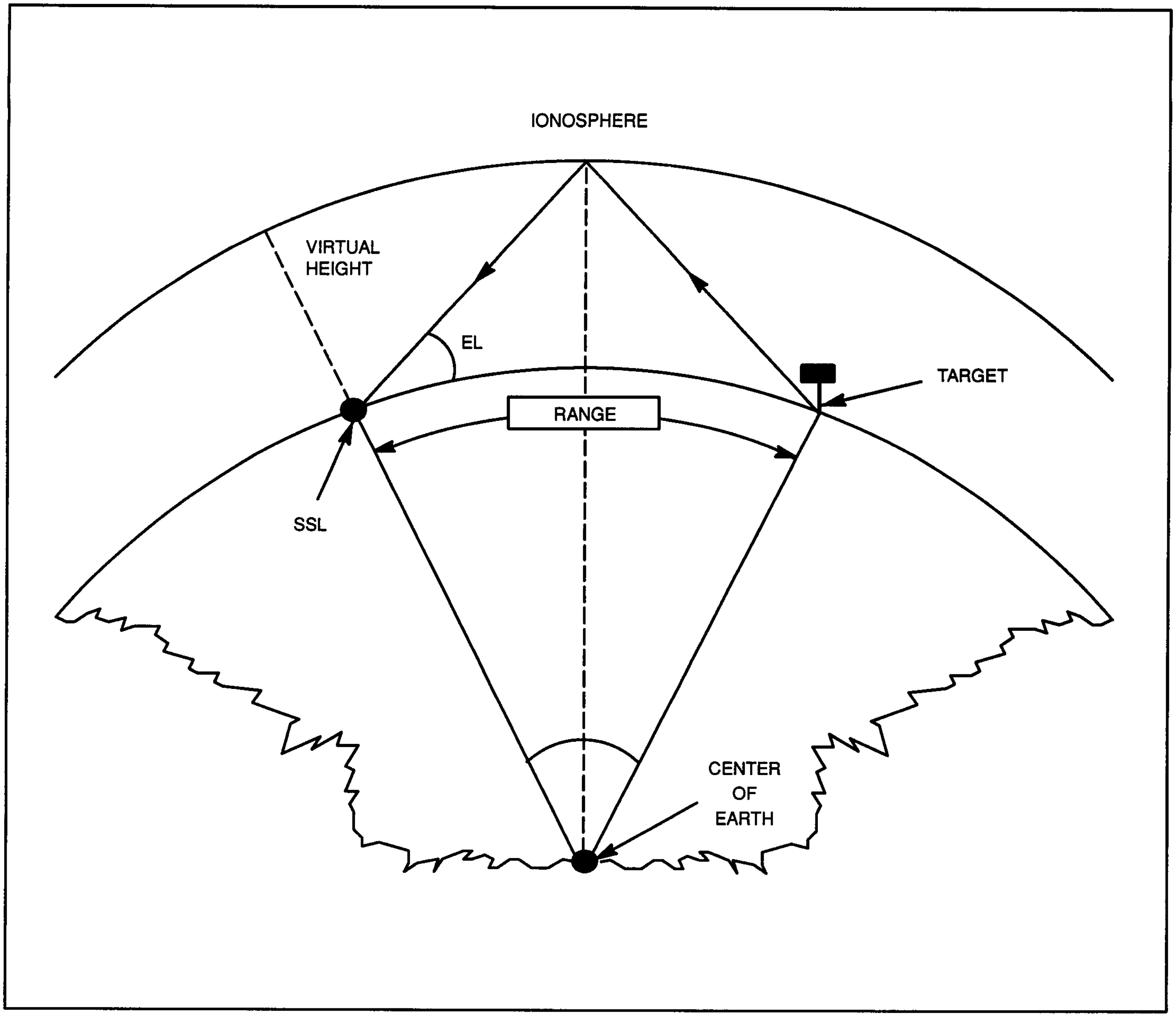


Figure 3-14. SSL operations concept.

Most SSL systems offer the following fundamental performance steps:

- The SSL computer is interfaced to the phase-measuring interferometer antenna array and to the ionospheric sounder.
- System data acquisition is controlled by a single operator.

Operator functions include—

- Identifying the target signal.
- Optimizing receiver tuning.
- Starting and terminating direction finding data collection.

Automatic functions of the systems include—

- Computing the target azimuth and elevation angles of arrival.
- Providing real-time measurement of ionospheric heights.
- Computing location coordinates.

CHAPTER 4

PERFORMANCE FACTORS

Strategic direction finding is normally conducted against transmitters located a great distance from the DF site. The radio waves are reflected or refracted by the atmosphere prior to interception. This is commonly referred to as sky wave direction finding (SWDF). Strategic DF sites at echelons above corps are normally a minimum of 150 kilometers from the forward line of own troops (FLOT).

Tactical direction finding is normally conducted against enemy transmitters located close to the DF site. The direct wave component of the transmitted wave is normally used to locate the transmitting antenna. This is referred to as direct wave direction finding (DWDF). Tactical DF equipment is normally located within 5 to 15 kilometers of the FLOT.

Airborne radio direction finding (ARDF) is the term used to identify the DF effort conducted from an airborne platform. ARDF may be used in either a strategic or tactical situation.

STRATEGIC FACTORS

Strategic direction finding sites are quite often designed to provide DF coverage over vast geographic areas such as an entire or large portion of a continent. Nets of this nature will frequently have sites established along a baseline thousands of kilometers in length. Bearings are acquired on sky waves arriving at the DF antennas. The major influencing factors concerning SWDF operations include the—

- Distance from the transmitting antenna.
- Sky wave propagation.
- Transmitter power.

To illustrate the distance factor, imagine a strategic direction finding site located in the skip zone (Figure 4-1).

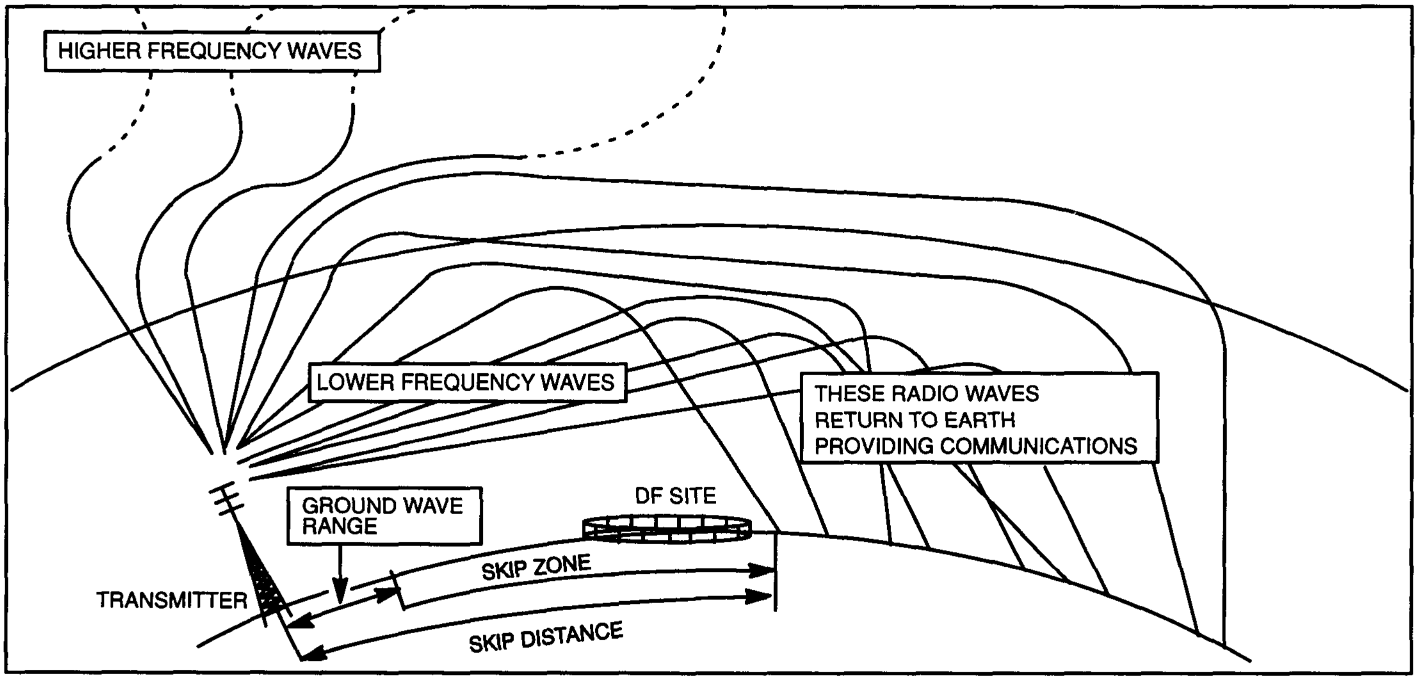


Figure 4-1. DF site located in skip zone.

The skip zone is that area where the ground wave can no longer be detected and the sky wave has not yet returned to the earth after being reflected or refracted off the ionosphere or troposphere. A SWDF site in the skip zone would not be able to receive the transmitted signal. Therefore, it could not obtain a bearing. (Strategic DF errors caused by radio wave propagation are discussed in Chapter 7.)

Sky waves and multihop transmissions (Figure 4-2) are dependent upon the frequency used and the power of the transmitter. The transmission range is affected when a low-powered transmitter is used. A signal from a low-powered transmitter that travels a great distance to the strategic site will normally be weak and fading. This results in no bearing being obtained on the signal, or if a bearing can be obtained the reliability will be questionable.

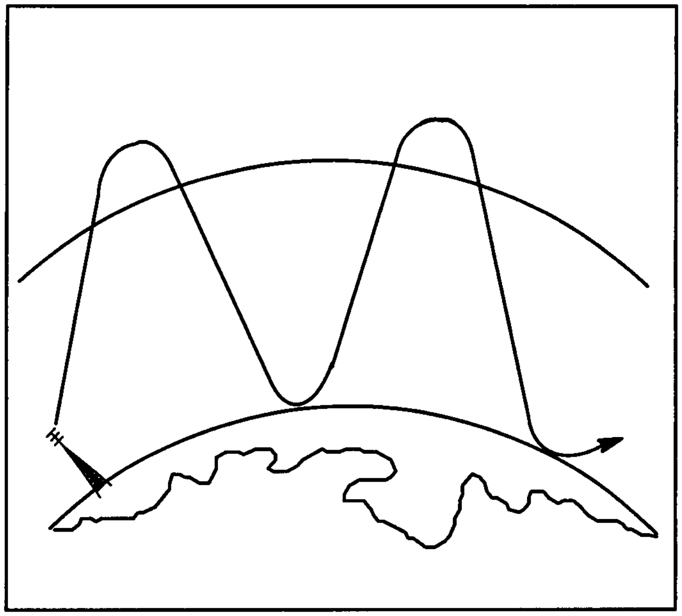


Figure 4-2. Sky waves and multihop transmission.

TACTICAL FACTORS

Consider a tactical situation where the predominant enemy frequencies used are 30 megahertz (MHz) and above. Normally, the characteristics are as follows:

- Communications are short range and line of sight.
- Frequency modulated voice is the primary type of transmission.
- Transmitters are usually highly mobile, either man-packed or vehicle mounted. They commonly use whip antennas which are omnidirectional and vertically polarized.

An important factor in tactical radio direction finding is wave propagation. The following paragraphs identify and discuss wave propagation factors.

Ground Wave

The waves radiated from a transmitting antenna spread out into the atmosphere and along the earth, as well as into the earth. Because of the conducting properties of the earth, some of the energy is reflected from the earth's surface. The part of the wave not reflected enters the earth where the energy rapidly dissipates as heat. Other portions of the waves spread out along the earth and into the atmosphere. They travel to the intended receiver as well as to the DF set. The resulting ground wave is composed of one or more of the following wave components:

- Direct wave.
- Ground-reflected wave.
- Surface wave.

Direct Wave

Direct waves travel directly from the transmitting antenna to the receiving antenna. The direct wave is not appreciable y affected by the earth's surface, but it is subject to refraction in the atmosphere between the transmitting and receiving antennas. The direct wave is the principle means of transmission in tactical very high frequency (VHF) communications, so it is important in tactical direction finding operations.

Ground-Reflected Wave

A ground-reflected wave reaches the receiving antenna after being reflected off the ground. If both the transmitting and receiving antennas are located on the ground, the difference in path lengths between a direct wave and a ground-reflected wave is small. However, these waves may arrive at a tactical DF set out of phase.

This reduces the received signal strength, particularly at frequencies below 30 MHz. Tactical communications conducted below 30 MHz are primarily with the surface wave component.

Surface Wave

A surface wave travels directly along the surface of the earth. Although it does extend above the ground, its strength is diminished with increasing height. A surface wave is affected primarily by the conductivity and dielectric constant of the ground over which it travels. It is the primary component acted upon by groundbased tactical DWDF systems taking bearings on frequencies below 30 MHz. Three important influencing factors of a surface wave are—

- Frequency.
- Terrain.
- Polarization.

Frequency. Frequency, along with transmitter power, affects the range of the signal. While ground waves are produced at all frequency ranges, sky waves are generally possible only at frequencies below 20 to 30 MHz. Any DF effort targeted above this range will be working with ground waves. Below this range, tactical equipment can actually work with sky waves and ground waves. Generally, surface wave performance is greater at lower frequencies. These ground waves are unintentional by-products of transmissions whose main energy is directed toward the ionosphere rather than along the surface of the earth (Figure 4-3).

Terrain. Terrain is most influential on high frequency radio communications. The dielectric constant and the conductivity of the terrain over which the HF surface wave component travels can affect its range considerably. However, as previously stated, as the frequency of the transmitted signal increases, the surface wave decreases. Therefore, the electrical characteristics of the terrain have less effect on a signal as it increases in frequency.

Polarization. When a surface wave is horizontally polarized, the earth has a short-circuiting effect which causes the wave to dissipate rapidly into the ground. If a transmitted wave has some degree of both vertical and horizontal polarization, the horizontal portion will be quickly absorbed. Only the vertically polarized part of the wave will travel any appreciable distance. Because of this, it can be assumed that surface waves received can be considered to be vertically polarized. This is an important factor since most tactical DF systems employed against surface waves use monopole antennas to receive vertically polarized waves.

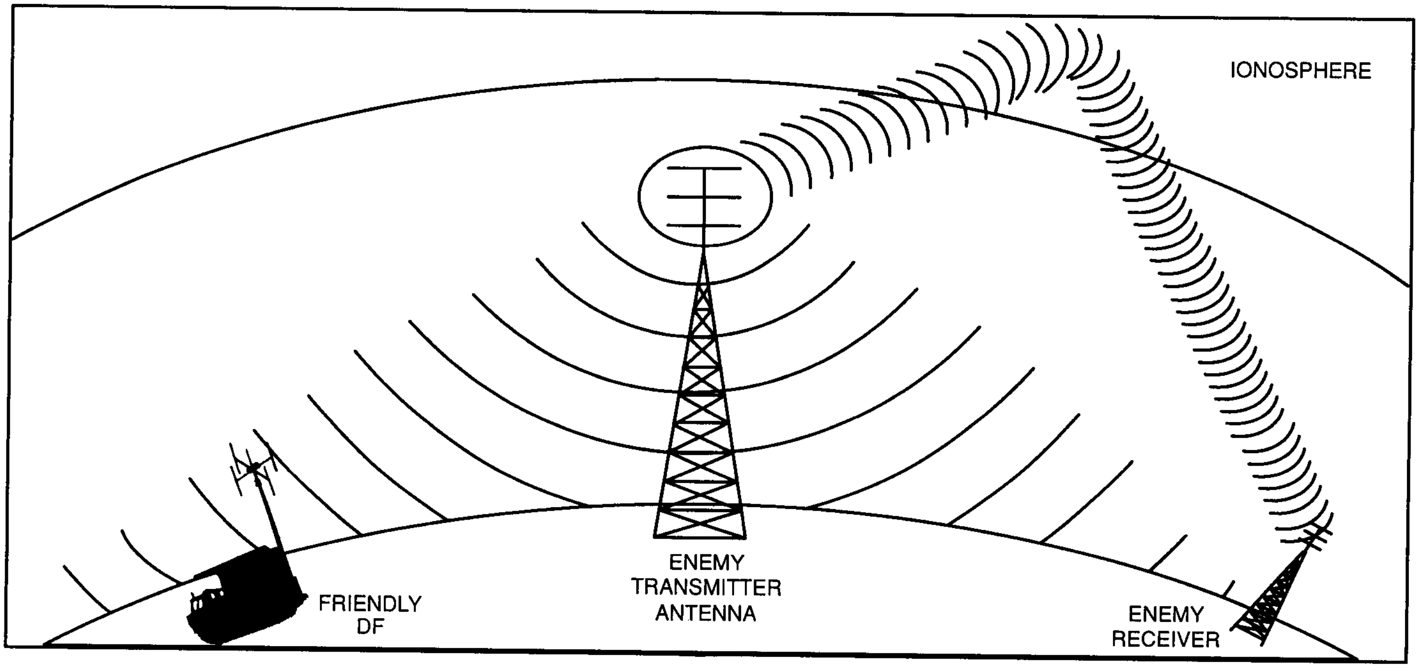


Figure 4-3. Ground wave DF.

Ground Wave Distance

The distance (from the transmitter to a tactical DF set) that a ground wave can be received is subject to extreme variations. It is affected by such factors as transmitter power, antenna type, terrain, man-made objects, and operating frequency. Advance estimates of expected ground wave range in a given environment can be made if some knowledge of the enemy's communications equipment and operating techniques are available. However, some actual operating experience in each situation is usually required before reliable range estimates can be made.

DIRECTION FINDING BASELINES

A groundbased DF baseline is that imaginary line or axis along which the DF equipment of a DF network (three or more DF sites) are deployed. The establishment of either a groundbased strategic or tactical DF baseline is a matter of placing the DF equipment so that good bearing angles for triangulation within the target area are possible. Triangulation is the intersection of bearings at the target area (Figure 4-4).

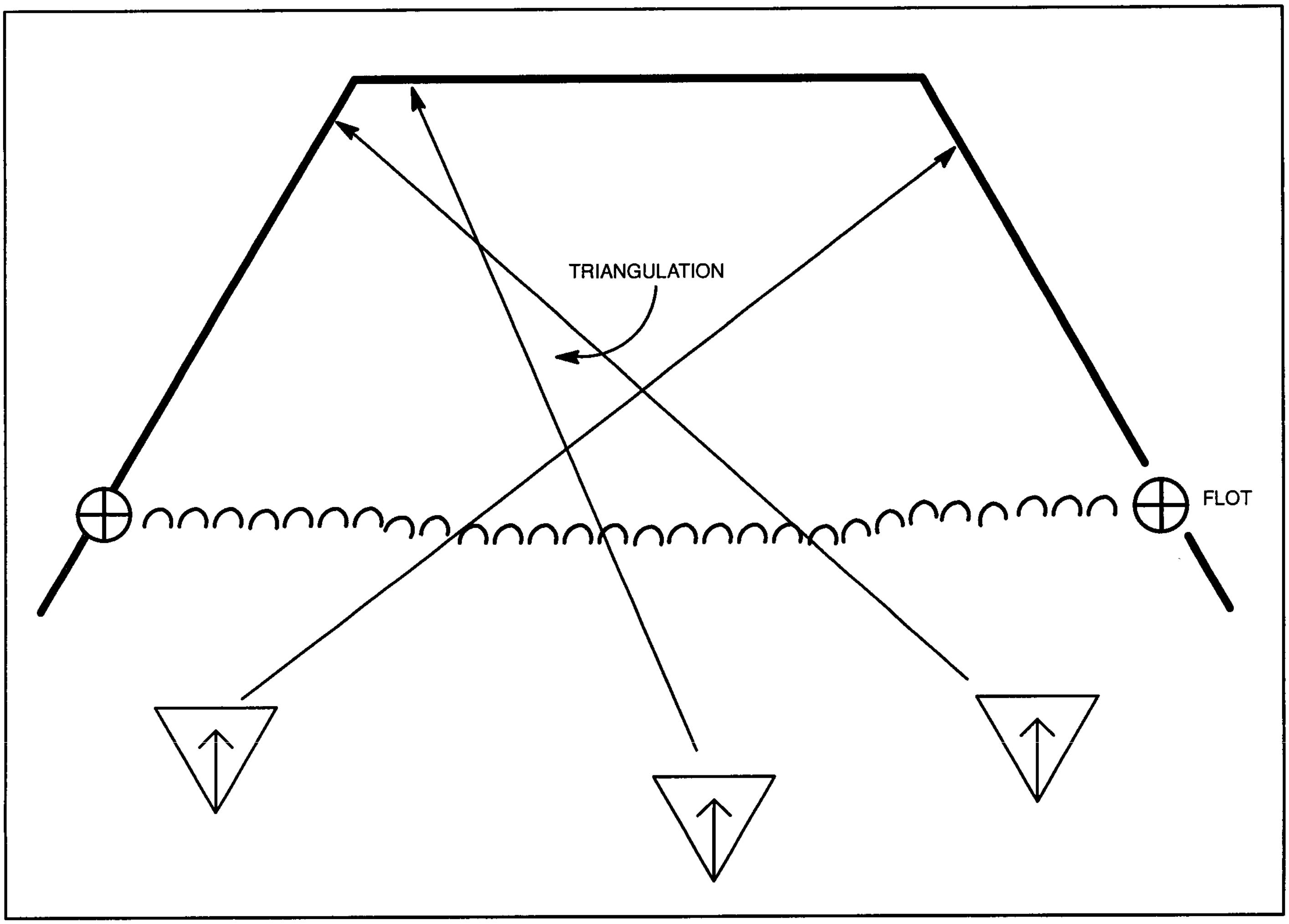


Figure 4-4. Triangulation.

Ideally, each of the DF sites should have an unobstructed wave path between the DF antenna and any point within the target area. In most cases, however, this is not possible. Tactical DF sites should be arranged so that portions of the target area that are *masked* or hidden from one or more DF sites can still be covered by at least three other sites. This is similar to setting up interlocking fields of fire for weapons. The exception, in the case of the DF equipment, is that each area must be covered by a minimum of three *lines of fire* instead of one or two (Figure 4-5).

A masked transmitter occurs whenever the enemy takes advantage of terrain features to hide their communications from our groundbased DF operations. Masking is most effective in line of sight communications. A situation in which a site is masked is illustrated in Figure 4-6, page 4-6.

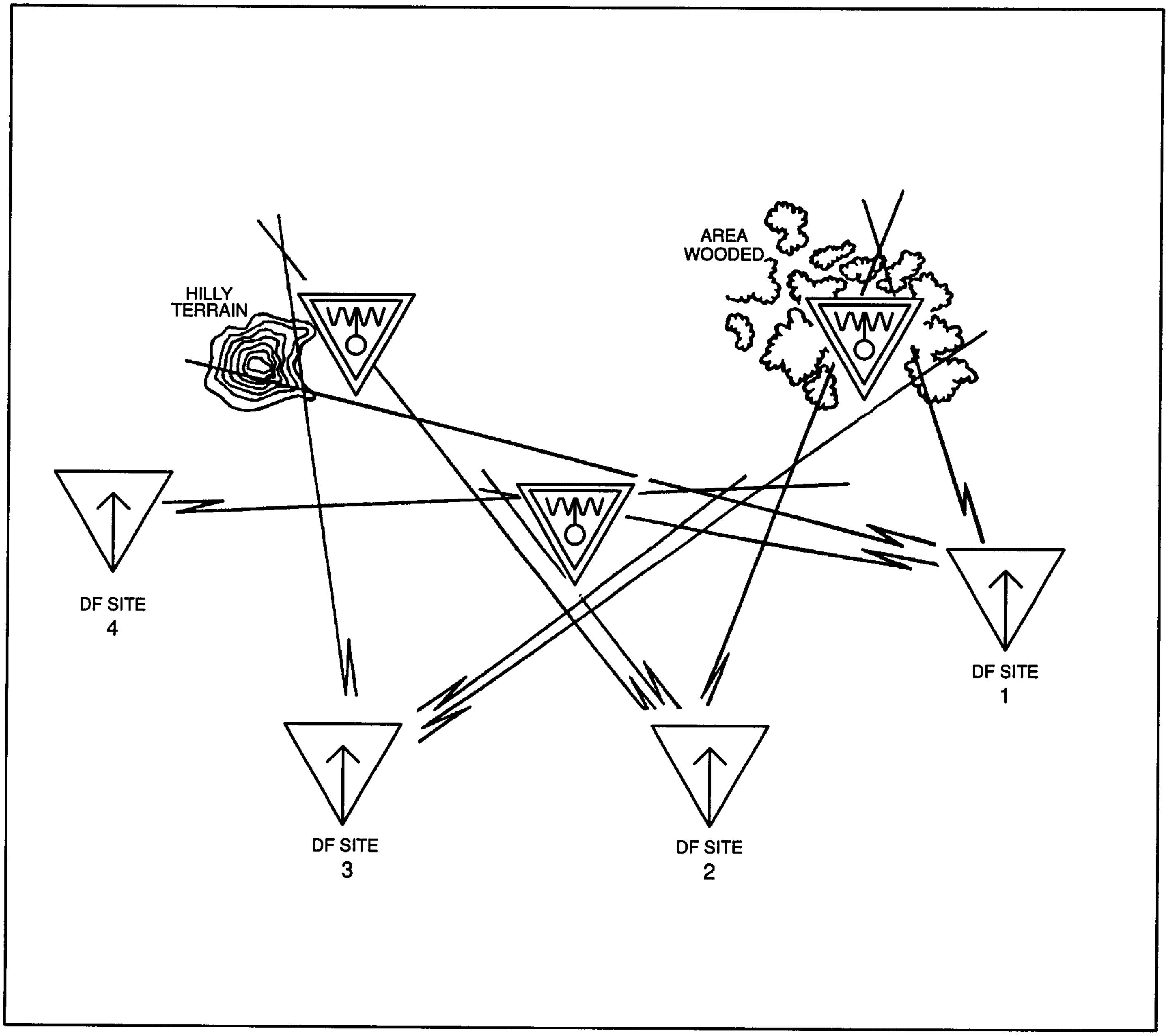


Figure 4-5. Target area coverage.

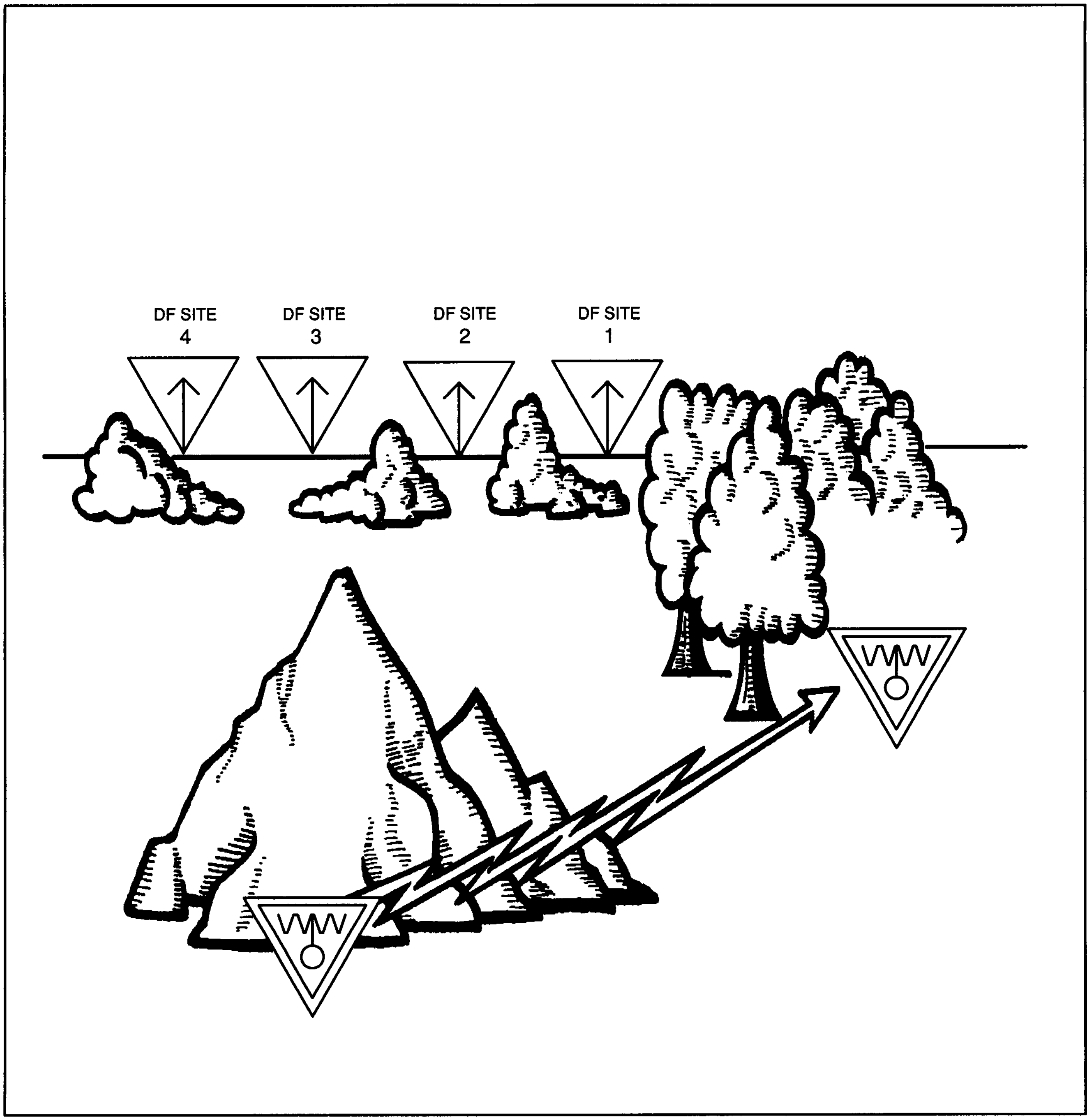


Figure 4-6. Enemy transmitter masked to our DF stations.

As you can see, when the transmitting antenna is hidden behind a hill, it is electronically hidden from the direction finding sites. However, the enemy is still able to communicate effectively with it outstation. Additionally, establishing a suitable DF baseline is affected by tactical, stragic, and technical consideerations. Essentially, there are two types of baseline configurations used to establish a groundbased direction finding network—concave and convex.

Concave Baseline

It is best to locate the DF sites on a concave baseline if it is expected that the target locations will be in a compact, narrow but deep frontal area. This situation is illustrated in Figure 4-7.

Using this baseline, triangulation from the DF site bearings is satisfactory at longer ranges. Triangulation is excellent at short ranges.

Convex Baseline

If the target locations are anticipated to be located over a wide flanking, short, in-depth area (Figure 4-8), a convex baseline is suitable.

Using a convex baseline provides a reasonable azimuth angle over a wide front. It is probable that the convex baseline will satisfy the average tactical or strategic situation.

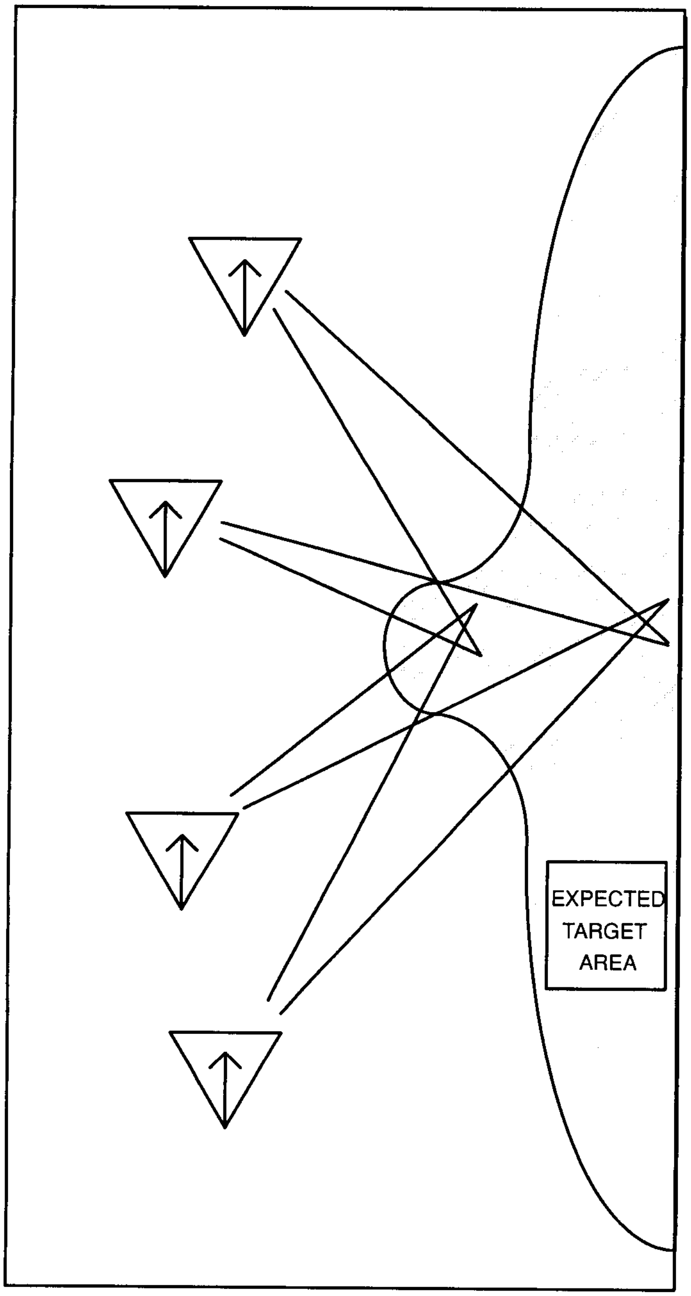


Figure 4-7. Concave baseline.

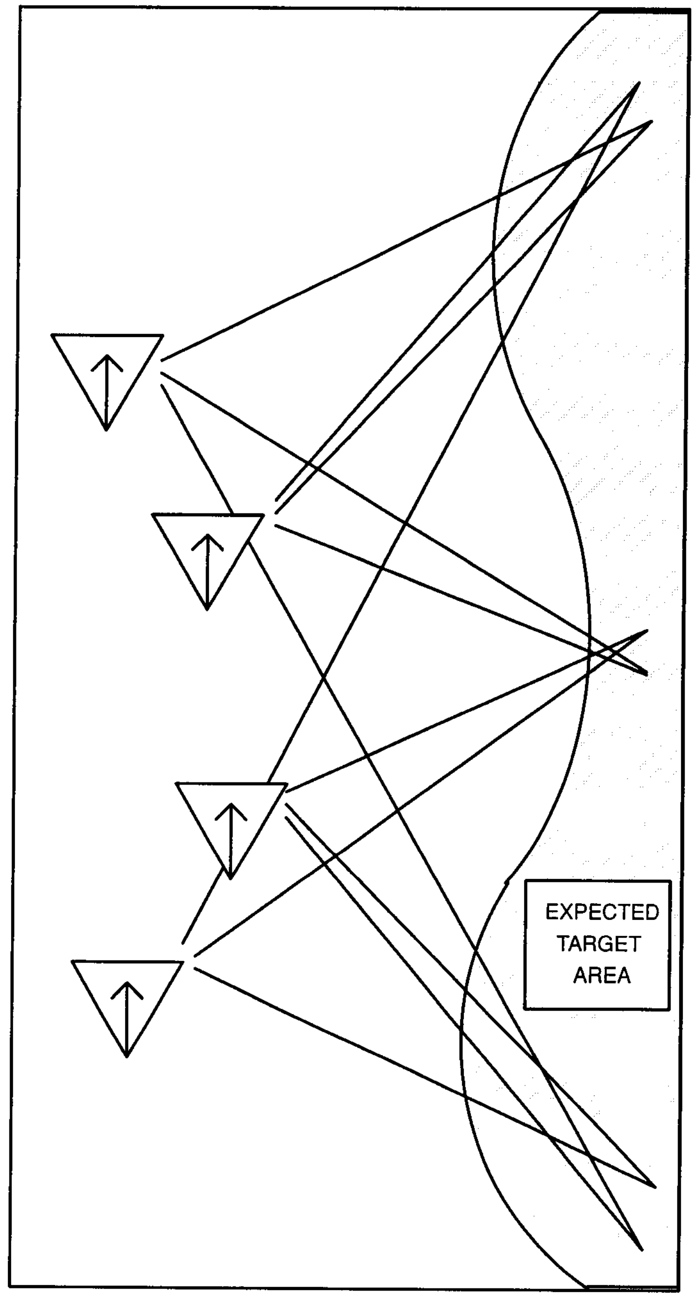


Figure 4-8. Convex baseline.

Baseline Distance

The baseline distance is a straight-line distance that separates the two outermost DF sites (Figure 4-9).

As a rule of thumb, the depth at which a DF network can effectively locate enemy transmitter antennas is equal to the total distance of the baseline joining the two outermost DF sites. This distance is then measured from the center of the imaginary baseline to the target area. For example, if the DF baseline is 80 kilometers in length, the net fix location capability is 80 kilometers in depth (Figure 4-10).

Establishing a tactical DWDF baseline is dependent on the mission, enemy, terrain, troops and time available (METT-T). The tactical commander determines the areas available for the siting of the DF equipment within the area of operations. However, the target area to be covered dictates the baseline configuration employed in most situations. It should also be noted that an effective DF baseline is dependent upon equipment capabilities. In some situations, conditions maybe prohibitively unfavorable for tactical DWDF operations. This is because of impossible terrain conditions, unusual propagation factors, or baseline restraints.

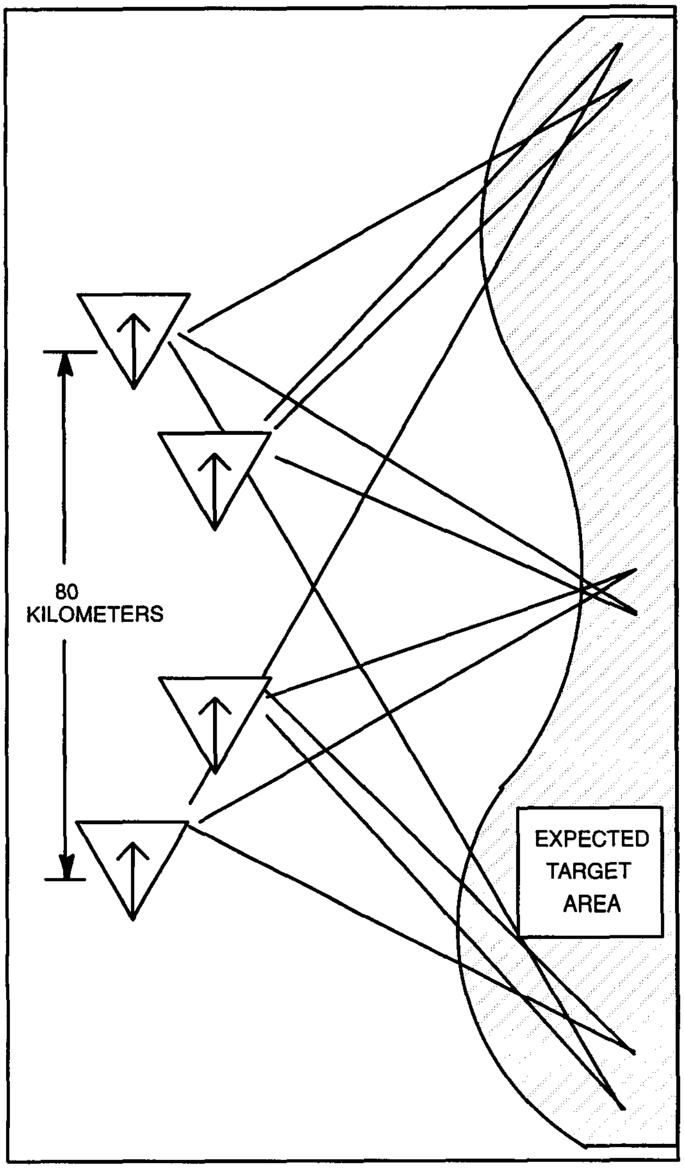


Figure 4-9. Baseline distance.

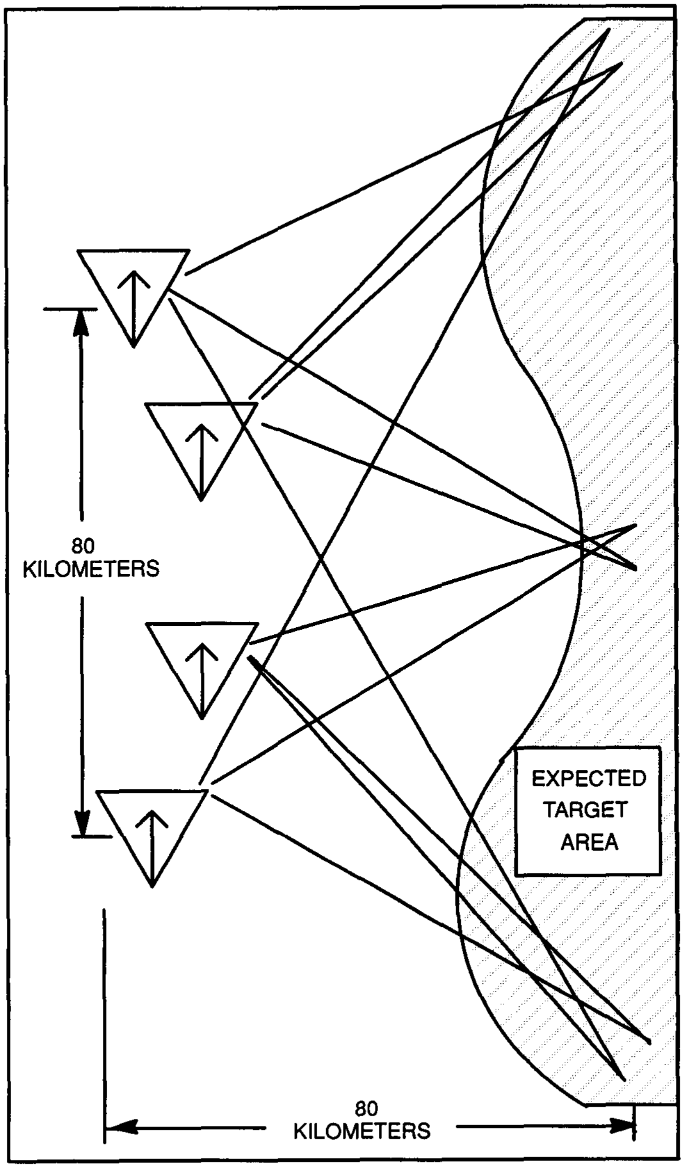


Figure 4-10. Net fix capability.

AIRBORNE RADIO DIRECTION FINDING

In the ARDF effort, aircraft are used as DF sites. These aircraft are used to supplement groundbased DF systems by providing an aerial platform to extend the radio horizon. There are several factors, however, which affect ARDF operations. The most important factors are the weather and the availability of airspace. Obviously, storms and adverse weather conditions will keep ARDF aircraft on the ground. Because ARDF aircraft operate at relatively low altitudes and slow speeds, they are vulnerable to surface-to-air missiles and hostile aircraft. Therefore, to accomplish the mission, ARDF aircraft must have the freedom of airspace.

Groundbase direction finding baseline principles are also applicable to ARDF. However, ARDF operations do not have the possible restraints that could hinder establishing a groundbased DF baseline; for example, terrain restrictions or the availability of land. Considering that the airspace will be controlled by friendly forces, ARDF aircraft only have to maneuver for a baseline behind the FLOT. In single ARDF aircraft operations, a baseline is that flight pattern where a minimum of three LOBs or line of position (LOP) are taken on a target, resulting in the location of the target transmitter antenna (Figure 4-11).

Operations involving more than one aircraft (Figure 4-12, page 4-10) require that each aircraft fly a track which provides as wide a baseline as possible. As with groundbase systems, a minimum of three LOBs are required to accurately locate the target.

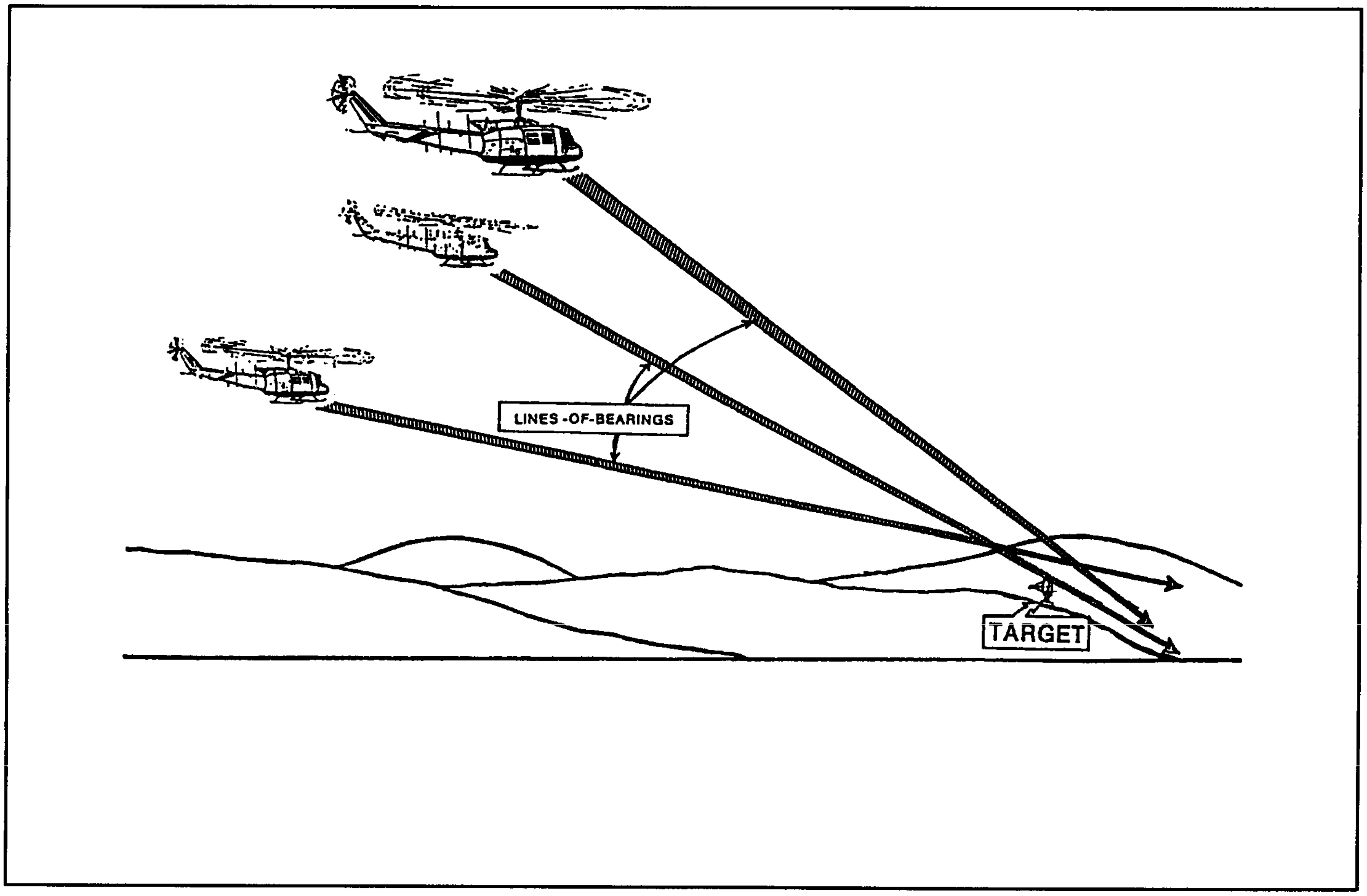


Figure 4-11. Single aircraft deployment.

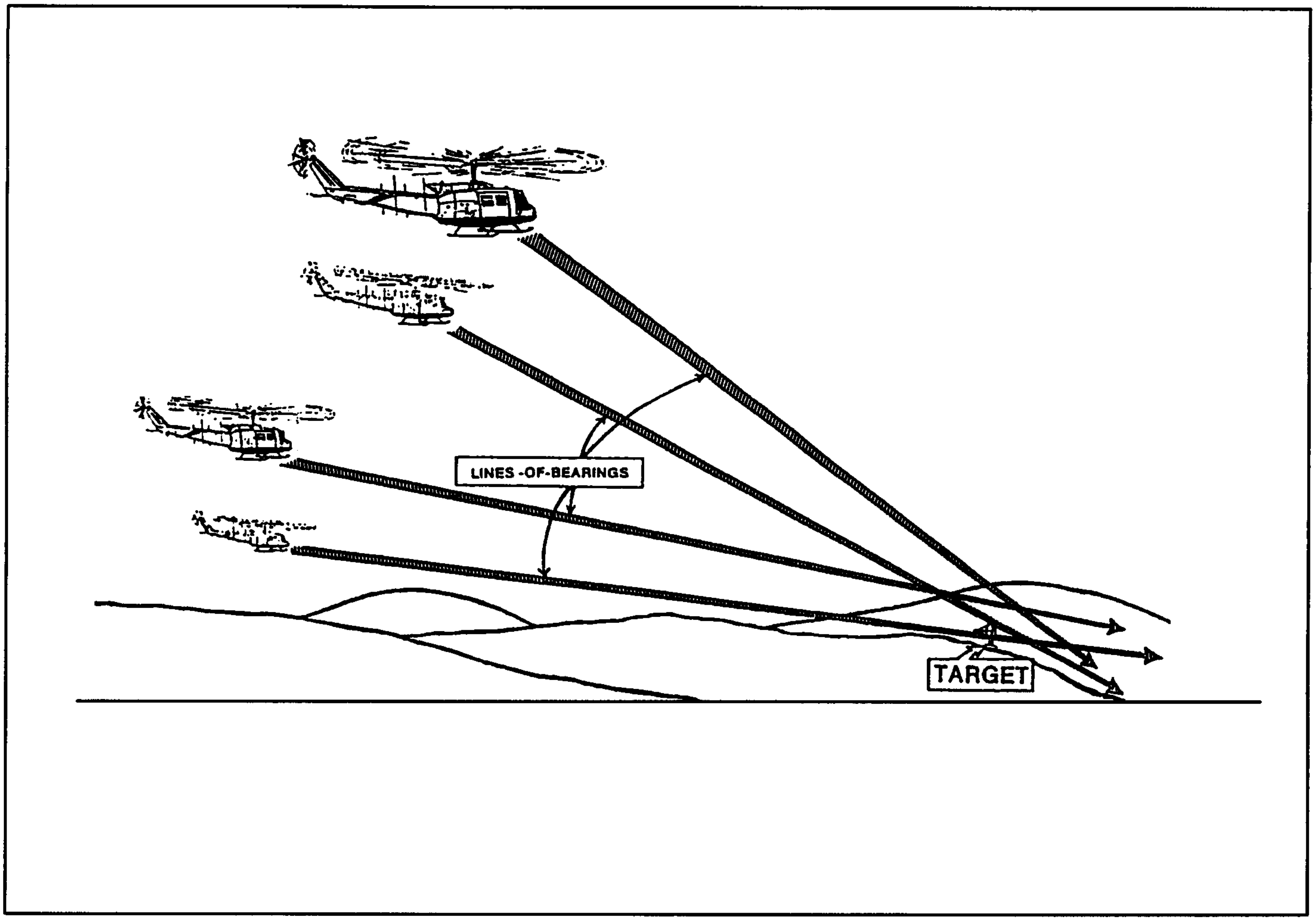


Figure 4-12. Multiple aircraft deployment.

CHAPTER 5

SITE DEPLOYMENT

It is not the intent of this section to address all aspects of a strategic or tactical direction finding site. Rather, the purpose is to establish general guidelines for use in strategic and tactical DF site deployment.

NOTE: EAC groundbased DF can be employed in semifixed or mobile configurations, as either strategic or tactical assets.

STRATEGIC

Normally, EAC and strategic direction finding sites are distantly located from their net control station (NCS). A noncommissioned officer, referred to as the DF site supervisor, is in charge of an EAC or strategic DF site. In many cases, these direction finding sites are not located near any military support activity. Therefore, as the direct representative of the commander, the duties and responsibilities of the site supervisor are diversified and numerous. The site supervisor is directly responsible to the commander for—

- **Mission.** This includes the day-to-day site operation (equipment operation and maintenance) and accomplishing the mission as directed by the NCS.
- **Security.** This includes physical security of the DF site (equipment and personnel) and classified information security (communications security (COMSEC)).
- **Personnel.** This includes the health, welfare, recommendation for promotion, discipline, and counseling of DF site personnel.

TACTICAL

A team chief is normally in charge of tactical communications and noncommunications DF site operations. A team chief is directly responsible to the platoon leader for—

- **Mission.** This includes the day-to-day operation (equipment operation and maintenance) and accomplishing the mission as directed by the MI battalion tactical operations center (TOC) (division) or the MI brigade TOC (corps).
- **Security.** This includes survivability of the equipment and personnel in a hostile environment.
- **Personnel.** This includes the health, welfare, recommendation for promotion, discipline, and counseling of DF site personnel.

SITE LOCATION

Regardless of whether a DF site is strategic or tactical, once it has been installed its location must be accurately determined and reported. If a site's location is erroneously calculated, reported, and placed on a plotting map or entered into a computer, it will result in an inaccurate determination of target locations. There are three methods of determining a site location—

- Resection.
- Geodetics.
- Satellite derived, global positioning system (GPS).

Resection

Determining the location of a DF site by sighting two or three known features, from the DF site, is called resection. First, orient the universal transverse mercator (UTM) 1:50,000 map using the compass. Locate the two or three known positions on the ground and mark them on the map. Using the compass, measure the magnetic azimuth from the DF site to one known position. Convert this azimuth to a grid azimuth. Change the grid azimuth to a back azimuth (refer to FM 21-26) and draw a line on the map from the known position back toward the DF site. Repeat for each known position. The intersection of the lines is the location of the DF site (Figure 5-l). Using three lines, a triangle may be formed. If this triangle is large, check the procedures. *Do not* assume the DF site is located in the center of a large triangle.

Geodetics

Geodetics is the determination of a site's position through the use of mathematics and the positioning of celestial bodies. Due to the complexity and time involved in the computation, this method normally is used for permanent strategic DF sites. This field manual does not provide the computation procedures.

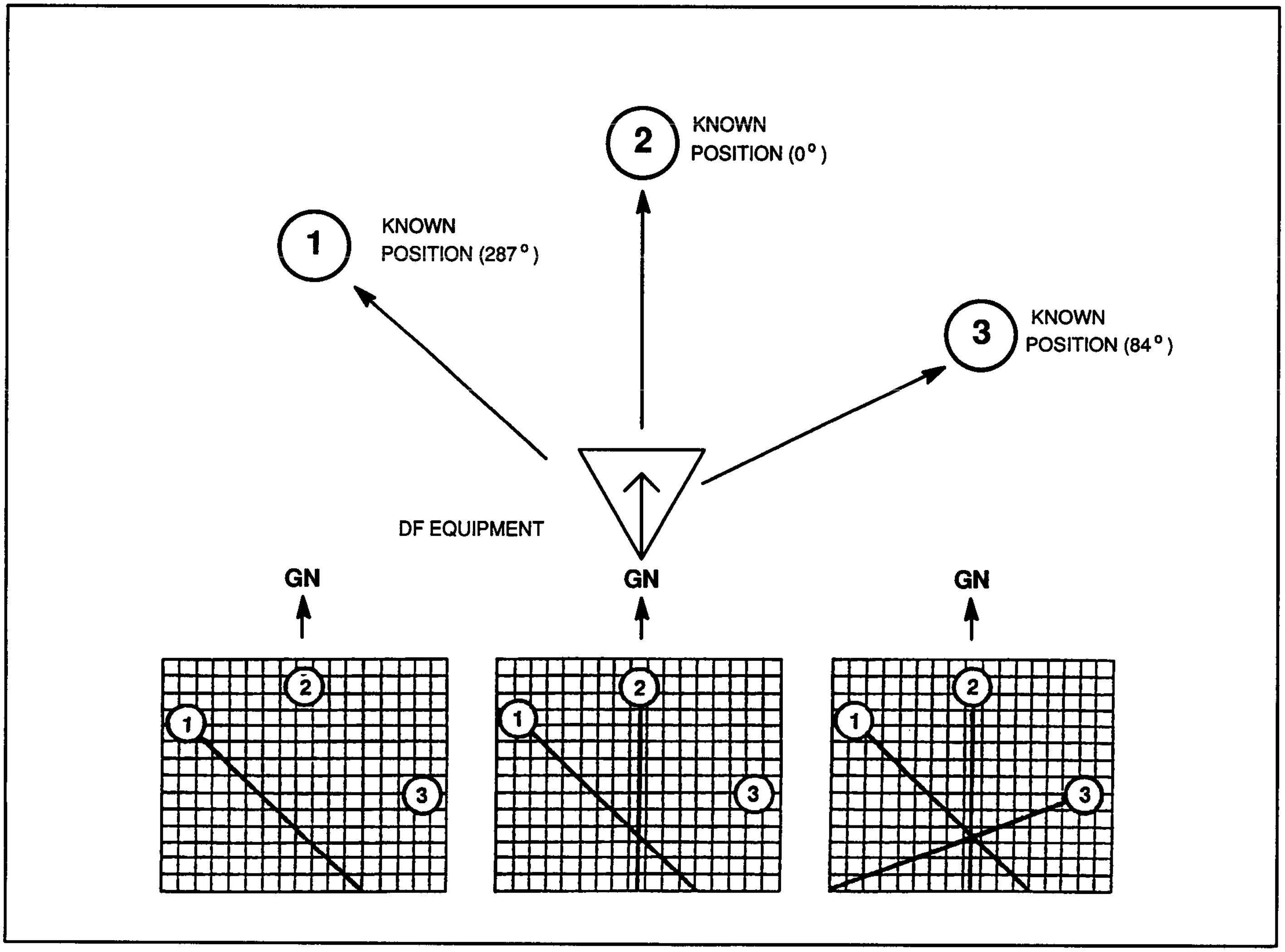


Figure 5-1. Resection.

SITE ORIENTATION TECHNIQUES

Whenever DF equipment is installed in a new location, it is necessary to orient the site's antenna(s) to either true, magnetic, or grid north. What orientation method used depends on the equipment employed and the established reporting criteria for LOBs.

True, Magnetic, and Grid North

True north is the actual direction of the earth's north pole. Magnetic north is the direction of the north magnetic pole. It is indicated by the N (north seeking) end of the compass needle. Grid north is the direction of the vertical grid lines usually found on military maps. The difference in direction between true north and magnetic north, or between true north and grid north, is known as declination (Figure 5-2).

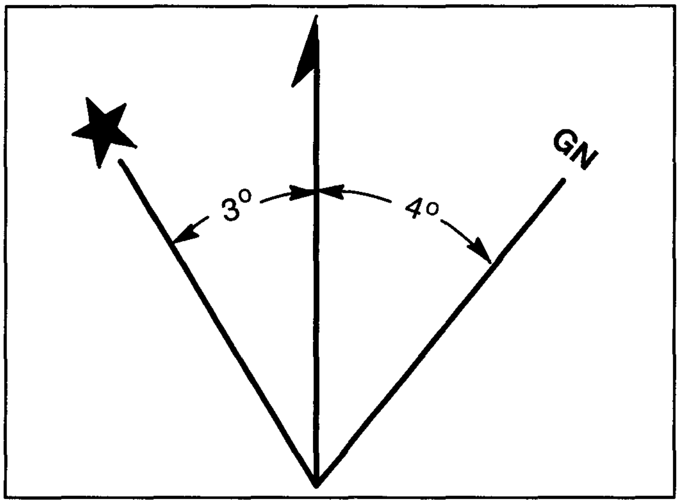


Figure 5-2. Declination diagram.

True North Declination

True north declination is the fixed difference in direction between true north and grid north. True north declination varies in different localities. Actually, it varies at different points on any one map, but on a tactical map the variation is so slight that the average declination can be used without introducing an appreciable error.

Magnetic Declination

Magnetic declination is the angle between true north and magnetic north. In localities where a compass needle points east of true north, magnetic declination is east. Where a compass needle points west of true north, the magnetic declination is west. Where true north and magnetic north are the same, magnetic declination is zero. The magnetic declination in any given locality is subject to gradual change, the amount of which can be calculated from the declination diagram. Annual change is frequently expressed as E or W (east or west) to avoid ambiguity in the change of direction.

SITE CRITERIA

The following site criteria should be used as a guide in selecting either a strategic or tactical DF site location. These are optimum considerations that cannot always be achieved, especially under tactical conditions. For example, a volatile tactical situation, the availability of land in strategic and tactical situations, and many other factors may require some site criteria compromise. Site criteria is as follows:

- The area should be substantially flat for approximately 90 meters from the DF antenna(s). It should also have no more than a gentle slope for at least 180 meters.
- The area should be the highest level area in the vicinity. A site in a valley is usually unsatisfactory.

-

  wavelengths of the lowest frequency to be used for

- If the DF site must be placed on or near a shoreline, it

  of interest (Figure 5-3).
- The earth at or around the site should have uniformly high conductivity and moisture content. Areas

  meet this requirement. Rocky or sandy soil is a poor location for a direction finding site. However, areas having low conductivity are preferable to areas having high conductivity spotted with rock formations, sand, or a varying moisture content.
- Regions where there are abrupt gaps or changes in elevation of the earth should be avoided. Sharp changes in terrain elevation usually indicate the presence of rock or mineral outcropping or underground streams.
- The site should be removed from buildings, wire fences, power or telephone lines, radio antennas, railroad tracks, buried metal conductors (cables and pipelines), sharp ground contour changes (mountains, cliffs, and ravines), chimney stacks, water towers, rivers, lakes, and streams.
- Distances to be maintained between the direction finding site and these obstructions, to minimize their effect on accuracy, are listed in Table 5-1.

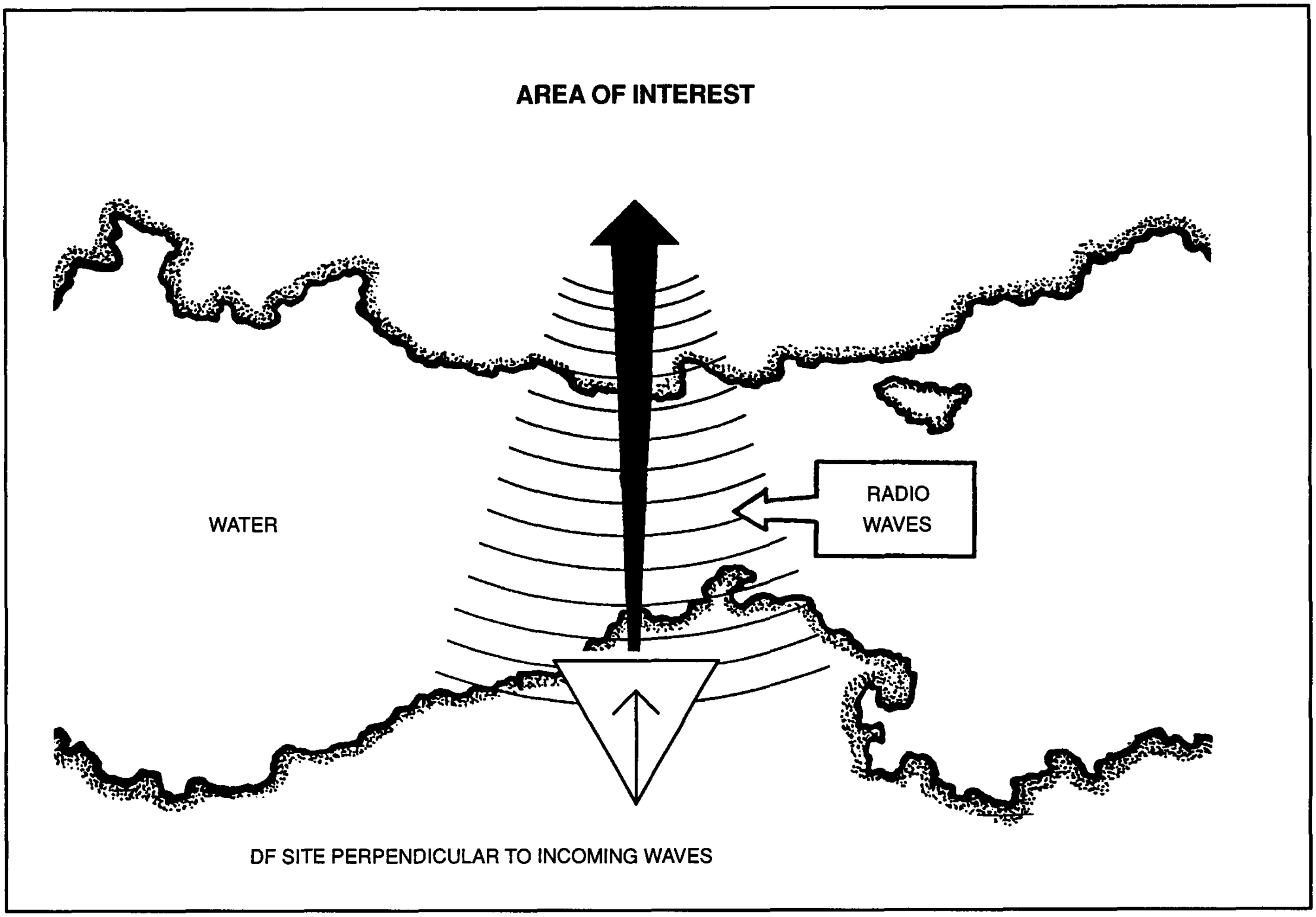


Figure 5-3. DF site located on the coast.

Table 5-1. Preferred distance to be maintained from obstacles.

OBSTACLES	DISTANCE TO BE MAINTAINED
Scattered trees and single small buildings.	185 meters
Wire fences.	275 meters
High cliffs and deep ravines.	1.6 kilometers or farther
Buried metallic conductors.	275 meters
Chimney stacks and water towers.	450 meters
Railroad tracks and overhead conductors (utility lines and antennas).	450 meters
Mountains.	10-50 kilometers
Rivers, streams, and lakes.	550 meters

Strategic Guidelines

The specific guidelines apply for strategic direction finding systems. Some strategic DF sites may not be able to adhere to the following criteria due to environmental, climatic, geographic, or political conditions. In these cases, the NCS of that site is responsible for considering and approving any exception—

- The DF shelter should be located in the quadrant of least interest (where incoming enemy signals are not expected). It should be as far from the antennas as the real estate will permit (Figure 5-4, page 5-6).
- The DF antennas should be positioned in the area of primary interest (where incoming enemy signals are expected). The antennas will be as far from other site equipment such as vehicles, generators, and petroleum, oils and lubricants (POL) as the real estate permits.
- No structure or other equipment should be located closer than 300 feet from the nearest DF antenna or in line of the area of prime interest. All incoming power cables should be buried to a depth of at least 1 foot, beginning a minimum of 500 feet from the site area. Power cables inside the DF antenna array or within 50 feet of the antennas should be buried to a depth of at least 3 feet. The direction of buried electrical cables should be indicated by nonmetallic cable signs posted every 200 to 500 feet.
- Strategic DF sites should be declared a restricted area by the commander and posted with nonmetallic signs. Signs should not exceed a height of 3 feet. They should be printed in black letters on a white background. Where required, the signs should be multilingual. Signs should be spaced approximately every 100 feet along the perimeter of the DF antennas. The signs should also be positioned so that they face all quadrants of the DF site.
- Perimeter lights should be placed within 5 feet of each comer of the equipment facing outward. The lights should not exceed 5 feet in height. Electrical wiring for the lights should be kept to a minimum length and buried to a depth of 3 feet.
- Associated equipment such as vehicles, generators, supply shelters, and POL should be arranged so as to lie along a center line opposite the area of primary interest. Vehicles should be parked as far away as possible, with a minimum of 500 feet. They should always be parked in the area behind the quadrant of least interest.

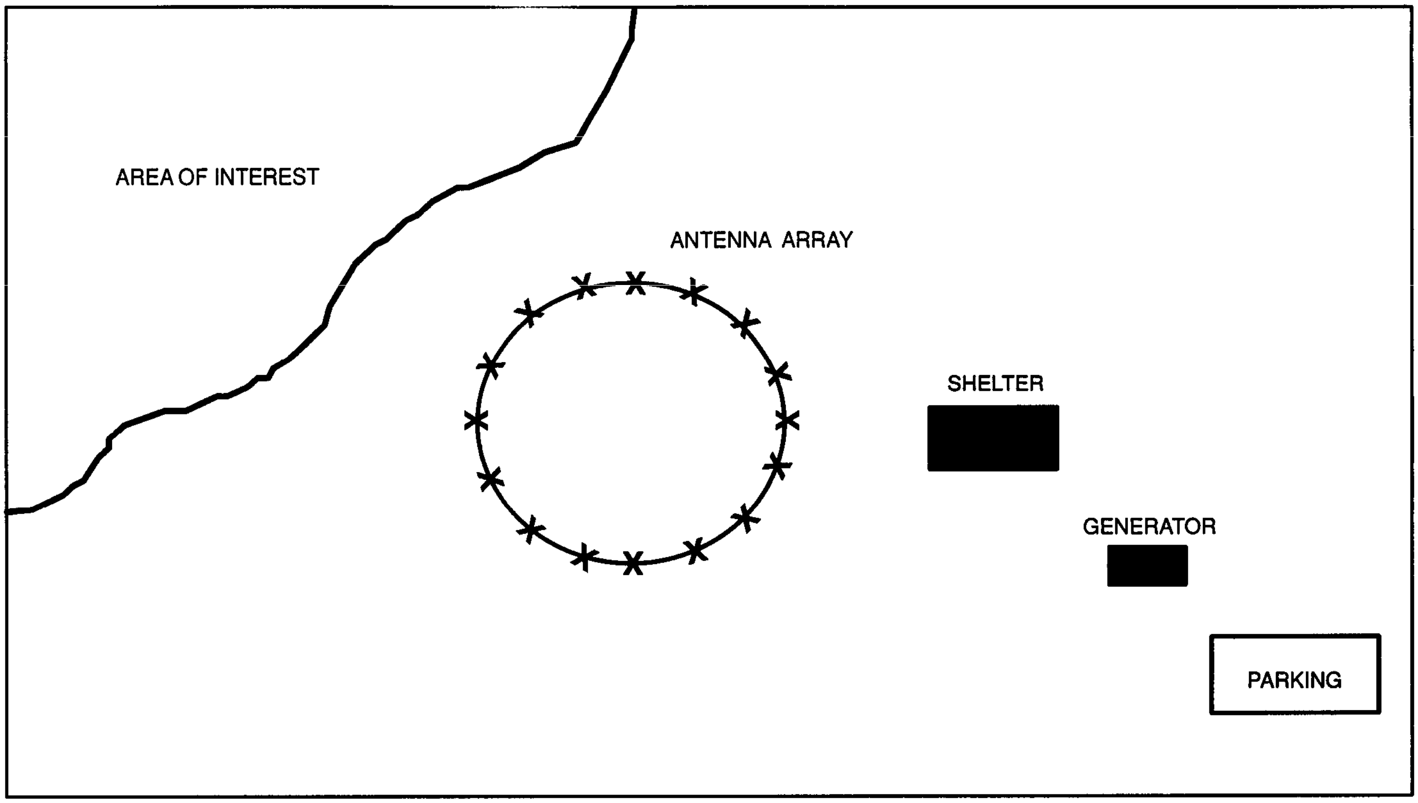


Figure 5-4. DF shelter located outside of antennas in the area of least interest.

Tactical Guidelines

It would be impossible to address every tactical situation in which the platoon leader and team chief might find themselves. Therefore, the following paragraphs will provide general guidelines on tactical site selection and battlefield survival.

A primary consideration in selecting a tactical intercept or DF site location is the ability to receive the target emitter signals from the area of interest. A major consideration for deployment of tactical DF systems is obtaining radio LOS for targets. Radio line of sight is the straight-line path between a transmitting and receiving antenna that is not blocked by the curvature of the earth (Figure 5-5).

Good VHF communications depend on LOS radio wave propagation. Likewise, tactical groundbased DF systems must be deployed within LOS range of the area of interest for intercept and direction finding. Additionally, DF sites must be able to communicate with their NCS.

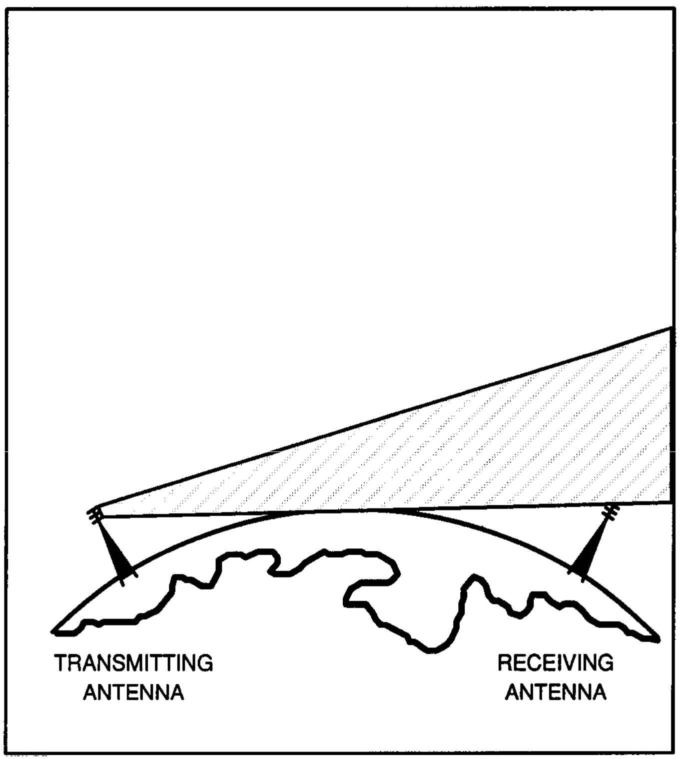


Figure 5-5. Line of sight restrictions.

All tactical intercept or direction finding systems have common requirements that must be met if the equipment is to provide combat information and intelligence to the supported commander. These requirements are—

- Ability to intercept the enemy signal.
- Effective DF baseline.
- Freedom from enemy detection.
- Close proximity to supported elements.

Ability to Intercept the Enemy Signal

Wide variations in the signal strength may exist within relatively small areas. Hills and mountains between the enemy transmitting antennas and the intercept/direction finding equipment limit the quality of intercept and could cause inadvertent DF errors. (Further information is provided in Chapter 7.) The direction of arrival of the enemy's signal can also be affected by barbed wire, armored vehicles, or other metallic objects that could possibly negate the site's original technical advantages. Enemy VHF signals normally are not affected by the ground on which they travel. However, signals are reflected and reradiated by objects in their wave path. Obstructions in the near vicinity of the site are particularly objectionable. The closer the obstruction is to the DF site, the greater its adverse effect on the site.

Effective DF Baseline

An effective DF baseline must be established. As previously discussed, a direction finding baseline is normally convex or concave to the target area (Figure 5-6).

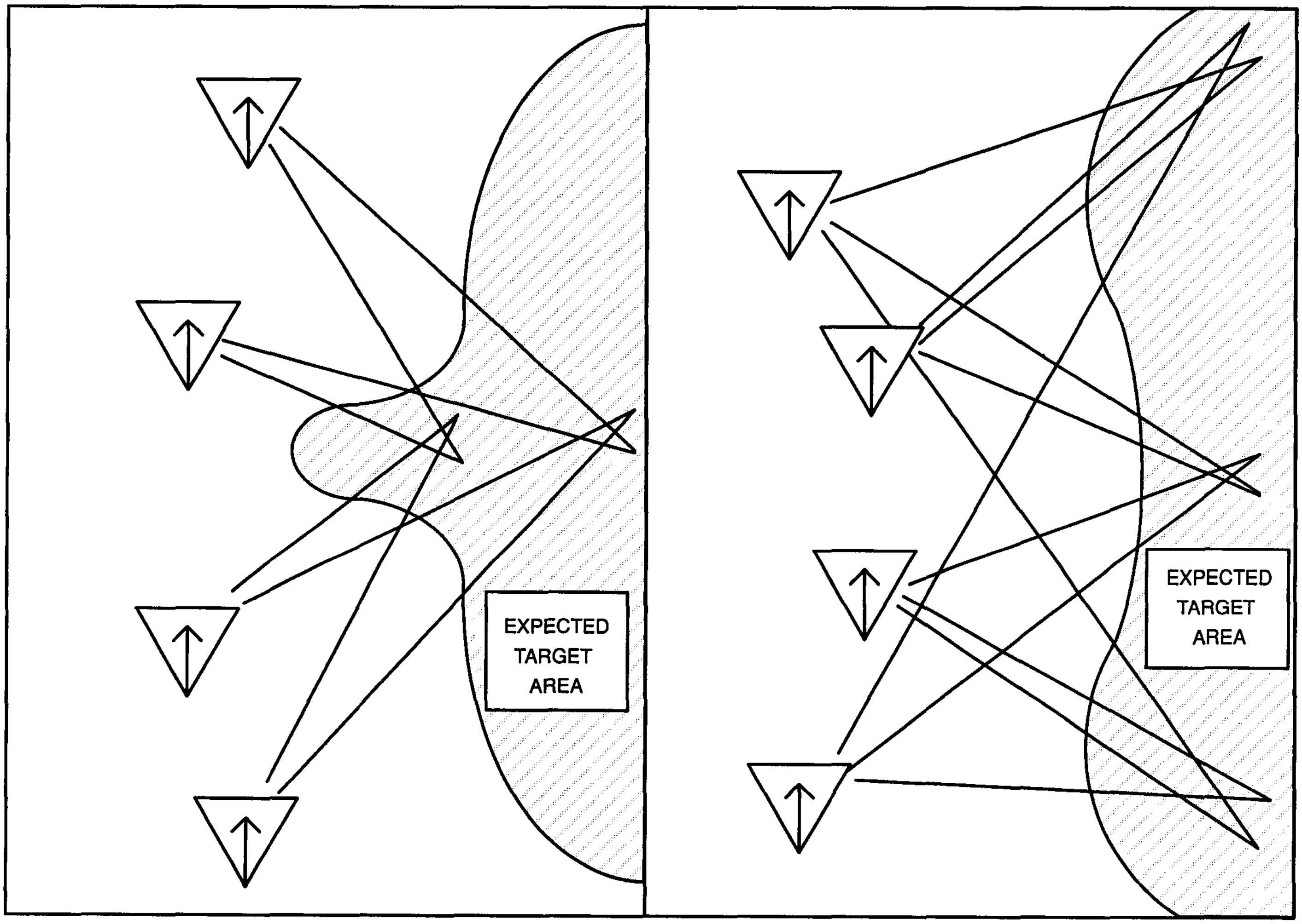


Figure 5-6. Concave and convex baselines.

As illustrated in Figure 5-7, when the tactical DF baseline is approximately 20 kilometers in length, the effective target area depth is approximately 20 kilometers. There are instances when the need for establishing an adequate baseline to locate enemy transmitter antennas requires placing one or more direction finding systems in an undesirable location. If an effective baseline cannot be established, direction finding results may be unsatisfactory.

Freedom From Enemy Detection

Intercept/direction finding personnel should have the freedom to perform their mission during combat to provide current intelligence and combat information. Military intelligence personnel are armed with individual weapons, but this is not sufficient to engage an enemy combat unit. Therefore, the intercept/direction finding system and the survival of personnel depend on their ability to operate undetected by the enemy. Combat should be avoided if at all possible. Intercept/direction finding equipment destroyed during combat may not be replaced for the duration of the conflict. Platoon leaders and team chiefs should look for good potential concealment when locating a site. They must become experts at camouflage. Locations selected for intercept/direction finding operations should provide the best cover and concealment possible consistent with good reception. However, some amount of signal impairment must be tolerated if the intercept/direction finding system and personnel are to survive in a tactical environment.

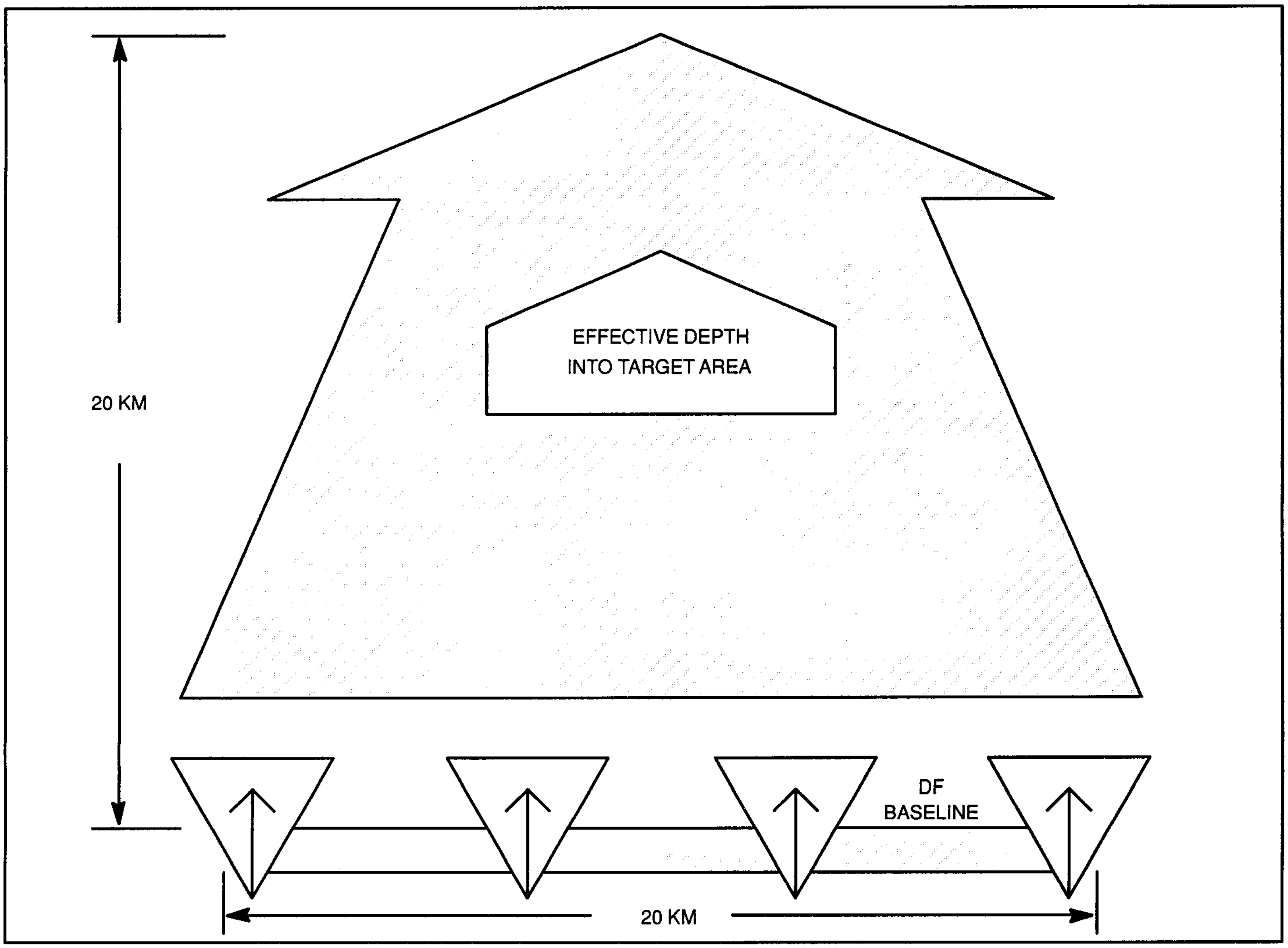


Figure 5-7. Baseline effectiveness.

Close Proximity to Supported Elements

The intelligence and electronic warfare support element (IEWSE) is the MI battalion's liaison to the maneuver brigade. The maneuver brigade commander and staff work closely with the IEWSE to develop an intelligence plan which will effectively integrate electronic warfare (EW) support into the operational scheme. The IEWSE coordinates and resolves terrain siting conflicts of all the MI battalion assets within a supported brigade's sector.

The IEWSE closely coordinates with the S3s of the maneuver brigade and the MI battalion. The IEWSE ensures that essential information on the progress of the maneuver brigade operations is passed to the MI battalion TOC so timely mission adjustments can be effectively integrated into the maneuver effort.

The company team commander is responsible for coordinating support with neighboring units for the MI battalion assets within an assigned maneuver brigade area. The company team commander, the IEWSE, and the MI battalion S3 work closely together on mission requirements and combat service support for the deployed platoons, so that the deployed platoon leaders can concentrate on mission accomplishment. If a platoon is deployed into a sector and is not part of a company team, the platoon leader must fulfill the role of the company team commander.

SITE SELECTION

Geographic locations of a tactical intercept/direction finding site depend on several factors. The frequency range and propagation characteristics of the enemy transmitters are important. For example, intercept/direction finding operations directed against VHF targets are usually located in a forward area. As previously stated, the intercept/direction finding equipment must be within LOS of the enemy's transmitting antennas. Operations directed against enemy transmitters operating in the HF spectrum can be located well to the rear of the FLOT.

The MI battalion S3, with the technical control and analysis element (TCAE), normally selects the general locations for MI battalion assets. The IEWSE coordinates and resolves the locations with the maneuver brigade staff. The platoon leader coordinates with local units as directed by the S3 and performs site reconnaissance for specific intercept/direction finding site locations. Generally, one primary and several alternate sites are selected. The first consideration in reconnaissance of a site is the terrain. The site must be accessible and relatively flat. The intercept/direction finding equipment must be able to be taken into and out of an area. This must be done in any type of weather and by more than one route when the command to "move out" is given. The site location should provide for rapid, disciplined movement. The movement would be in conjunction with the result of rapid advances by friendly forces or retrograde movement to avoid capture and compromise or destruction by the enemy.

Advanced planning can simplify site reconnaissance and the selection of primary and alternate sites. A detailed map study of the entire area of operations is part of the planning process. An excellent aid is a modified area map with the contour lines color-coded by elevation. Color coding can be accomplished with felt-tip pens, grease pencils, or crayons. This information is extremely helpful when selecting a VHF site that operates by LOS. Color-coded changes in elevation and high ground areas adjacent to the selected site(s) are readily apparent.

The platoon leader or team chief should also conduct limited bearability tests during the reconnaissance. A bearability test determines how well the intercept/direction finding equipment can receive enemy signals of interest. When conducting the bearability test, the platoon leader must consider the friendly signal density. Heavy friendly signal activity may prevent successful intercept at an otherwise desirable site. There may also be times when a platoon leader or team chief will not have time to conduct a thorough or detailed reconnaissance trip. The combat unit may be involved in very rapid movements and the collection and jamming (C&J) platoon may be forced to move just as rapidly.

When this happens, it is crucial for the platoon leader or team chief to retain as much order and purpose to their movements as possible. The basics of site selection and defense preparation remain constant. They must be considered regardless of the posture of the supported command. If the platoon leader or team chief cannot obtain a proper site location in the given area, the MI battalion can assist and resolve the problem with the maneuver brigade staff through the IEWSE. The company team commander provides additional assistance as directed by the S3.

Once a site location has been identified, the platoon leader or team chief must determine the location of adjacent units. Defensive measures must be coordinated with them. Fields of fire and protective positions must be identified, known, and understood by the platoon leader, team chief, and intercept/direction finding operators. The platoon leader or the team chief should draw up a site defense plan. The plan is placed into effect as soon as the team arrives on site. Additionally, the platoon leader or team chief should take the time to stake the area, indicating exactly where the equipment should be positioned. The platoon leader or team chief normally makes a rough site map and strip map for the equipment driver to follow.

BATTLEFIELD SURVIVAL

Because some intercept/DF systems may be located close to the FLOT and because of their unique antennas, their positions may be observed by enemy forward observers. Considering that attack on these systems by indirect fires is a probability, EW platoon leaders, team chiefs, and intercept/direction finding personnel should be knowledgeable of the enemy doctrine. This knowledge will enhance the survival of the intercept/direction finding systems and personnel.

Threat

The doctrine for the current threat to United States (US) forces calls for the employment of massive amounts of indirect fire. The majority of this fire will be preplanned and delivered as a coordinated part of the overall combat operation.

Artillery fires will be directed by observers operating from advance observation posts. The observers will be located in the forward lines of motorized rifle or tank units or main observation posts. The main observation post for a motorized rifle or tank battalion normally is within 500 to 1,000 meters of the FLOT. Forward observers are equipped with binoculars, range measuring equipment, and communications equipment. They can communicate directly with the artillery firing units. They can also detect targets out to 5 kilometers with their observation devices.

Not only can massed artillery fires against intercept/direction finding systems be called and delivered quickly and effectively, but attack helicopters could be used against intelligence gathering systems. Because of the helicopter's lethality and the skill of pilots in using terrain flight tactics, it is possible that enemy commanders will task these assets to attack US intercept/direction finding systems. US tactical intercept/DF systems must be properly camouflaged and positioned to survive against the enemy.

Camouflage

Camouflage can contribute to the survival of intercept/direction finding systems by reducing the enemy's ability to see the equipment. See is used here because the technology of sensors has advanced parallel with that of weapons. Seeing is no longer strictly a capability of the human eye. Enemy forces use sensors which can detect targets in the ultraviolet wavelength (shorter than visible). They can also detect targets in the broader near and far infrared and radar bands (wavelengths longer than visible). Intercept/DF systems have unique antenna systems, so camouflage techniques must be used to reduce the probability of detection by enemy observers. Sensors attempt to locate and identify equipment by means of radar image, visual image, or temperature change.

The US Army has implemented two basic camouflage concepts that provide protection from detection, either visually or electronically—

- Shape-disruptive painting.
- Lightweight camouflage screen system (LCSS).

Shape-disruptive painting is commonly called pattern painting or camouflage painting. This type of painting provides protection from image intensifying sensors such as the sniper scope and from cameras employing detection film.

LCSSs are usually referred to as garnished screens. They are manufactured as either radar scattering or radar transparent. The garnish of the radar-scattering screen contains minute fibers of stainless steel which inhibit the passage, reflection, and return of a radar signal. These screens are most effective against older, less sophisticated radar equipment. The radar transparent version is made without these fibers and can be used without altering the effectiveness of the intercept/direction finding system. Obviously, the antennas of these systems cannot be camouflaged without degrading intercept or direction finding accuracy.

Positioning

Certain siting procedures can be followed which reduce the visibility of intercept/DF equipment even though the antennas of these systems cannot be camouflaged. Natural terrain features can be used to keep the antenna from standing out in a silhouette. The systems can be located in front of a hill or tree line, with the antenna below the top of the hill or trees. This reduces the visibility of the station and the antenna by obscuring their outline (Figure 5-8).

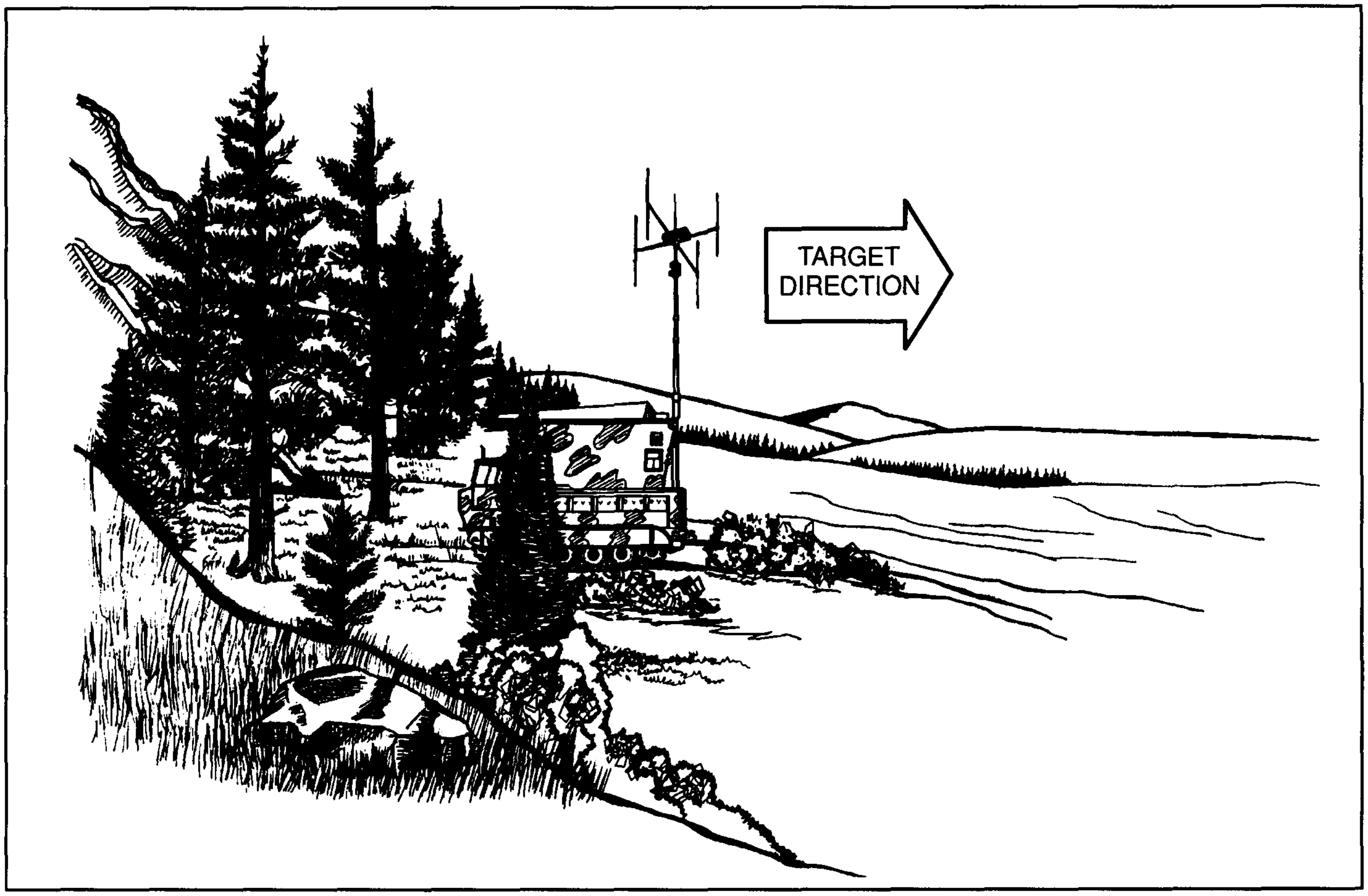


Figure 5-8. Reduced antenna visibility.

To a forward observer, the intercept/direction finding system profile would appear to be a continuation of the profile of the objects around it. Additionally, trees near the antenna can offer certain advantages as well as disadvantages. Foliage can be used to mask the antenna system from unwanted signals. That is, if the equipment is positioned so that the foliage behind and to each side of it extends higher than the antenna. However, foliage located between the antenna and the enemy transmitter antenna has an adverse effect on signal reception. Trees with heavy foliage absorb radio waves; leafy trees more than evergreens. Therefore, intercept/direction finding antennas should extend above the surface of the vegetation level when looking at the enemy transmitter antenna (Figure 5-9).

Redeployment

In a tactical situation, the intercept/direction finding systems must be redeployed frequently if they are to accomplish their mission and survive a hostile environment. This is due to the—

- LOS requirements for VHF intercept and DF. A significant change of the FLOT or the area of interest also requires redeployment.
- Area of interest of the supported division being larger than the area which can be covered by the intercept/direction finding systems. This requires frequent redeployment to adequately cover the desired area.
- Tactical intercept/direction finding systems requirement to stay within LOS of the target areas. This makes them susceptible to visual targeting and the possible detection of their communications equipment. Frequent redeployment reduces the chance of the enemy being able to effectively target and fire on them.

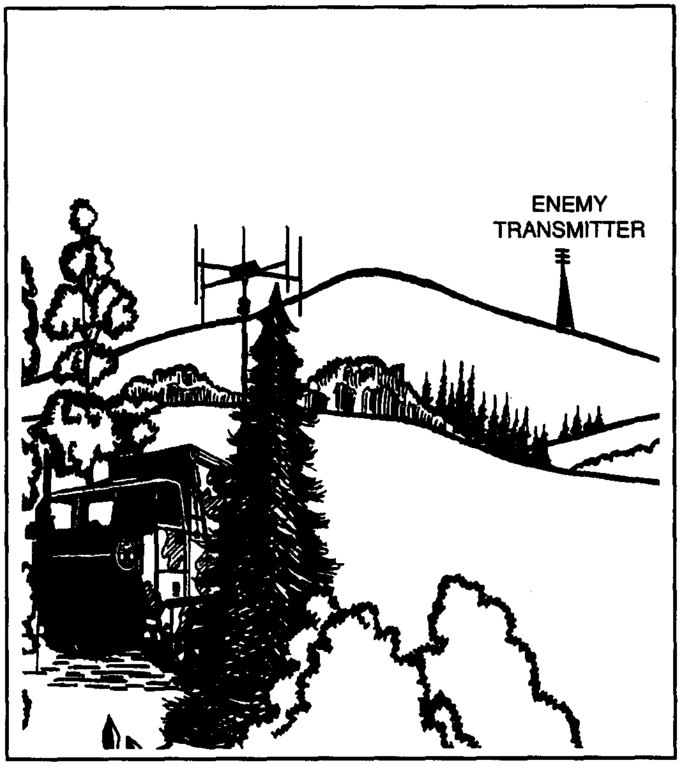


Figure 5-9. *Looking* at the enemy transmitter antenna.

AIRBORNE DIRECTION FINDING DEPLOYMENT

Fixed wing airborne direction finding systems are normally located at an airfield in the corps area. Heliborne systems operate from tactical sites with their parent aviation brigade units. Associated equipment is also located in close proximity to the airfield or tactical site.

ARDF aircraft requires flight patterns that may present the aircraft as targets to hostile forces. Depending upon the terrain, altitude, and distance from the FLOT, the aircraft could be acquired by hostile radar or by the enemy. If the aircraft comes within operational range of the weapon system, they can be attacked by surface-to-air missiles or by airborne interceptors. Due to the classification of this book, survivability tactics will not be discussed.

CHAPTER 6

TASKING AND REPORTING

While strategic and tactical DF share similar basic fundamentals, they differ in other areas. For example, different equipment is used. Strategic direction finding is normally performed from either a fixed or a semifixed posture. Tactical direction finding operates from a mobile posture. There are also disparities between the distances from strategic and tactical DF sites to their net control stations.

Strategic sites are typically located several hundred kilometers from their NCS. Real estate of most allied countries (who host our strategic direction finding nets) is at a premium. Negotiation for land is not an ongoing process. Barring a wartime situation, the likelihood of moving a strategic DF site from one location to another is extremely remote.

Tactical DF sites, normally located within 5 to 15 kilometers of the FLOT, are usually 10 to 15 kilometers from their NCS. Real estate for tactical groundbased DF systems must be coordinated with the supported combat commander. Due to the battlefield environment, frequent moves must be anticipated. Differences in equipment, distances from site to NCS, and deployment all affect tasking and reporting procedures.

COMMUNICATIONS

A prerequisite for direction finding tasking and reporting is rapid and secure communications. Strategic direction finding nets normally use secure telecommunications equipment for tasking and reporting, while tactical DF tasking and reporting are normally accomplished using secure VHF radios. National Security Agency (NSA) approved manual encryption systems are available and are used to secure communications.

STRATEGIC TASKING

Strategic tasking is the assignment of a target or targets to the mission of a strategic DF net control station. Placing a target on the DF mission also includes the priority of the target. The priority determines which target will be tasked to the net in the event two targets of different priorities are active simultaneously. Generally, the mission of a strategic NCS fluctuates with the number of targets on assignment. Targets normally will be added and deleted on a daily basis. Specific information concerning mission assignment can be found in USSID 103.

The purpose of tasking is to determine the location, or in some cases direction only, of a transmitter from the NCS. Tasking may originate from a higher headquarters or it may be local. In either case, requests for direction finding must come to the NCS for action. A strategic DF NCS is normally collocated with an intercept station. Intercept operators request bearings or the location of suspected or known enemy transmitters. Direction finding operators usually do not search the frequency spectrum for targets of interest. Rather, DF requests are received from intercept operators. The basic terminology commonly used at strategic and some tactical direction finding net control stations is listed in the glossary.

The following functions are presented in a chronological sequence to illustrate how strategic DF net control stations task their DF sites for bearing returns on target emitters:

- The intercept operator requests a bearing or the location on an enemy transmitter.

- The DF controller records the tip-off along with amplifying target information. This includes call signs, frequency, and type of traffic being passed, if any. This permits rapid identification of the target signal.
- The DF controller passes the target information to the DF flash operator.
- The DF flash operator notifies the DF sites of the target and provides tracking so they may obtain a bearing.

This sequence is repeated many times each day. In some strategic nets hundreds of targets are flashed to the DF net daily. Tasking the DF sites to provide a bearing on a transmitter does not complete the direction finding process. To satisfy the intercept operator's request for a location, each bearing from each DF site must be reported to the NCS so that analysis may be performed for reporting.

STRATEGIC REPORTING

Strategic reporting originates at each DF site. The reportable product is a bearing. After the DF site operator determines a bearing on the flashed target, it is returned to the NCS through the report net. The DF operator may be unable to obtain a bearing on some targets. This could be due to natural or man-made co-channel interference, signal strength (weak, fading signal), or target terminating its transmission before the DF operator could obtain a bearing. This would result in the DF site operator submitting a negative bearing return. (Negative bearing returns are defined in USSID 103.)

Regardless of the results obtained at the NCS (whether valid or negative), all bearing returns are collected on each flashed target and the bearings are plotted. Plotting is performed either by hand or computer. Detailed plotting and analysis is covered in Chapter 8. Once the bearings on a target have been plotted and a location has been determined, the location is reported to the requester. This is done to help identify the target as well as to preclude redundant DF requests. Higher headquarters and local policies dictate detailed strategic direction finding reports and reporting procedures. Additional information can be found in USSID 103.

TACTICAL TASKING

As previously mentioned, tactical direction finding operations are influenced by several factors. The most important are the—

- Tactical environment.
- Mission.

It is anticipated that the next war will be unpredictable and fast moving. Groundbased tactical DF equipment may have to be moved several times daily to maintain pace with the supported commander's forces.

The priority intelligence requirements (PIR) and information requirements (IR) of the supported division or corps commander will drive tactical DF tasking. Initial hostilities may find our forces with a limited enemy communications data base available for intelligence gathering operations. Building an adequate data base normally takes several days. The MI battalion TOC at division and the MI brigade TOC at corps provide intercept and DF guidance during this initial period. The possibility of identified targets being placed on assignment for tactical DF is remote during the initial stages of hostilities.

In most situations, general guidance on target designated frequencies is provided to the intercept and DF operators. The frequencies are those known to be used by specific enemy elements such as artillery, armor, and rocket forces. The frequencies to be monitored for enemy activity depend on the supported commander's PIR and IR. Therefore, initial tactical direction finding efforts are dependent on intercept. A LOB is taken on all intercepted targets. If possible, a location of that transmitter is determined. Once a significant data base has been developed, the MI battalion TOC or MI brigade TOC will then provide more selective DF tasking to its tactical DF assets.

TACTICAL REPORTING

All direction finding bearings in a strategic net are reported immediately to the NCS. In tactical direction finding, the DF team, the platoon operations center, and the TCAE (collocated with the MI battalion TOC) are partners in the DF process.

The voice collection teams in support of division operations normally report LOBs as directed by the MI battalion TOC. As desired by the supported commander, the MI battalion TOC may direct that all bearings be reported immediately to the supported brigade. Normally DF bearings taken by the voice collection teams are reported to the C&J platoon headquarters. Here the transcription and analysis team can perform quick plots if time permits and then, as directed, transmit the bearing results to the TCAE in the MI battalion TOC/supported brigade.

The noncommunications collection team reports all LOBs to the EW platoon headquarters which passes them to the MI battalion TOC. As directed by the supported commander, derived geographic locations are then passed directly to the brigade or the fire support element.

Voice collection teams assigned to the operations platoon in support of corps report their bearings as directed by the brigade operation center. Normally the teams report their bearings to the transcription and analysis team of the operations platoon. Here, if time permits, they may be quickly plotted and then transmitted to the supported command or the MI brigade TOC. This, of course, will depend on the supported commander's desires. The ARDF systems and the noncommunications collection team in support of corps report their DF results directly to the MI brigade TOC.

At the MI battalion TOC or MI brigade TOC all bearings are consolidated, plotted, and, time permitting, integrated with other intelligence. Using groundbased DF and ARDF results, locations of enemy communications and noncommunications transmitters are determined. These locations are provided to the supported commander on a near real-time basis.

CHAPTER 7

ERRORS

To effectively plot direction finding bearings (or evaluate and report the most probable location of a target area) the person doing the plotting must know about direction finding errors. This information will influence their interpretation of the bearing intersection. Also, the supported commander should understand that due to the influence of DF errors, enemy transmitter antennas cannot be pinpointed. However, a possible area can be identified where it is *highly probable* that the enemy transmitter antenna is located. This chapter describes common types of errors and their effect on direction finding.

SOURCE ERROR

Source error is a disruption of radio waves introduced at or near the enemy transmitter antenna. It can be caused by a specific type of directional antenna employed. It could also be caused by ground conditions at the antenna site which alter the normal radiation pattern of the antenna. If the DF equipment is farther than 15 kilometers from the transmitting antenna, the size of the source error is usually small. If the DF equipment is closer than 15 kilometers (as with the majority of our tactical DF systems), the source error will cause an inaccurate DF bearing.

PATH ERROR

Path error is caused by deviations of a radio wave from the great-circle path between the transmitting antenna and the DF system. This deviation is caused by the radio wave being absorbed, reflected, reradiated, refracted, or a combination of these factors. The more important sources of path error are—

- Scatter.
- Refraction.
- Reflection.
- Reradiation.

Scatter

In some instances, a small portion of the radio wave entering the ionosphere is scattered instead of being gradually bent and returned to earth. This scattered radio wave may be projected in any direction and is returned to the earth at random angles (Figure 7-1 and Figure 7-2, page 7-2).

The scatter phenomenon accounts for signals sporadically received in regions that are in a skip zone. Error caused by scatter normally affects strategic direction finding sites but has little or no effect on tactical DF systems.

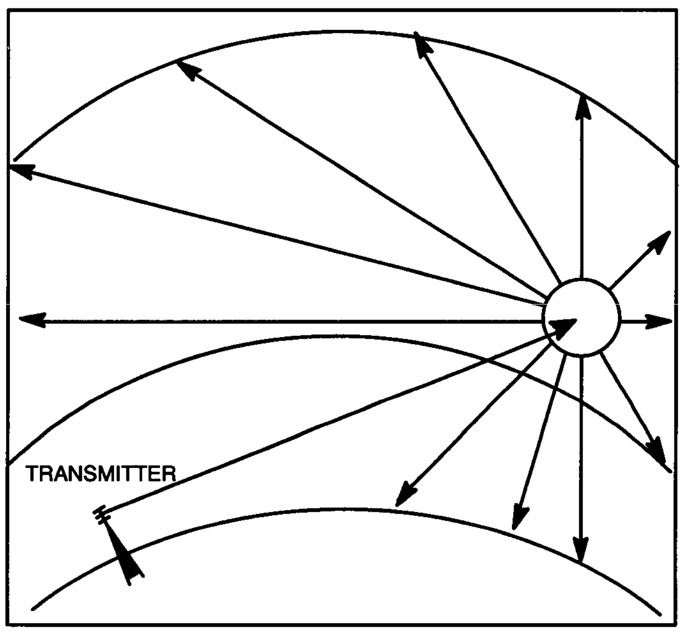


Figure 7-1. Short scatter.

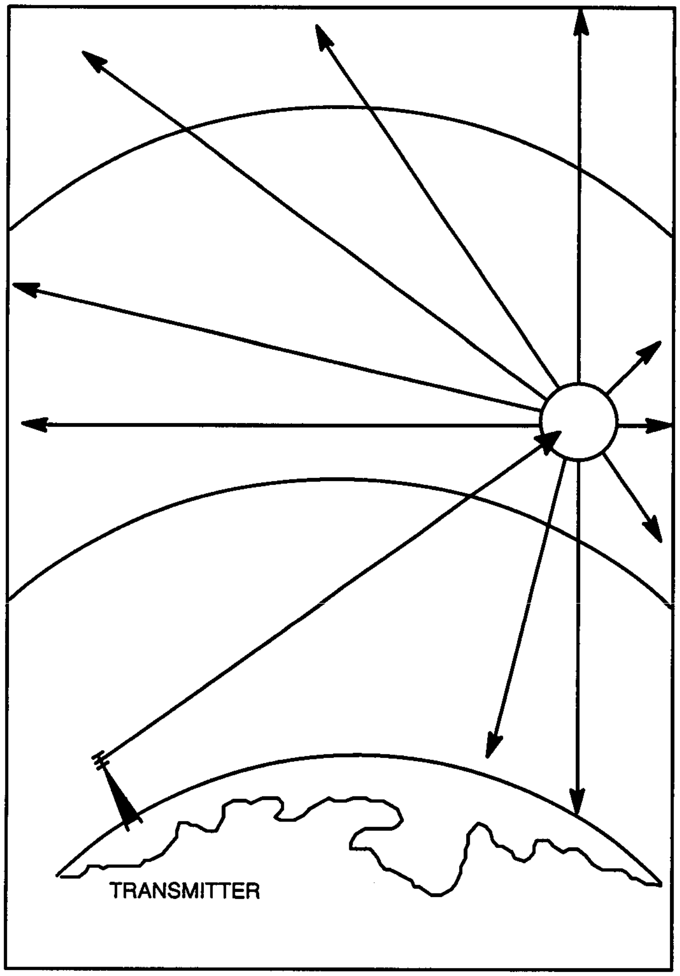


Figure 7-2. Long scatter.

Refraction

Radio waves (electromagnetic in character) are bent or refracted from their normal path when they pass from one medium to another. For example, the velocity of a radio wave over salt water is greater than its velocity over land or fresh water. As a result, when a radio wave crosses a coastline at an oblique angle, as illustrated in Figure 7-3, its direction is appreciably altered. Refraction error is particularly pronounced when either a DF site or the transmitting antenna is near the coast. This effect will also vary with the transmitted frequency.

Reflection

Reflection often causes incorrect DF bearings. A radio wave traveling over or close to cliffs, mountains, or tall buildings will in all probability be reflected (Figure 7-4).

The degree of reflection is immeasurable. It depends upon the obstacle and the frequency of the transmitted wave. Generally, DF errors are greatest from reflection when the reflecting mediums are located in the vicinity of either the transmitter or the DF equipment. Reflection error will affect both strategic and tactical direction finding systems.

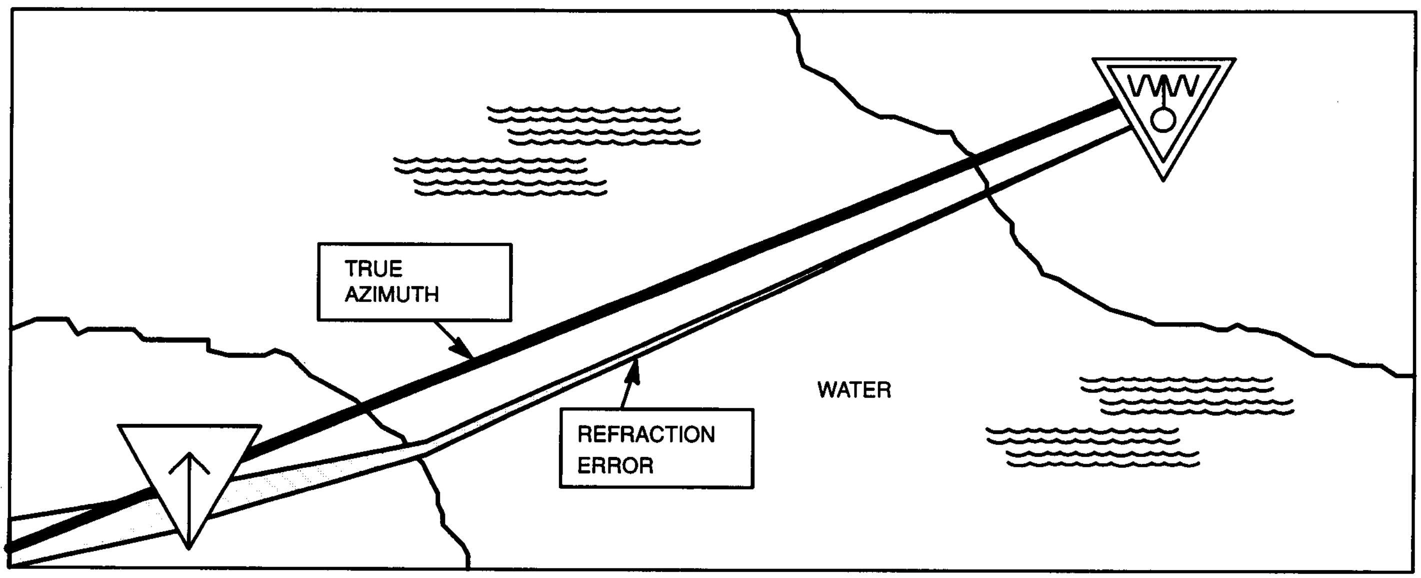


Figure 7-3. False azimuth indicated by refraction error.

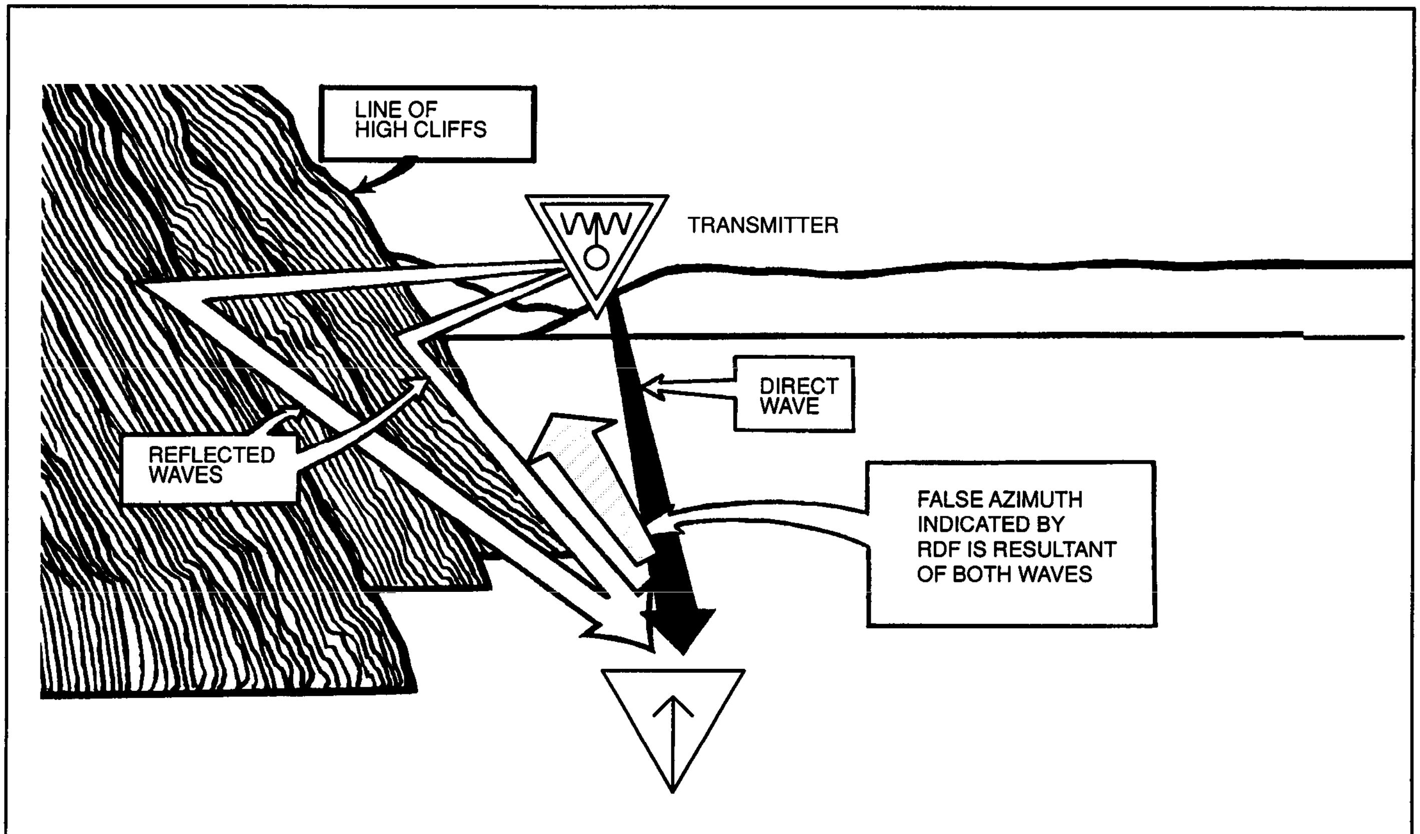


Figure 7-4. Reflection of a radio wave.

Reradiation

This effect occurs mainly because of the reradiation of the radio wave by metallic objects that are resonant at the frequency of the received wave. As a result of reradiation, the radio wave intercepted by the DF equipment may be abnormally polarized. An abnormally polarized signal makes the azimuth reading or bearing very difficult to determine. Reradiation error normally occurs in the vicinity of the direction finding site. Therefore, at strategic and tactical DF sites it is important to adhere. if at all possible. to the site criteria guidelines presented in Chapter 5. Barbed wire, trucks, tanks, other combat vehicles, and metal buildings can cause reradiation error.

POLARIZATION ERROR

Polarization error occurs when an undesired component of a radio wave induces voltage in a DF antenna. This undesired voltage blurs the bearing and makes an azimuth reading difficult to determine. For example, a vertical loop or an Adcock direction finding antenna (Figure 7-5, page 7-4) is designed to receive vertically polarized radio waves.

If the received wave is abnormally or randomly polarized (contains vertically and horizontally polarized components), the voltage induced by the two components may combine. The azimuth reading on the signal will be difficult, if not impossible, to determine. The effect of polarization error depends upon the ability of the DF antenna (loop or Adcock) to discriminate between the desired component (vertically polarized wave) and the undesired component (horizontally polarized wave) of the received signal. Polarization error is common in most DF operations.

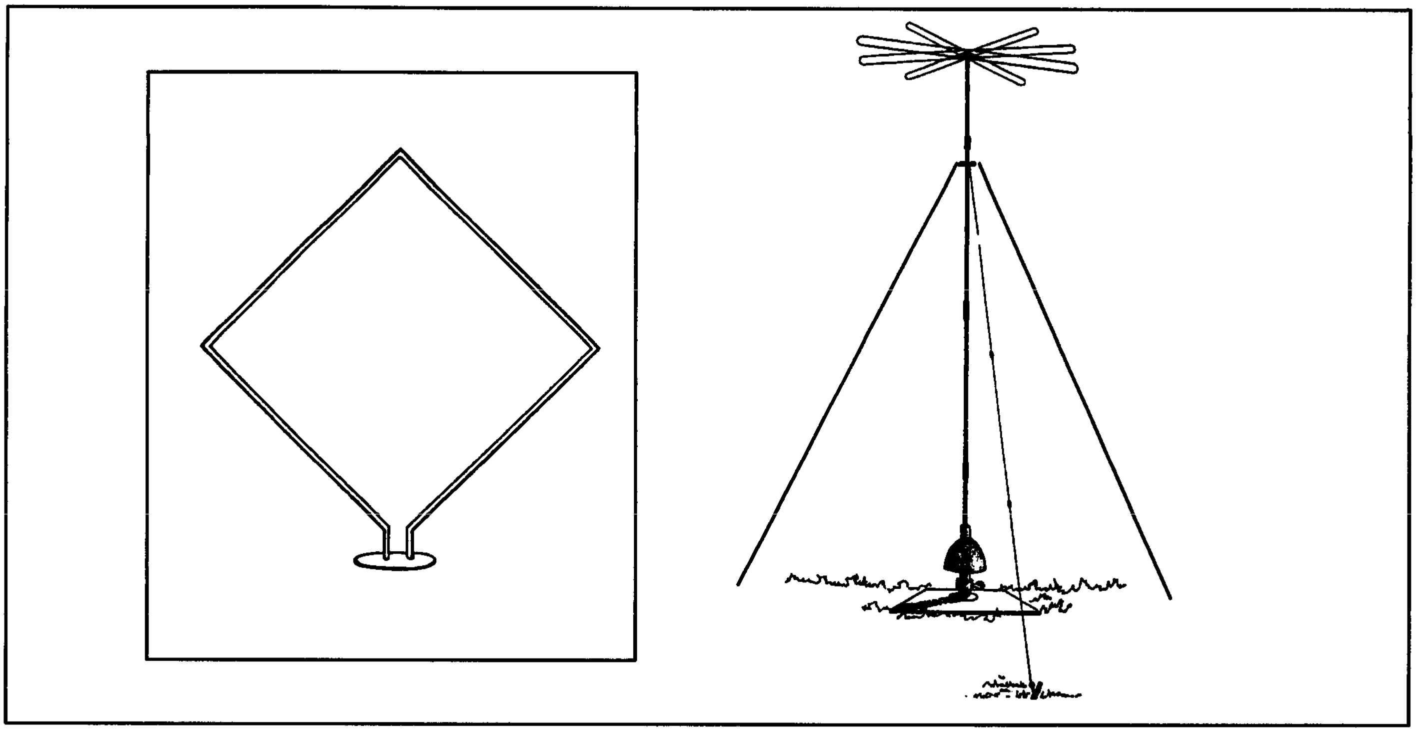


Figure 7-5. Vertical loop and Adcock antennas.

SITE ERROR

Site error occurs in the immediate vicinity of the direction finding site. Site error may be a result of one factor or a combination of several factors. Orientation of the DF system's antennas is extremely important in obtaining maximum DF accuracy. Whenever a direction finding site is setup in a new location, its antennas must be precisely oriented to a known reference point. This produces an accurate measurement of the arrival angle of the wave front. Without this accuracy, the plotting of the reported bearings is of no value. (See Chapter 6.)

Radio waves can be reflected from their original paths by various obstacles. The DF equipment will measure the actual angle of arrival at the DF antenna. Therefore, the DF antenna should be positioned where the wave path is least susceptible to outside influences. The DF equipment then will give the most accurate representation of the true direction of radio wave travel.

Obstructions in the near vicinity of strategic and tactical direction finding sites contribute to site error. The closer the obstruction is to the DF site, the greater its adverse effect on the accuracy of the site's bearings. Errors caused by obstructions in the vicinity of the site can be eliminated by careful site selection.

Although in many cases the best available site location is far from ideal, definite measures for improving the site from a technical standpoint can be taken. For example, strategic DF sites (which are not substantially flat for at least 90 meters from the DF antennas) can be leveled off with a bulldozer or grader. If it is impossible to level the entire area for 360 degrees coverage, at least those areas within the azimuth arc of primary interest should be flattened. Natural objects such as trees and low vegetation should be cut down or uprooted. Vehicles and personnel not actually engaged in operations at the DF site should be kept away from the antenna system. Tactical DF site improvement is difficult because many compromises must be made for the sake of survivability. However, general site selection guidelines were provided in Chapter 5. They should be followed with discretion when selecting a tactical DF site.

INSTRUMENT ERROR

Instrument error is introduced by the DF equipment itself. Groundbased strategic and tactical DF equipment is designed to perform with a system bearing accuracy of plus or minus 2 degrees. It should be understood, however, that this accuracy is provided within an electronics laboratory where the equipment is unaffected by environmental or human effects. This accuracy provides a point of comparison and should never be used to predict the accuracy of target acquisition.

Normally, DF instrument error is dependent upon the general condition and adjustment of the equipment. A lack of a good maintenance program may also introduce instrument error. The DF operators can contribute to this problem if they perform poor first-echelon equipment maintenance. Various calibrations and adjustments must be performed at regular intervals. These procedures are described in associated DF equipment technical manuals. They improve equipment performance and result in more accurate DF results.

Daily bearings on known transmitters (check bearings) should be taken at strategic DF sites. These transmitters are commonly called *check targets.* They are used to show if the accuracy or calibration of the DF equipment is acceptable. The check targets must represent the entire frequency spectrum and distances required in DF operation. Any appreciable deviation of the DF bearings (from the known bearing or the bearings normally obtained on a check target) should be investigated immediately.

OPERATOR ERROR

Operator errors are reduced to a minimum when operators have received sufficient training and experience. Newly assigned direction finding personnel must be trained by their supervisor. The DF training program is a supervisor responsibility. Although the service school responsible for training operators provides excellent instruction in many areas, there is no substitute for on-the-job training. Additionally, DF operators must be alert at all times when operating the equipment. For example, DF operators are required to take bearings on many signals that are weak or fading. Through training, the operator learns to obtain an azimuth on the weak or fading signal when it appears strongest or most stable. Under adverse conditions, an efficient DF operator normally takes several readings and then determines the azimuth by averaging the readings to a mean bearing.

CHAPTER 8

PLOTTING AND ANALYSIS PROCEDURES AND TECHNIQUES

A DF plotter and analyst have an important job. They plot and evaluate the locations of transmitting antennas. This result is then used to determine enemy intentions or uncover enemy locations. At a strategic site, the DF analyst's product may reveal a mobilization for war or a sudden shift in defensive posture. The analyst acts as a catalyst by drawing on the raw data from the field and processing it into a viable product for battlefield commanders or national consumers.

This chapter provides reference to a multitude of procedures and techniques for plotting and analysis. Yet, as the word analysis implies, there is an element of human judgment involved in the process. Choosing the correct technique for the situation and applying the procedures correctly is imperative for mission accomplishment. Without sound plotting and analysis, the best DF equipment in the world would be useless.

DEVELOPING MAP PROJECTIONS

A map that is used for DF plotting and analysis is a graphic representation of a portion of the earth's surface. Although drawn to scale, no map is absolutely accurate since it represents the earth as a plane or flat surface. No portion of the earth's surface can be spread out into a flat plane without some *stretching* or *tearing*. This is illustrated by attempting to flatten either the cap of an orange peel or a portion of a hollow rubber ball. The outer portion must be stretched or torn before the central part will flatten. However, there are some surfaces which can be spread out in a flat surface without stretching or tearing. These are called developable surfaces. Surfaces which cannot be spread out in a flat surface, such as a sphere, are called nondevelopable surfaces.

Three well-known developable surfaces are the cone, plane, and cylinder. If a paper cone is cut from its base to the apex, the conical surface can be spread out in a flat surface without tearing or stretching (Figure 8-1). If such a cone is flattened, any line or curve drawn on it will have exactly the same length as before. In the same manner, if a cylindrical surface is cut from base to base, the whole surface can be rolled out into a plane or a rectangle (Figure 8-2). In this case, there is no stretching or tearing of any part of its surface.

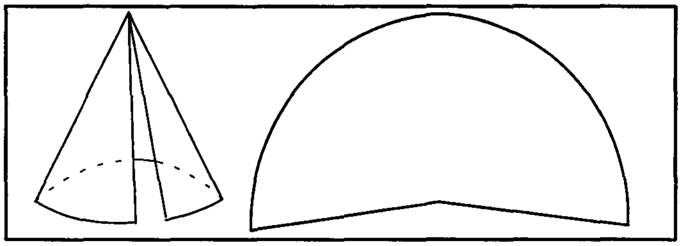


Figure 8-1. Conical surface.

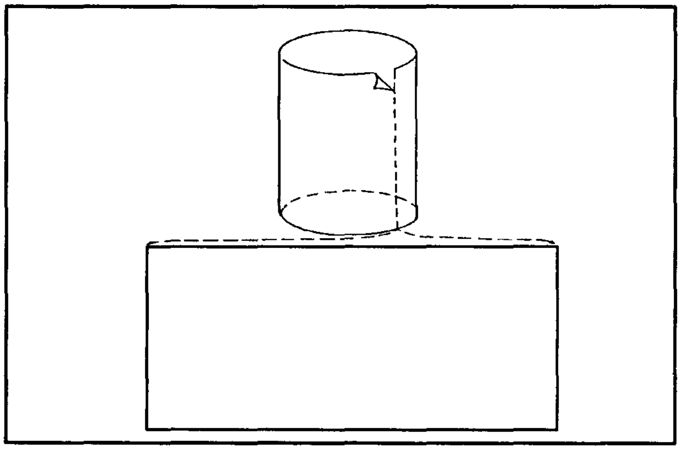


Figure 8-2. Cylindrical surface.

Since the spheroidal shape of the earth cannot be represented on a plane without distortion, a compromise must be made to obtain the most practical features for a specific use. Many different types of map projections have been devised. Each has special merits for its intended use, while compromising other features. The map projections used for direction finding plotting must be a type that a straight line, from a given point, will indicate the true azimuth. Two map projections commonly used for DF plotting and analysis are—

- Universal transverse mercator projection.
- Gnomonic projection.

Universal Transverse Mercator Projection

The universal transverse mercator projection is produced through the use of a cylinder. To project means literally to *throw forward.* A map projection is the network of coordinates picked off the globe and thrown upon a surface. A mercator projection is a mathematical projection very similar to what would be formed by projecting lines from the center of the earth to a cylinder. The cylinder fits around the earth and touches at the equator (Figure 8-3).

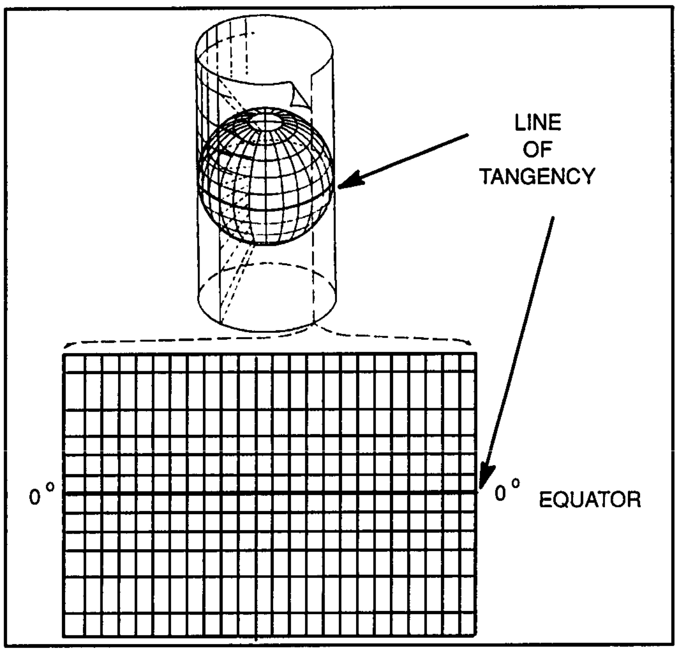


Figure 8-3. Mercator projection.

If the image of the earth could be projected against the cylinder and fixed there, the cylinder could be cut open and laid out flat. This would result in a sheet map that is comparatively accurate in the equatorial region. However, it is more and more distorted as the polar regions are approached. The line of tangency of the mercator projection is a horizontal line—in this example, the Equator. Turning the cylinder across its former horizontal line—that is, transversing it—results in the transverse mercator projection (Figure 8-4).

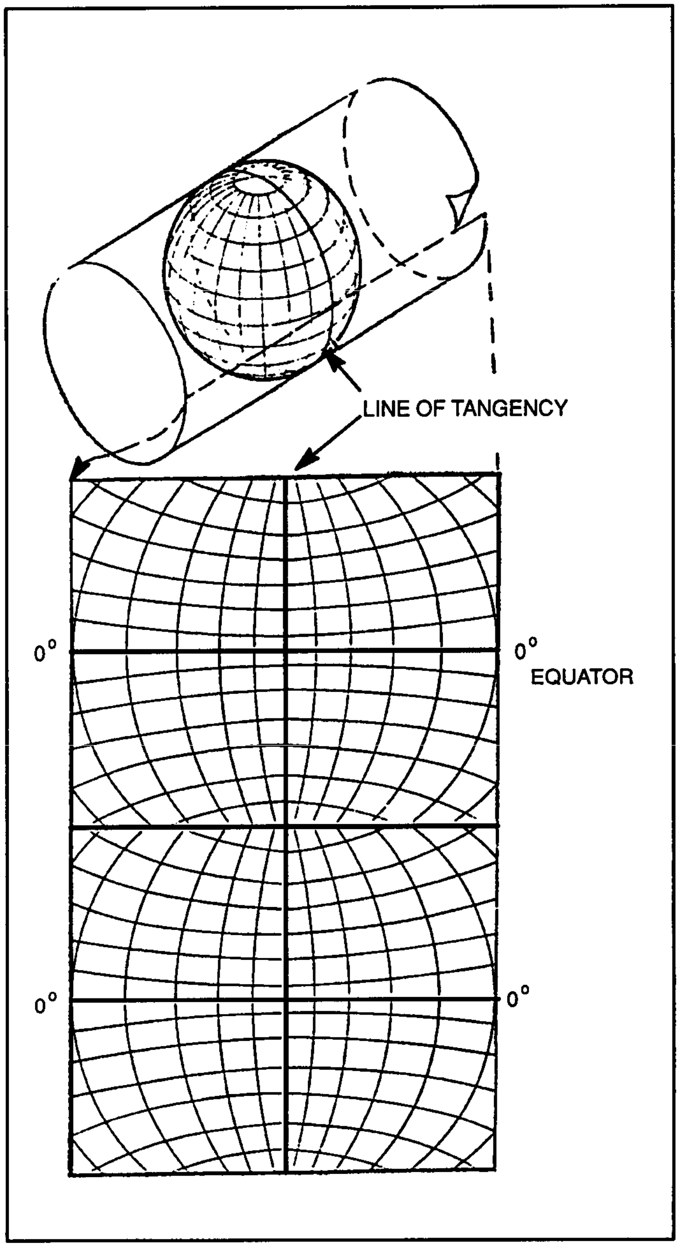


Figure 8-4. Transverse mercator projection.

The significant difference is that the transverse mercator projection uses a longitudinal or a vertical line as its line of tangency in place of a horizontal line (Equator) used in a mercator projection. By choosing several lines of longitude or meridians as lines of tangency, several transverse mercator projections can be constructed. When laid side by side, the entire land mass of the earth is mapped in north-south sections with a minimum of distortion.

The universal transverse mercator projection is the most common map projection used for tactical military purposes. It can be easily oriented for combat situations and readily used with a compass to find a true azimuth from any given point on the map. The UTM system makes it possible to plot from point to point using a straight line called a rhumb line. Advantages of using a universal transverse mercator projection for direction finding plotting are—

- Individual map sheets of the same scale may be joined to forma map of a larger area.
- Direction finding plotting and analysis within 200 miles on either side of the line of tangency can be accomplished with an ordinary protractor (true compass rose).
- There are no north-south plotting limitations.

Gnomonic Projection

A gnomonic projection of the earth is derived by projecting the surface of the globe, from its center, upon a planar surface. The gnomonic projection is the most commonly used map projection system for long-range strategic direction finding plotting and analysis. It is particularly useful when plotting across great expanses of ocean. This projection method represents all great circles as straight lines. This is the projection's chief merit. This is important in DF plotting and analysis because the shortest route between two points, a straight line, is always a portion of the arc of a great circle. As a general rule, radio waves travel in great circle routes. The limitation of producing a gnomonic projection is that only a quarter of the globe, or 90 degrees, can be projected. Distortion beyond 90 degrees becomes severe and renders the projection useless for direction finding purposes.

Advantages of using a gnomonic projection for strategic direction finding plotting and analysis are as follows:

- Radio waves will appear as straight lines throughout the projection. There are no distance limitations imposed; only that of the area encompassed by the map.
- Strategic direction finding sites need not be located within the boundaries of the projection. As long as you know the latitude and longitude of the DF site, you can compute for the points where the site's bearing will enter and exit the projection.

Due to the amount of distortion in this type of projection, protractor plotting is limited to those areas located within 4 degrees of the point of tangency. Most strategic sites are established on a baseline located outside of the 4 degree area around the point of tangency. Bearings from these sites (as well as those sites located off the chart) require mathematical correction to compensate for map distortion. Mathematical correction methods are presented in Chapter 9.

PLOTTING

The following terms are commonly used in strategic and tactical plotting facilities:

- Line of bearing.
- Cut.
- Fix.

A line of bearing is the angular measurement of a radio wave in degrees from a given reference (true, magnetic, or grid north) (Figure 8-5).

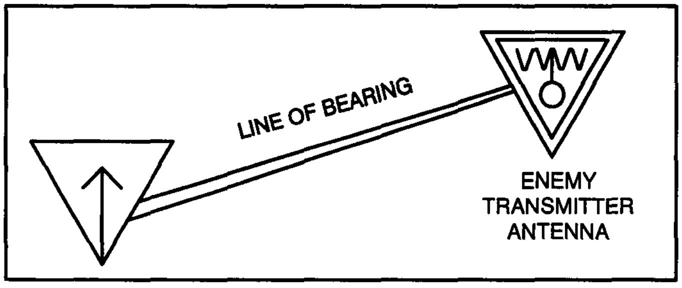


Figure 8-5. Line of bearing.

A cut is the point of intersection of two DF LOBs (Figure 8-6).

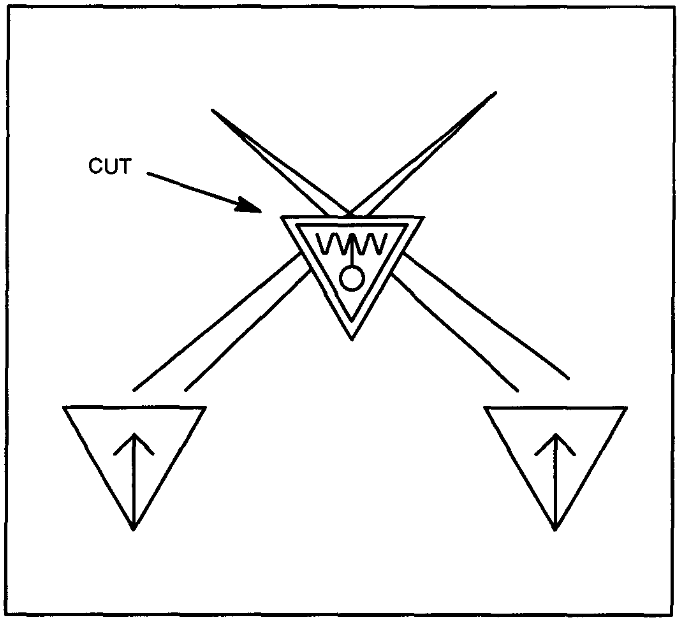


Figure 8-6. Cut.

A fix represents three or more DF plotted bearings that intersect (Figure 8-7).

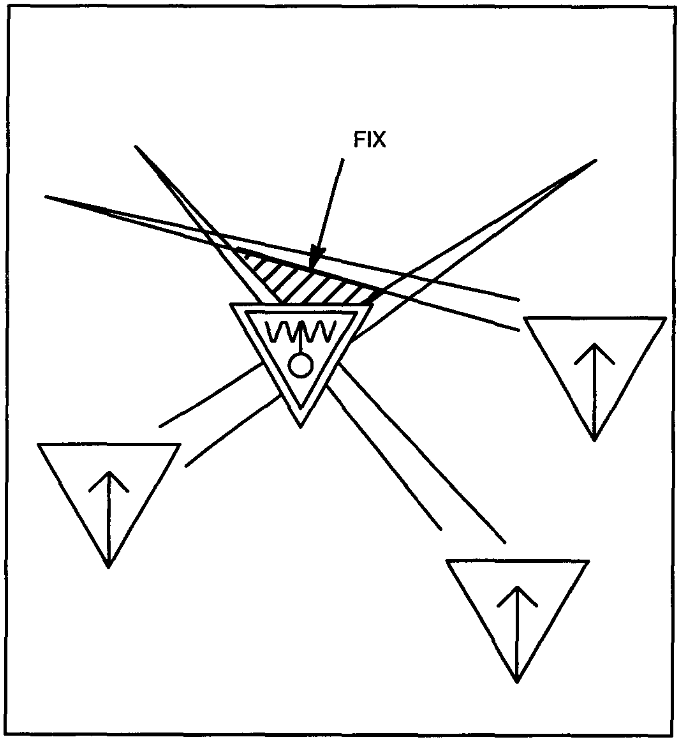


Figure 8-7. Fix.

Plotting a Line of Bearing

The simplest method of plotting a bearing is with a protractor and straightedge. Point A in Figure 8-8 represents the known location (by grid coordinates) of a DF station. This is entered as a tick mark (') on the map or overlay. In the example, the index of the protractor is placed to coincide with point A and is accurately aligned along the north-south grid lines by using dividers or parallel rulers. Either true or grid alignment may be used. Magnetic orientation is not used. While grid and true north reference lines are corrected throughout the map, magnetic declination is accurate only at the center of the map. As the scale of the UTM increases so does the inaccuracy of the magnetic orientation. Plotting at distances greater than 200 miles along an east-west axis will require a gnomonic projection. This is because the UTM becomes too distorted. (This includes combining several UTM maps.) The bearing taken by the DF station is measured in degrees from grid north and is indicated by another tick mark at the appropriate degree on the protractor. The protractor is removed and the straightedge aligned along two tick marks. The bearing is then plotted by drawing a line along the straightedge from the station location through the degree tick marks. Extend the line a sufficient length into the target area. The enemy's transmitting antenna is probably located along this line.

NOTE: The protractor may be aligned with a grid or true north, depending on DF equipment or reporting criteria.

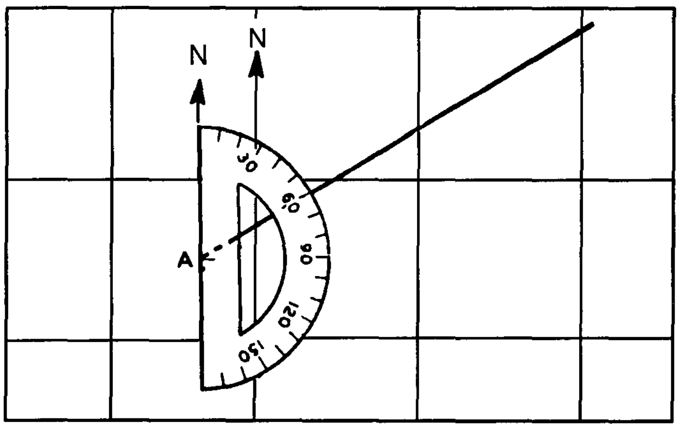


Figure 8-8. Plotting a bearing.

Plotting a Cut

Using the method outlined above, the bearing from a second DF station is plotted. The intersection of the two plotted bearings is identified as a DF cut (Figure 8-9).

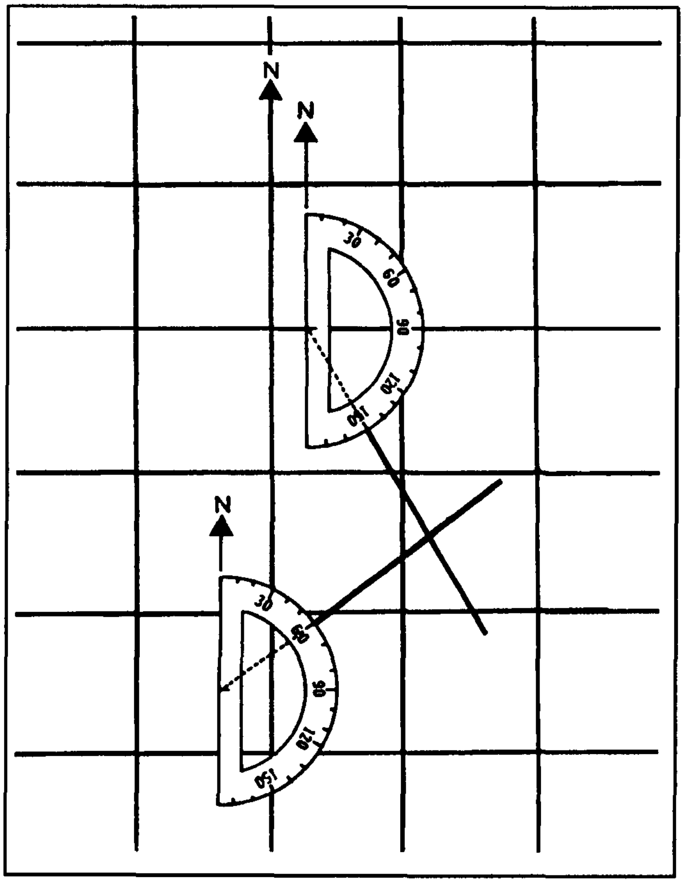


Figure 8-9. Plotting a cut.

Plotting a Fix

If three or more direction finding sites are arranged along a baseline, the protractor may still be used. As illustrated in Figure 8-10, DF sites A, B, and C are plotted and have reported bearings of 60, 90, and 130 degrees respectively.

Again, the protractor and straightedge may be used to successively plot the bearings of each DF site at its map location. The lines may be extended to form a small triangle. They may join at a point if the fix is perfect. Figure 8-11 illustrates a perfect fix. However, a perfect fix is extremely rare and suspect.

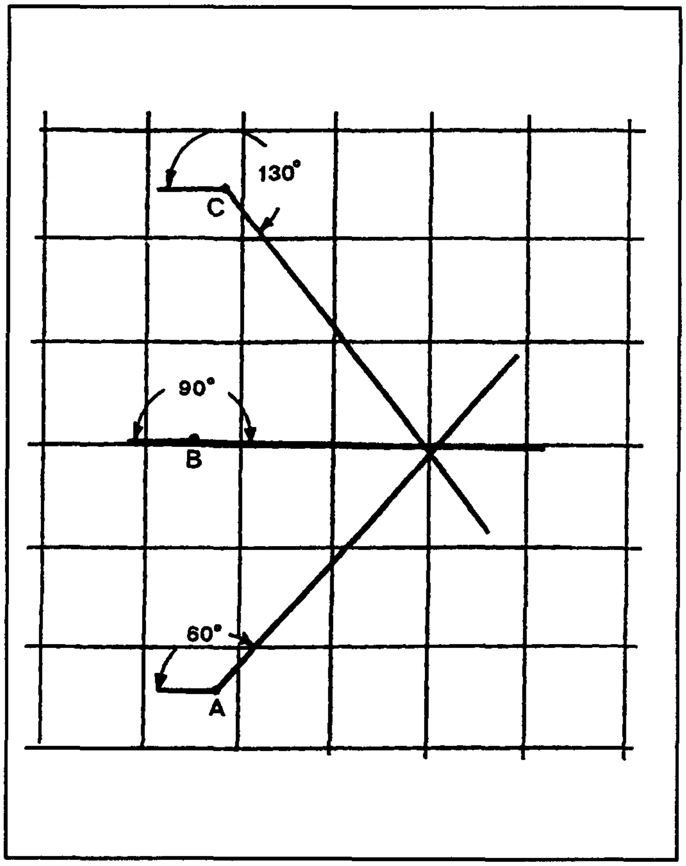


Figure 8-10. Plotting a DF fix.

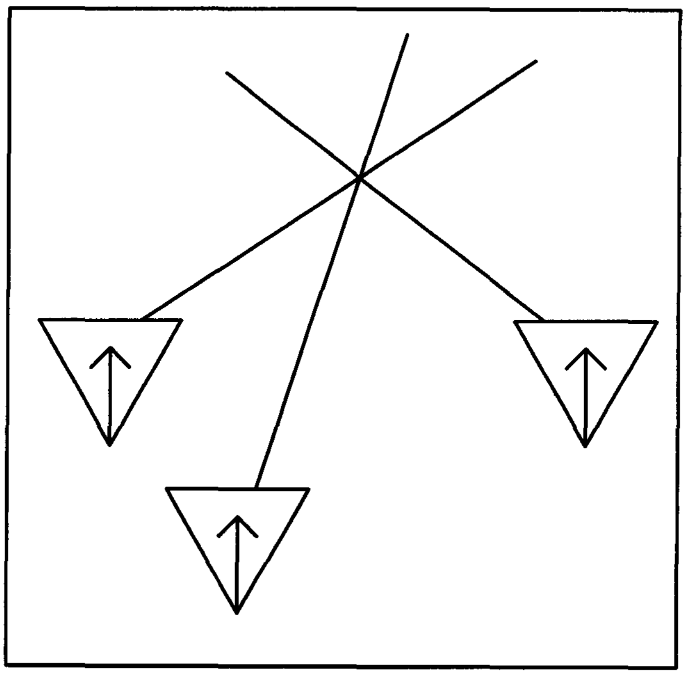


Figure 8-11. A perfect fix.

Map Size

The size and scale of the maps used in DF plotting and analysis depend on—

- Whether the direction finding effort is strategic or tactical.
- Range of the bearings to be plotted.
- Length of the baseline.

As previously mentioned, a gnomonic map projection is normally used for strategic plotting and analysis. The universal transverse mercator is used for tactical plotting and analysis. The range of the bearings or the distance from the DF sites to the target area obviously will affect the size of the plotting map. In a tactical situation, perhaps more than one map sheet may have to be joined with another to plot the DF sites' bearings. This is caused by the DF baseline being too long for a single map sheet. It could also be caused by the target area being too deep for a single map sheet. An ideal DF baseline should be the same length as the expected depth of the target area. Using a gnomonic map for strategic plotting, it is possible to have DF sites located off the map and still be able to plot their bearings. However, in a tactical situation this is not possible. The map size has to allow for all sites to be located on the map projection.

Plotting and Analysis Centers

The plotting procedures described above, while completely valid in terms of accuracy, are somewhat slow and laborious. A DF plotter/analyst would find it difficult to plot all the DF bearing returns using a protractor and straightedge because of the following:

- Advancement of direction finding state of the art.
- Greater number of bearings reported by individual DF sites.

Accordingly, DF plotting and analysis centers with in-depth analysis capabilities have been established. In these centers, plotting boards are used. They have the DF sites LOBs represented by strings which may be pulled out and lined on calibrated map-edge scales. The plotter/analyst simply notes the DF site, the reported bearing, and the calibrated edge scale for the particular reporting site. When the string is pulled out and aligned along the reported bearing on the appropriate map-edge scale, the bearing is plotted. Additional DF sites are plotted in the same manner. The intersection of bearings determines the most probable target location.

FIX ANALYSIS

Plotting and fix analysis is the practice of determining the best place to put the target coordinates and from that point, an area in which the target may conceivably be located.

Thus far, ideal plotting and analysis conditions have been discussed. In the practical application of DF plotting and analysis, the returned bearings are carefully evaluated by the plotter/ analyst. They determine the most correct or most probable location or best point estimate (BPE) of the target of interest. A perfect fix, with three or more bearings intersecting at an exact grid location, is rare. When plotting and analyzing, the plotter/analyst has many factors which must be considered.

The process of plotting and fix analysis is substantially influenced by several human factors in the evaluation of the DF site's bearings. As the plotter/analyst's experience builds and reported fix locations are confirmed by enemy contacts or other reliable means, the plotter/analyst will concede increasing credibility to one DF site over another. In other words, each DF site develops a *track record.* A change of DF operators at a particular DF site can also influence the analytical process. In spite of the standard assignment of reliability indicators, manual plotting and fix analysis is still greatly influenced by these human factors.

The DF plotter/analyst must also be aware of DF equipment characteristics. For example, the design characteristics of some direction finding equipment are plus or minus 2 degrees. (Different DF equipment has different accuracy ratios.) This means that a bearing return is not a straight line. It is an ever-widening, fanlike path. There is a high probability the transmitting antenna is located within this path. The center line of path A (Figure 8-12) has the highest probability that the target is located somewhere along this line. As the distance from the center line increases towards B, the target location probability decreases.

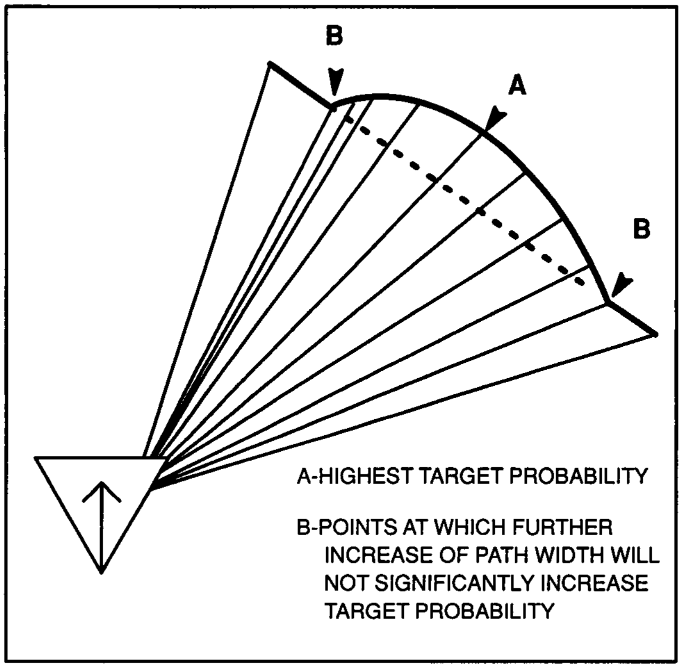


Figure 8-12. Bearing path.

Path width, or B, is determined during the design and testing of DF equipment. It is normally expressed as an angle, in degrees, based on mathematical calculations. Therefore, to determine the specific target area it is necessary for the bearings from two or more DF sites to intersect. A DF plotter must keep in mind that when the bearings intersect (Figure 8-13) the probable target area along each path is limited. It is limited to the width of the intersecting bearing paths at the point of intersection.

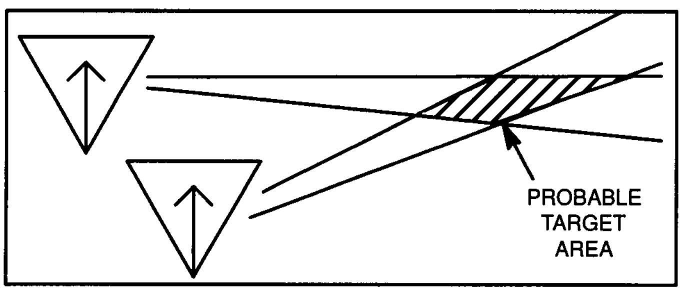


Figure 8-13. Intersecting bearing paths.

The direction finding fixes discussed in this chapter have all been *perfect* with all site bearings intersecting at an exact grid location. Of course, such a fix seldom occurs because of the inherent errors in DF operations. Significant contributions to direction finding inaccuracies are the—

- Continually changing electromagnetic environment of each DF site.
- Inherent equipment error.
- Operator error.
- Natural and man-made objects around the transmitting/receiving antennas.

Cut

It is possible to evaluate a cut. Obviously, such a plot is not normally used in DF reporting unless an extreme, high priority condition exists. However, the cut is frequently used at strategic DF sites for general distance or area observations and optimum antenna selection for intercept. A cut is not practical to obtain a fix point; therefore, an area must be determined in this analysis. Such a fix area is illustrated in Figure 8-14. If each individual bearing is represented by a fan-shaped figure centered about the bearing, it may be stated that there is a probability that the true bearing lies within this fan. This is called a fan bearing.

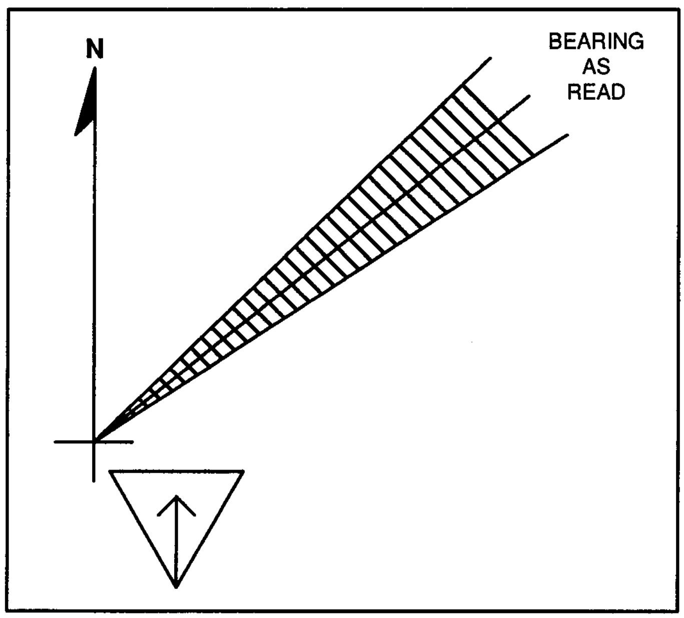


Figure 8-14. Fan bearing.

A two-station fan fix is shown in Figure 8-15. If each fan represents the limits within which there is a probability of 50 percent (1 to 1 chance) that the bearing lies there, then the cross-hatched portion represents the area in which there is a probability of 25 percent (1 to 3 chances) that the transmitter antenna lies there. Each site has its own standard deviation (SD). This is a measurement of the reliability of the sites' bearings based on the historical data base. (For more information on SD, see Chapter 9). By increasing the size of each bearing fan to the width of the DF site's SD, it may be estimated that the probability is 90 percent (9 to 1 chance) that each bearing lies within the fan, and that there is a probability of 81 percent (4 to 1 chance) that the transmitter antenna lies within the cross-hatched area. If the site SD is not available, expand the bearings to a total fan width of 10 degrees.

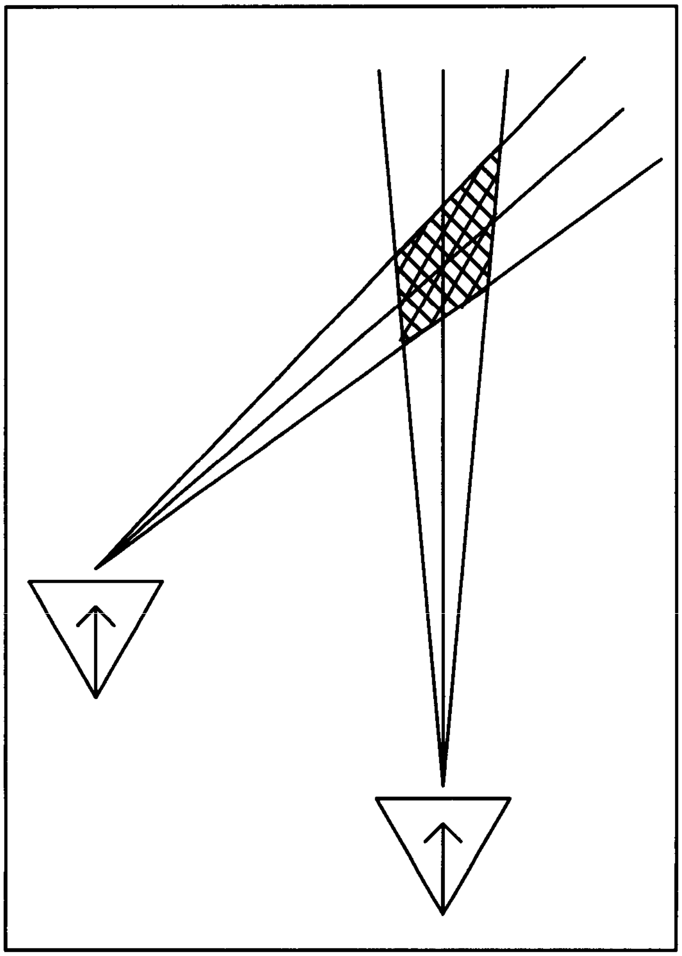


Figure 8-15. Two-station fan fix.

Extension of the two-station fan fix into fixes of three or more stations becomes very complicated and leads to ambiguous results. Even for a two-station fix, the area frequently becomes excessively large for any reasonable probability. However, by more refined mathematical considerations involving the theory of probability and the theory of least squares, it is possible to determine the size, shape, and location of a minimum area with a stated probability that the transmitter antenna lies within it. This applies to any number of DF sites involved.

Three-Station Fix

When plotting three bearings, one of three possible events occurs—

- No-fix situation, where a fix solution is not feasible.
- Perfect fix situation, where all three bearings intersect at a single point.
- Error triangle situation, where an area of probability is formed.

No Fix

As illustrated in Figure 8-16, a fix solution is not always feasible. This occurs more frequently with three-station plots than with plots of four or more stations. In many situations, the analyst will be cautious and will choose to report a no fix rather than risk reporting an erroneous location. For example, a triangle that encompasses a 3 by 3 grid-square area would not help to locate a mechanized infantry company. Due to the relatively low priority and speed of the unit, the plotter or analyst would consider the target information too inaccurate for use. However, if the same triangle was applied to a company transporting nuclear missiles, the target information (regardless of its accuracy) may be deemed of such importance that it justifies an inexact fix report. In such situations, use of each site's SD is helpful. Not all tactical sites will have these statistics available, but for those that do, such statistics will prove useful during analysis. Figure 8-17 illustrates how a large triangle can be reduced using SD. The bearing lines for the two sites are adjusted by applying twice the SD of each site. This produces a workable triangle for analysis.

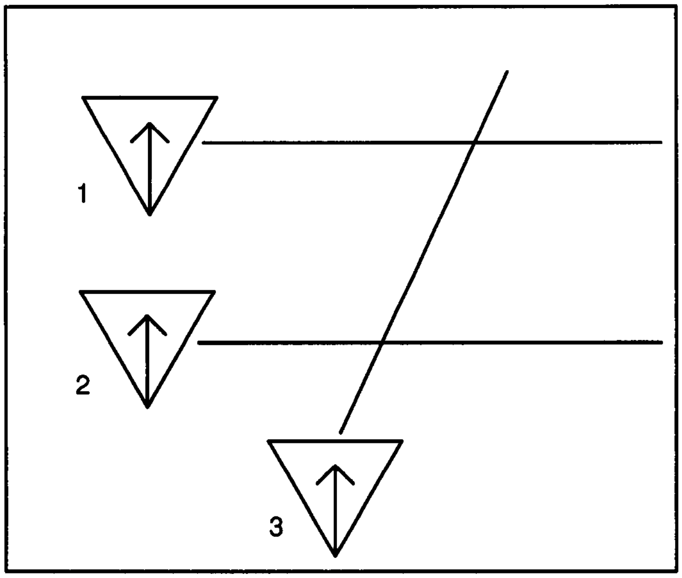


Figure 8-16. No fix.

Perfect Fix

Figure 8-18, page 8-10 illustrates a perfect fix situation. However, this plot could misdirect analysis. Such a fix does not guarantee that the point of intersection represents the exact location of the target transmitter antenna. Conceivably such a fix could be obtained if two or more bearings were in error.

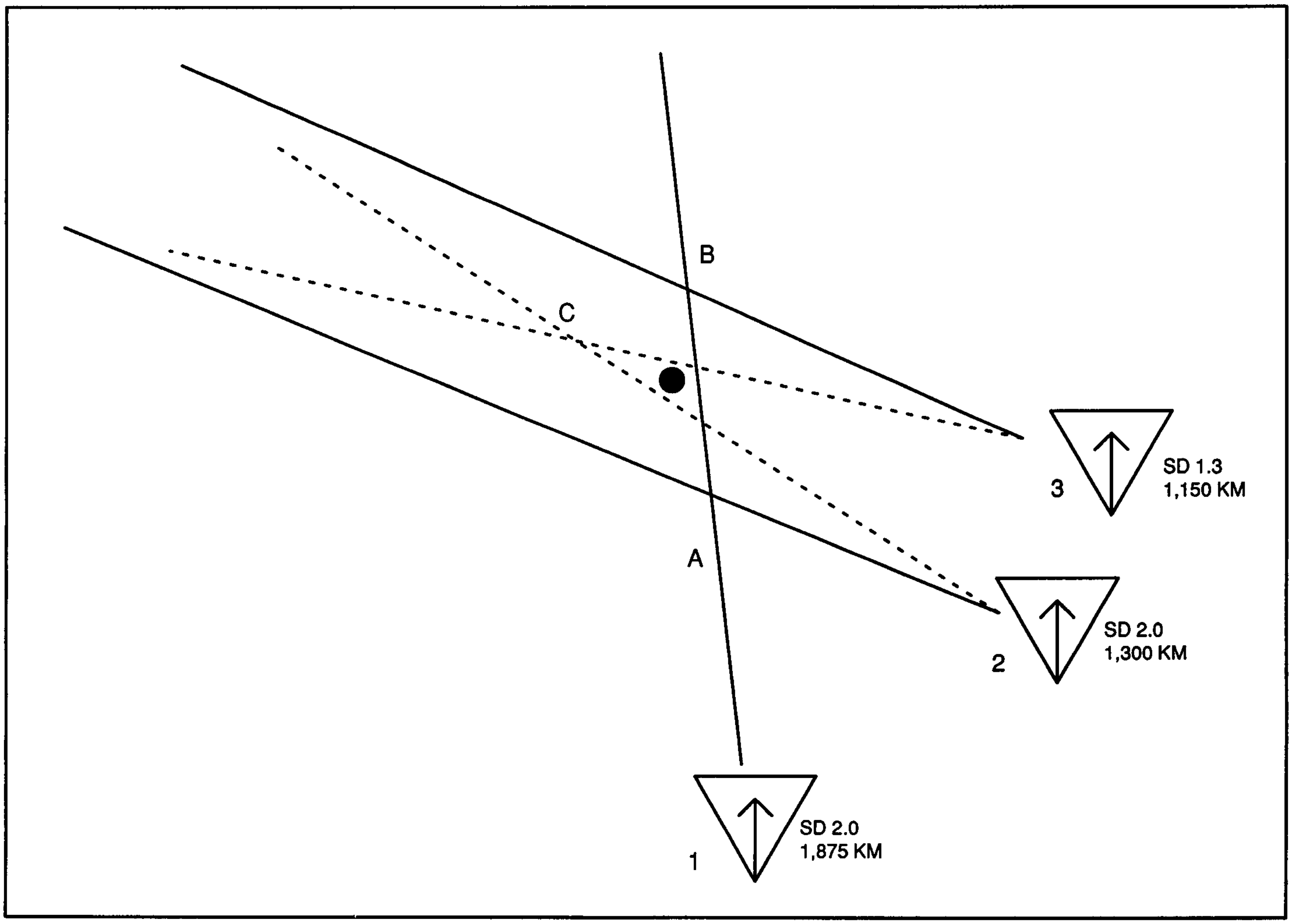


Figure 8-17. Using site SD to reduce triangle.

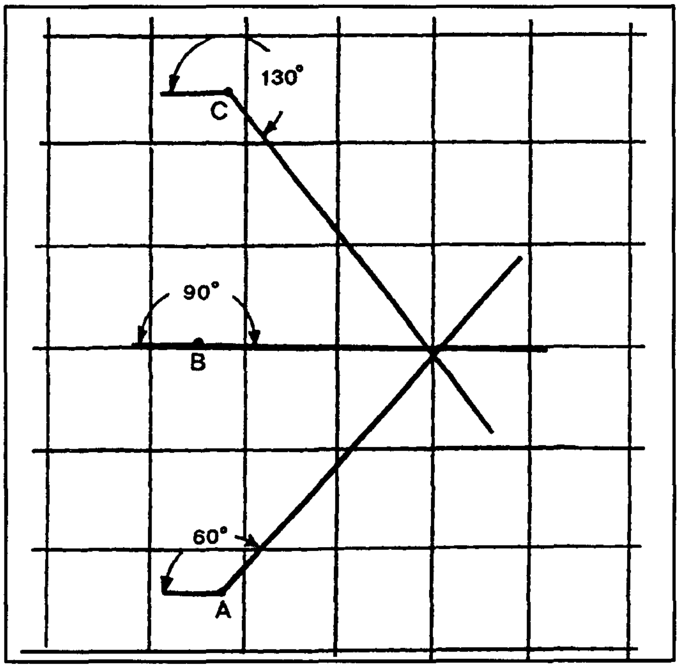


Figure 8-18. Perfect fix.

Error Triangle

This is the more usual type of three station bearing intersection found in DF analysis. It is sometimes called *triangulation* because the bearings intersect to form some type of triangle. There are many different methods employed to analyze a triangle to determine a fix point. These are—

- Bisection of the medians of a triangle.
- Bisection of the angles of a triangle.
- Steiner point.
- Visual inspection.
- Modified visual inspection.

NOTE: Strategic DF nets will most often use the visual inspection method. Prior to using this method, however, a reliable direction finding site data base must be established. The exceptions are those DF networks that use computers to do the plotting. As our dependence on automation grows, the computer assumes many of the duties once accomplished by a competent plotter. However equipment and power outages necessitate that every DF plotting facility train DF plotters how to manually plot using one of these methods.

Bisection of the Medians of a Triangle. To evaluate a fix using this method, the plotter simply draws a line from the midpoint of each median to the opposing angle. As illustrated in Figure 8-19, a line is plotted from the midpoint of line BC to angle A. Another line is plotted or drawn from the midpoint of line AC to angle B. The last line is drawn from the midpoint of line AB to angle C. The error triangle solution or probable target emitter location is the point where the three lines intersect or A'. This method should only be used on a case by case basis, where the immediacy of a report precludes the use of visual inspection or the construction of a steiner template.

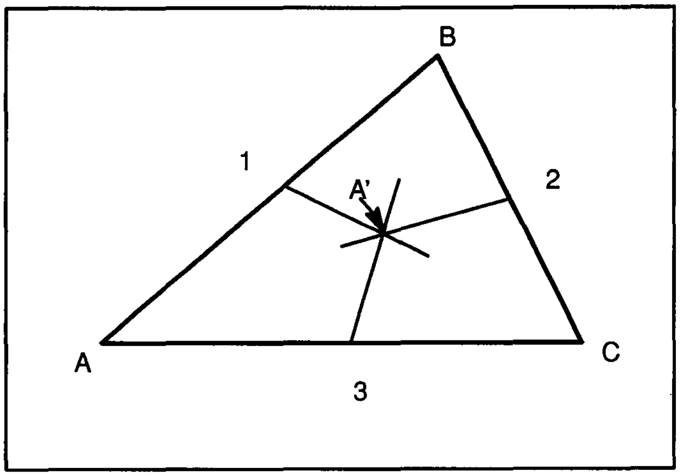


Figure 8-19. Bisecting the medians.

Bisection of the Angles of a Triangle. Determining the error triangle solution by bisecting the angles of the triangle is illustrated in Figure 8-20. The plotter must first determine the degree of each angle. Then each angle must be bisected. In Figure 8-20 the bisecting lines are drawn from angle A to point 1, from angle B to point 2, and from angle C to point 3. The solution (B') is the point where the three lines intersect. Conditions mentioned in the use of the bisecting the medians method must also be applied to the use of this method.

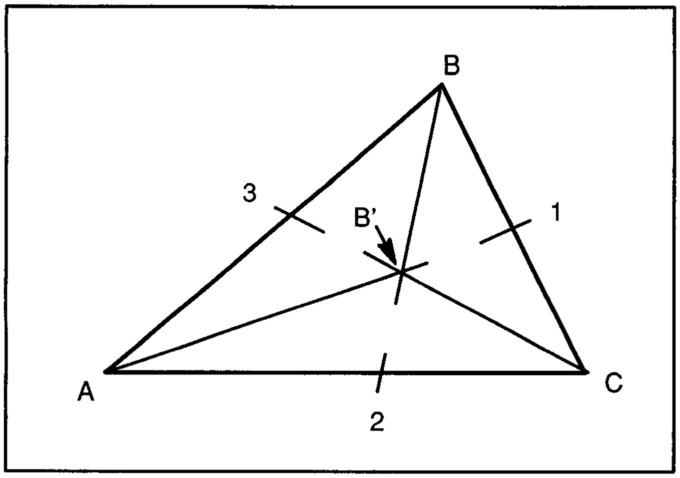


Figure 8-20. Bisecting the angles.

Steiner Point. The steiner point is the point at which the sum of its distances from the vertices of the triangle is at a minimum. The steiner point method is only used when speed and ease of analysis are required. The steiner point is located at the intersection of three lines drawn from the vertices of the triangle and making an angle of 120 degrees from each other. In an obtuse triangle having an angle of 120 degrees or greater, the vertex of that angle is the steiner point (Figure 8-21). For the remaining triangles having angles less than 120 degrees, the most practical method to place the steiner point is by constructing a simple equilateral template from transparent material.

To construct a template, draw a circle on a sheet of clear plastic. Ensure the circle is large enough in size to encircle your error triangles. Make a small hole in the exact center of the circle. Etch three lines from the center hole, exactly 120 degrees apart, to the outer circumference of the circle, thus trisecting the circle. Another method of template construction is to etch an appropriately sized equilateral triangle on a sheet of clear plastic. Then etch lines on the template from the vertices and punch a hole at the intersection. Either method of construction is equally accurate. When the template is completed, place the template over the error triangle formed after the three bearings are plotted. Rotate the template and align it until each of the 120 degree etched lines passes through each vertex of the triangle.

Mark the location (C') as illustrated in Figure 8-21. Place a pencil through the hole in the center of the template and mark this area. This is the steiner point or fix point. This mark is reported by grid coordinates as the most probable target emitter location.

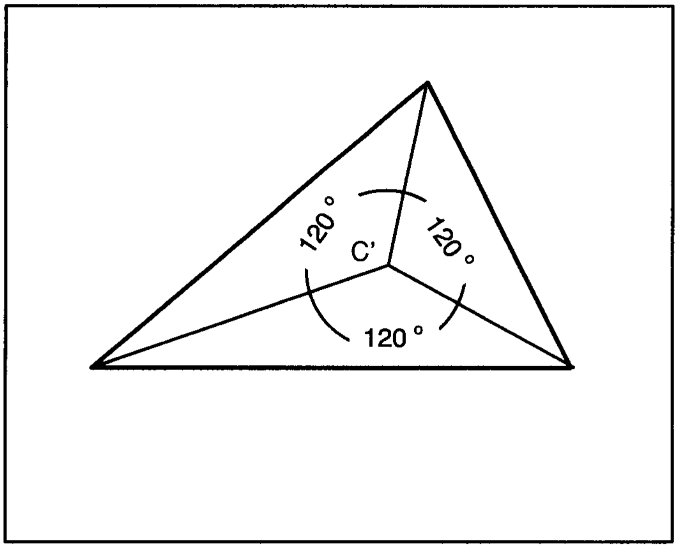


Figure 8-21. Steiner point.

Visual Inspection. Essentially, the visual inspection method involves analyzing all available data affecting the fix area and selecting a fix point based on all factors. The visual inspection method is the only analytical method approved by the United States Army Intelligence and Security Command (INSCOM) for use in strategic and EAC manual plotting analysis. This is the only method which applies an analysis of all five factors affecting DF capabilities. All of the factors may not be used in an analysis. The number of factors used depends on the unit mission, standing operating procedures (SOP), and equipment. Although this method consumes more time than other methods, it is the most accurate method available. The factors are as follows:

- Angles of bearing intersection. More consideration is given to bearings that intersect at or near right angles. This is because bearings at a 90 degree angle of intersection result in a smaller linear deviation than any other angle of intersection. As an immoderate example, we will use the range of strategic DF (Figure 8-22, page 8-12). A bearing intersection at a distance of about 375 nautical miles (Nm) from two DF sites with an angular deviation of about plus or minus 5 degrees from a right angle formed by bearings A and B represents about 52 nautical miles of linear deviation. At the same distance, an angular deviation of plus or minus 5 degrees from a 27 degree angle formed by bearings A1 and C represents about 149 nautical miles of linear deviation. In equilateral triangles, the fix point is placed in the center of the triangle.

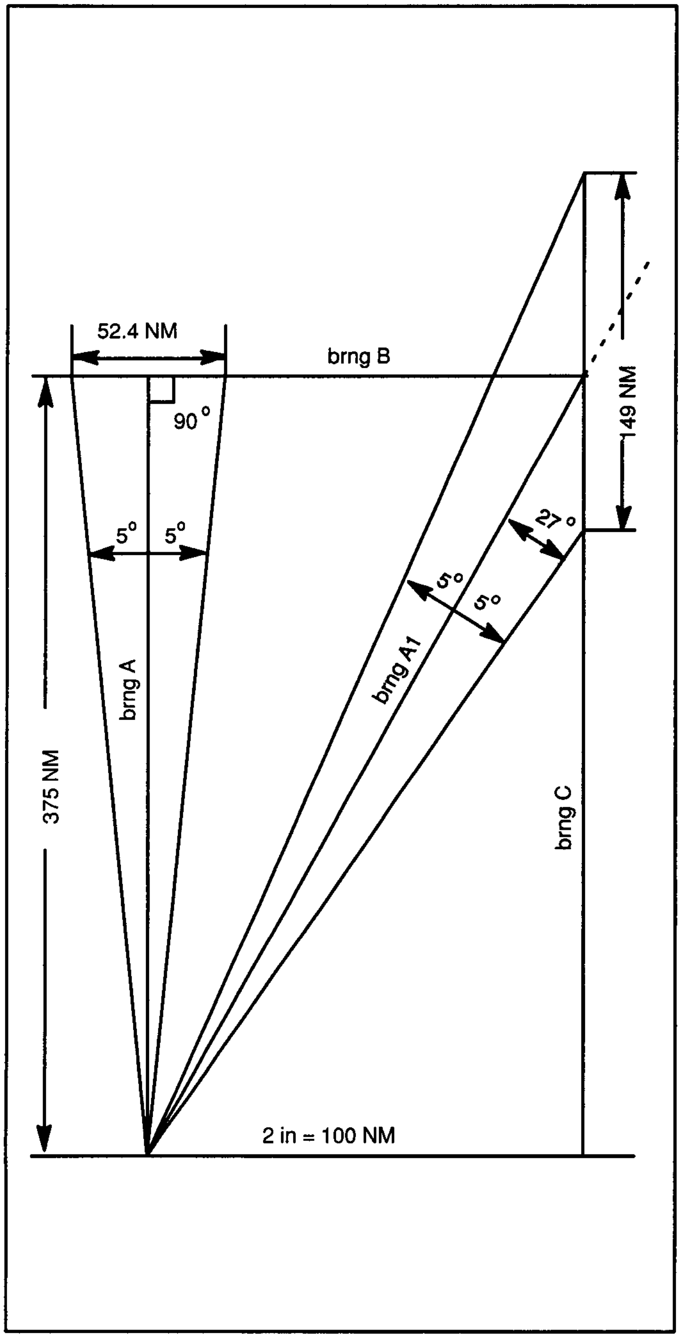


Figure 8-22. Bearing linear deviation.

Bearing classification. Some DF site operators measure the confidence factor (also known as degree of certainty or validity) in bearing accuracy. This measurement can be indicated by confirmed and doubtful tags on bearing returns. The confidence factor is produced by the DF operator. A confirmed bearing return indicates that the operator is sure the correct target has been acquired and the bearing is stable. A doubtful return signifies that either the operator is not sure it has been acquired or the bearing was not stable, or both. The DF plotter/analyst would trust a confirmed or high number bearing return more than a doubtful or low numbered bearing return.

Terrain. Since strategic DF systems measure the arrival angle of electromagnetic sky waves, terrain features have little effect on the measurement of the wave.

Known reliability of the DF site based upon past performance. Standard deviation measures the reliability of each DF site. Systematic error (SE) measures the accuracy of each DF site. Together, these statistics provide a qualitative measure of each DF site's potential (in comparison to the other DF sites) by reflecting the average accuracy of the site's DF results. A site with a low SD should normally be more reliable than a site with a high SD. Therefore, more consideration is generally given to sites with lower SDs. If a DF site usually has a low SE, and then suddenly the SE fluctuates considerably in either a positive or negative direction, the bearings from that site must be considered less reliable until the SE is stabilized.

Distance that a radio wave travels before reaching the DF site. The more distance between a DF site and the target, the less accurate the bearing returns are likely to be. In plotting and analysis, a greater confidence would be placed on sites closer to the target area.

Modified Visual Inspection. Due to the high mobility of most tactical DF systems, some of the factors used in the visual inspection method cannot be analyzed. In tactical analysis, angles of intersection, terrain, and bearing classification were the most important factors.

Therefore, the plotting method is modified to reflect tactical considerations. The modified visual inspection method is dependent on five factors as follows:

- **Angles of bearing intersection.** Naturally, tactical systems have less range, but the linear deviations are still appreciable.
- **Bearing classification.** In some tactical systems the bearing confidence factor (or bearing validity) may be measured by a numbering system (or LOB quality factor). The higher the quality factor, the better the bearing return. This factor is dependent on the amount of integration time of the DF system, the amount of time the target stays active, and the amount of bearing deviation in the bearing calcula–tions. The numbers may also indicate the number of samplings (shots) taken to obtain a mean bearing.
- **Terrain features between the DF site and the target, at the target area, and around the DF site.** With the exception of Quasi-Doppler and ARDF systems, terrain analysis is a very important factor when using tactical systems. Terrain features have a much more important role in tactical analysis. There are two parts to this analysis—the terrain between the DF site and the target and the terrain at the probable fix area.

NOTE: Terrain features between the DF site and the target, such as mountains and lakes, can deter the arrival angle of the bearing at the DF site. Therefore, the plotter/analyst would not place as much confidence in such a bearing return. Using the modified visual inspection method to produce the most probable target location, the DF plotter/analyst must examine the map in detail. When determining a fix point, the plotter/analyst must use common sense. The plotter/analyst must study the geographic qualities of the fix that have been produced. Should the indicated location be in the middle of a large lake, it is unlikely that the transmitter antenna has been accurately located. If the most probable fix location is atop an inaccessible crag or butte, the DF plotter/analyst must once again apply a little logic. The terrain features adjacent to the indicated location must again be examined. Transmitter antennas that usually serve a command or headquarters are likely to be located where such troop units would logically be stationed or encamped. Camps, trails, roads, water supplies, and similar terrain features must be evaluated when formulating the most probable fix location.

- **Site statistics.** Because of the tactical site's mobility, site statistics may not be available. With the exception of some EAC DF systems, site statistics are not a major factor in tactical DF plotting and analysis.
- **Distance.** Distance has a role in tactical plotting and analysis but, due to the short to medium range of targets, distance may not have as much of an affect as it does in strategic plotting and analysis.

Modified Techniques

Methods similar to those explained in the *three-station fix* section of this chapter can be used for fixes of four or more bearings. Only visual and modified visual inspection analysis implements the myriad of factors involved in the fix. All other methods are deficient in the area. For intersections resulting in an *error quadrilateral* (a polygon of four sides), the following methods could theoretically be used—

- Intersection of the two diagonals of the error quadrilateral.
- Intersection of the two diagonals of the quadrilateral formed by the steiner points of each of the four triangles of the error quadrilateral.
- Steiner point of the triangle formed by the three steiner points of the three triangles of the error quadrilateral.

Obviously, the preceding methods are time consuming and difficult. The visual and modified visual inspection method are easier, faster, and more accurate. The analytical technique is the same as described in the *three-station fix* section of this chapter. The following illustrations (Figures 8-23 through 8-34, pages 8-14 through 8-17) show the complete visual inspection process.

Visual Inspection Process

Angle of bearing intersection. In Figure 8-23, site 2 and site 3 bearings intersect at a near right angle. This factor would influence the analyst to place the target plot in that corner of the fix area.

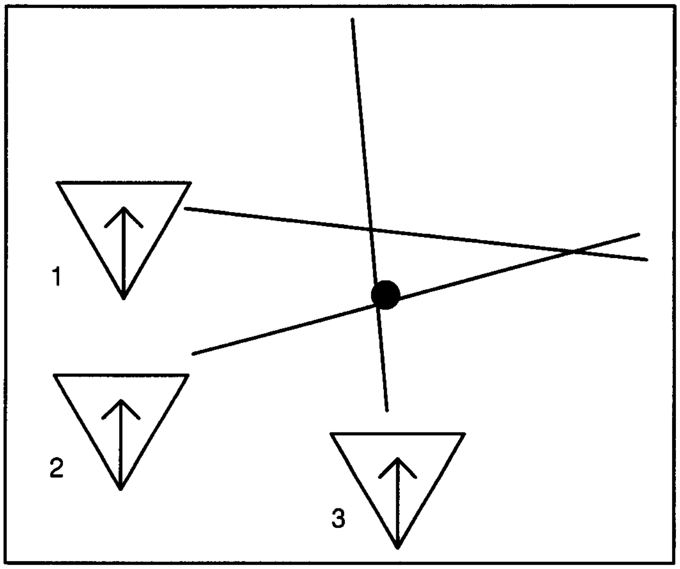


Figure 8-23. Angle of bearing intersection.

Distance factor. Distance is the influencing factor in Figure 8-24. Due to the distance of site 1 from the target, the analyst places more emphasis on the intersection of bearings from sites 2 and 3.

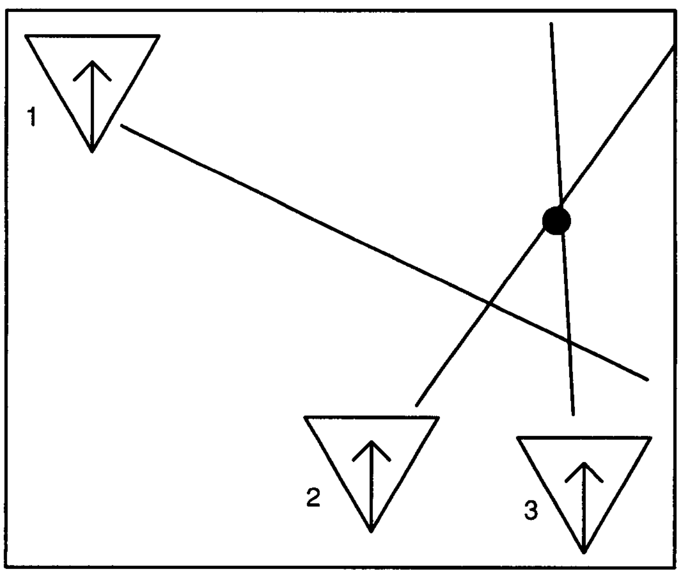


Figure 8-24. Distance factor.

Bearing classification. In Figure 8-25, site has a *doubtful* bearing return. The analyst would put more emphasis on the *certain* bearing returns of sites 2 and 3. The analyst places the fix point closer to the intersection of the certain bearing returns.

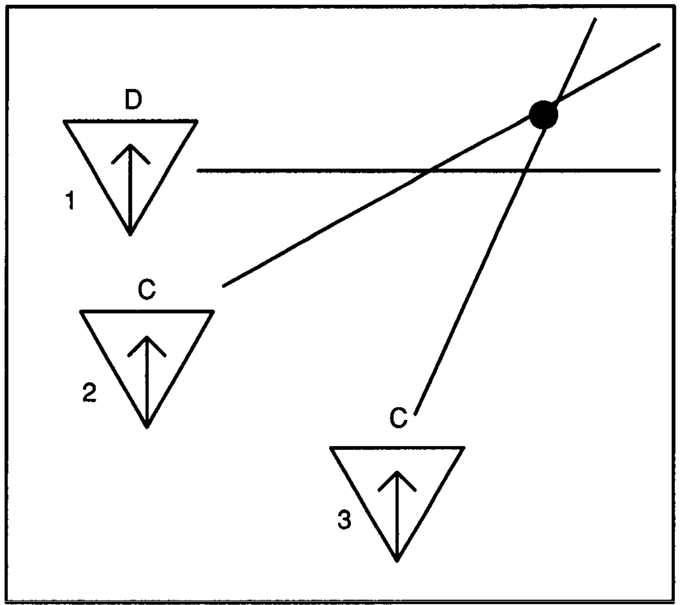


Figure 8-25. Bearing classification.

Equilateral triangle. When bearings form an equilateral triangle (as shown on Figure 8-26) and no other factors affect the analysis, the analyst would place the fix point in the exact center of the triangle.

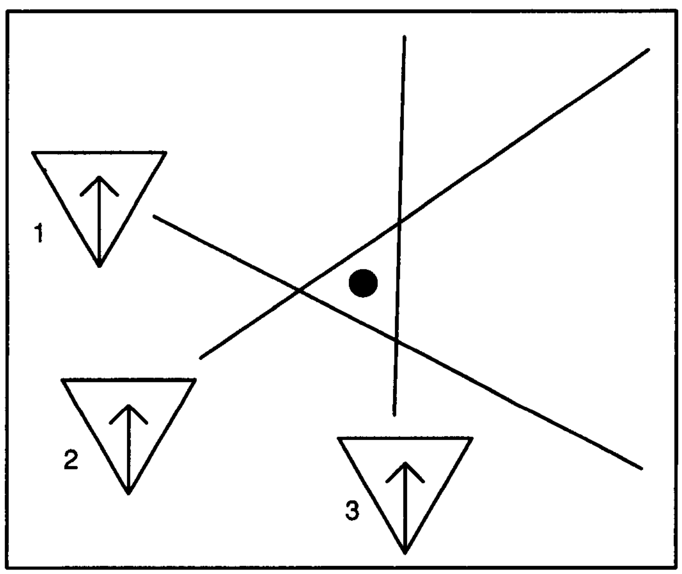


Figure 8-26. Equilateral triangle.

Site reliability. In Figure 8-27, site 3 has a high standard deviation. In this case, the analyst would place more emphasis on the bearing intersection of the lower SD sites (sites 1 and 2). The analyst would move the fix point to that part of the fix area.

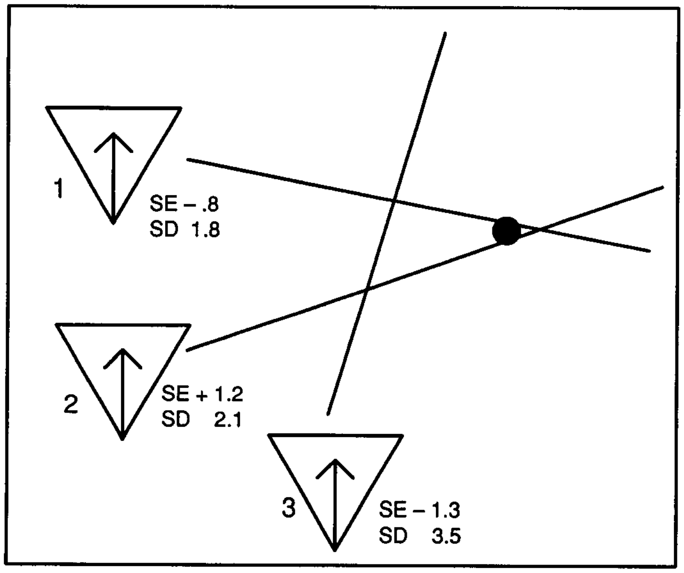


Figure 8-27. Site reliability.

Terrain. In Figure 8-28, a mountain interferes with the accuracy of site 1. Therefore, the analyst would place more emphasis on the intersection of bearings from sites 2 and 3, placing the fix point in that part of the fix area.

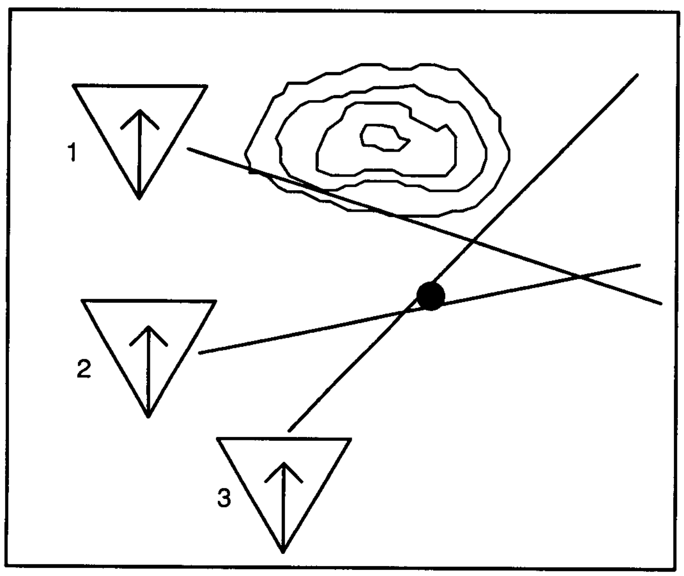


Figure 8-28. Terrain factor.

Up to this point, the fix analyst examples have been based on simple three site (station) triangulation with only one factor affecting analysis. In most DF nets, four or more sites are used to enhance productivity and accuracy. Numerous factors affecting analysis may be encountered in the selection of a single target's fix point within the probable fix area.

In example A (Figure 8-29), the best angle is formed by sites 2 and 4 (the most reliable sites). Site 1 has a doubtful bearing return and has a high SD. The bearing return from site 3 is probably not accurate because of the mountain. Considering these factors, the DF analyst would select a fix point closer to the bearing intersection of sites 2 and 4.

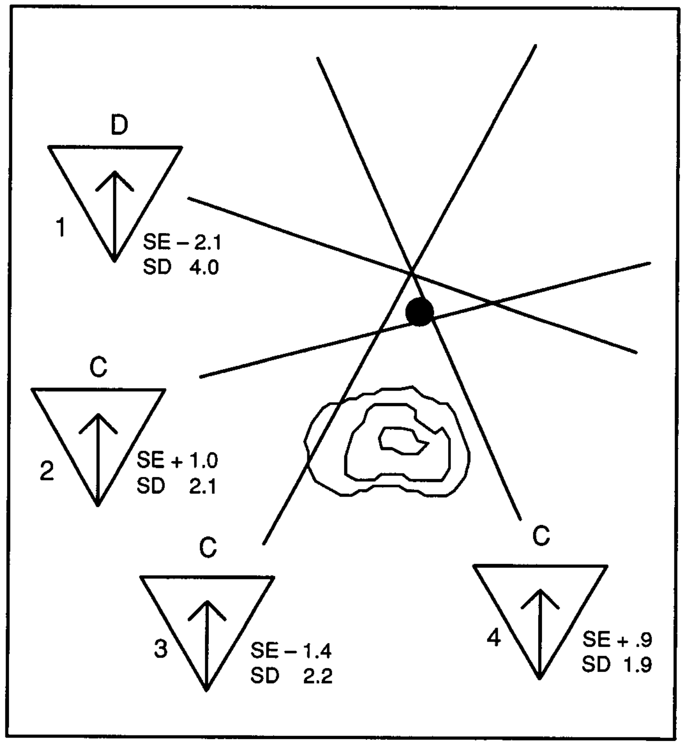


Figure 8-29. Example A.

In example B (Figure 8-30, page 8-16), although sites 1 and 3 form the best angle of intersection and are the most reliable sites, placing the fix point in that part of the fix area would put the target in the lake. Since the target is known to be a groundbased entity, the analyst would move the fix point onto the land.

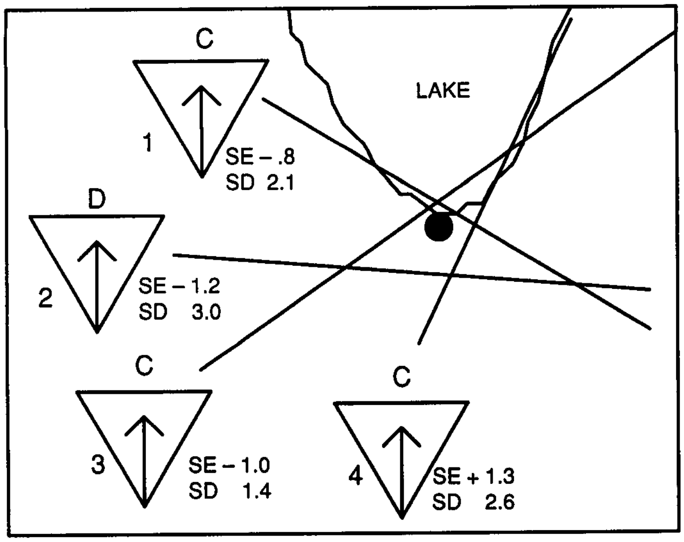


Figure 8-30. Example B.

In example C (Figure 8-31), site 2 has a doubtful bearing return and site 3 has a high SD. The best angle of bearing intersection is formed by sites 1 and 4. The analyst would place more emphasis on the best angle; plotting the target closer to the best angle of bearing intersection.

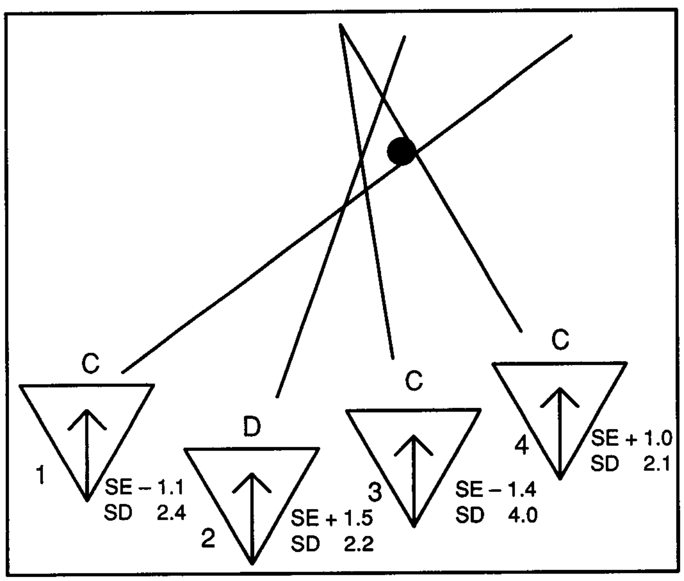


Figure 8-31. Example C.

In example D (Figure 8-32), site 4 has a doubtful bearing return and the highest SD. The analyst would rely more on the bearing returns of the other sites. Since sites 1 and 3 form the best angle of bearing intersection, the fix point would be plotted in that part of the fix area.

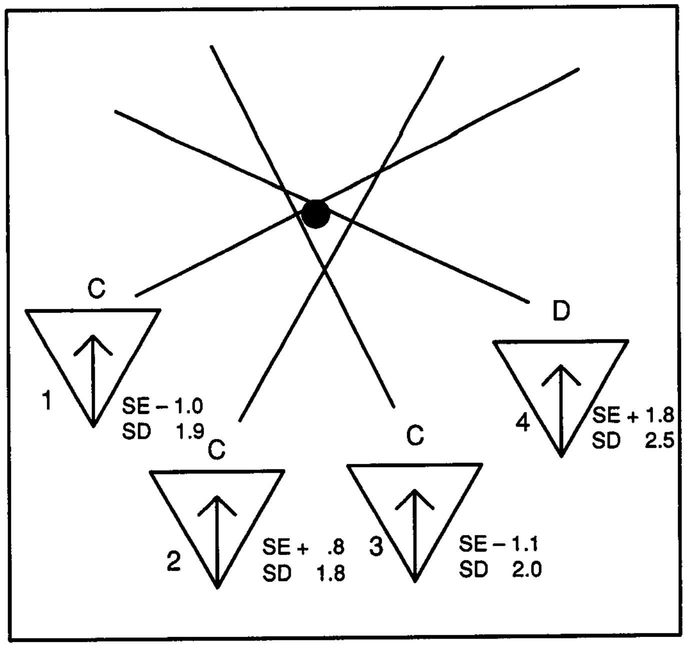


Figure 8-32. Example D.

In example E (Figure 8-33), site 1 has a doubtful bearing return and a high SD. Site 5 is near a mountain, which could cause some distortion. The best angle of bearing intersection is formed by the remaining three reliable sites. Since the analyst would not totally disregard the bearing returns from sites 1 and 5, **the** plot would be placed as illustrated to allow for their influence.

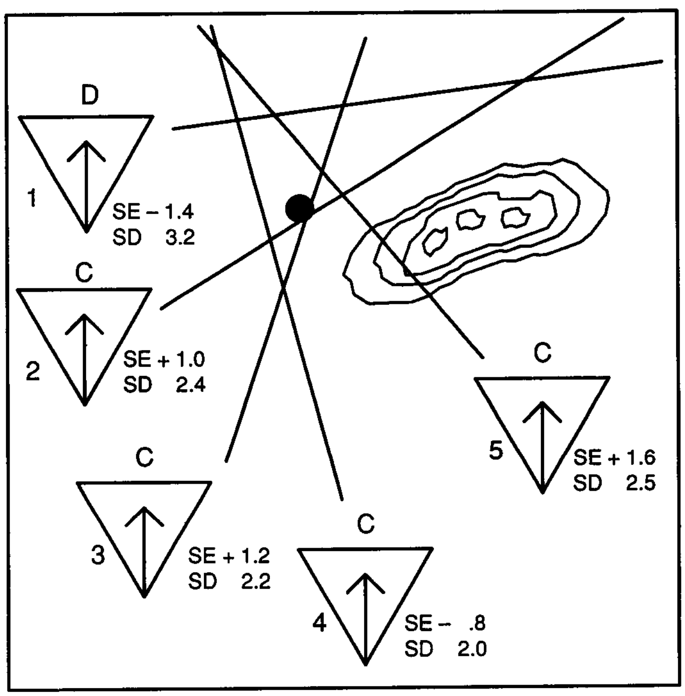


Figure 8-33. Example E.

In example F (Figure 8-34), the best angle of bearing intersection is formed by sites 2 and 4. Based on their SD, these sites are also the most reliable. Sites 1 and 3 have doubtful bearing returns. However, as indicated by the plotted bearing returns from the other sites, site 1 and site 3 bearings are within the area of probability and should be given some consideration. The analyst would shift the fix point from the best angle of intersection in order to include some influence from these sites.

In example G (Figure 8-35), a bow tie is created in the plot. The fix point is shifted toward the bearing generated by site 1 because of the reliability. Applying the secondary bearing (adding or subtracting twice the SD) to the configuration would move bearing 2 toward the area indicated by the other bearings. If twice the SD of site 2 had not entered the indicated fix region, the bearing would have been discarded as a wild bearing.

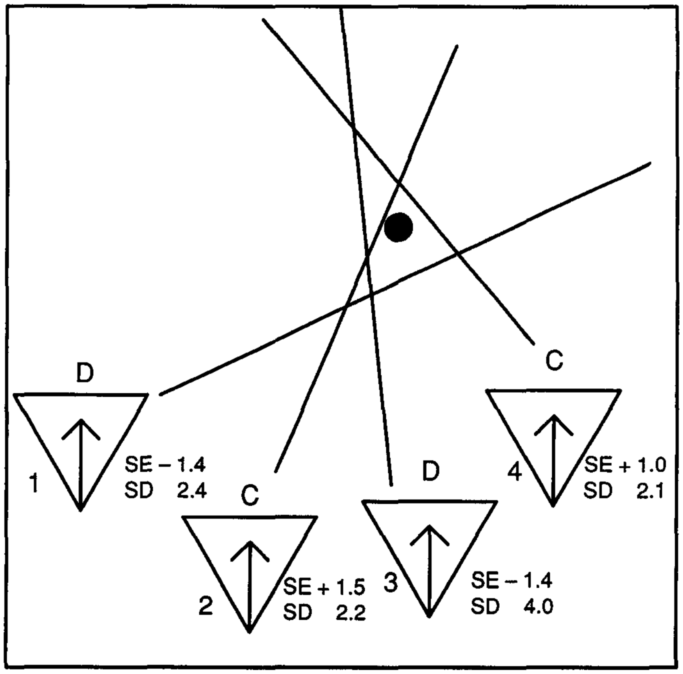


Figure 8-34. Example F.

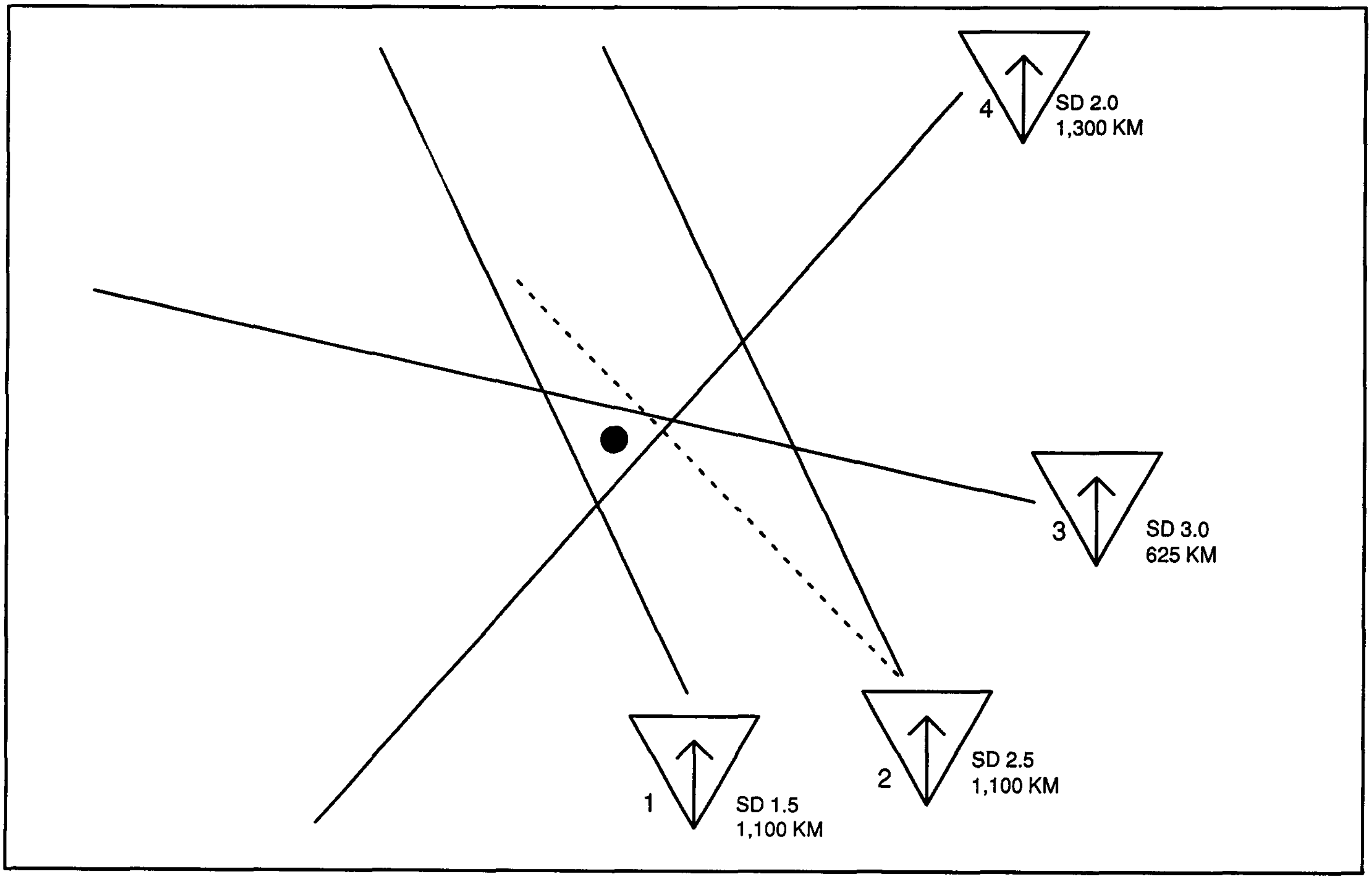


Figure 8-35. Example G.

Single Station Locator Plotting and Analysis

To plot the bearings from the SSL site, ordinary border coordinate or corrected compass rose (CCR) methods can be used (see Chapter 9). To plot the range from the SSL site, a series of semicircular or circular Range patterns can be placed equidistant from the SSL site that equate to various distances from the site (Figure 8-36). The increments of circular Ranges used depends on the operating distance of the particular SSL system.

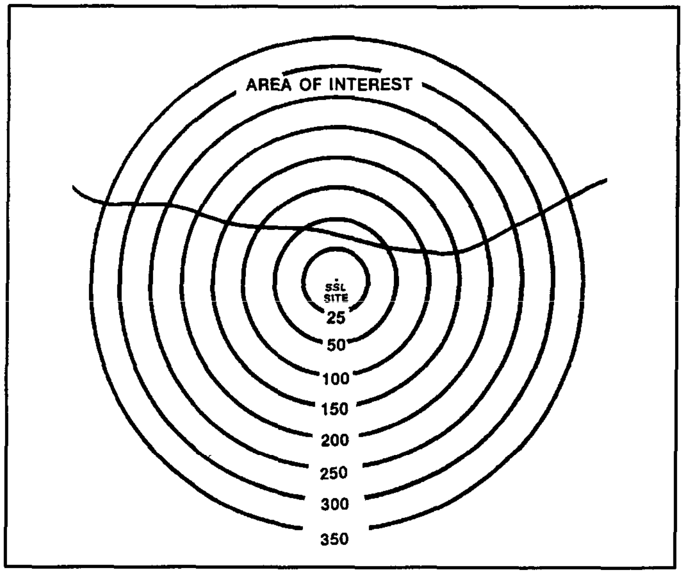


Figure 8-36. Circular Range pattern.

The analytical processing of SSL data is radically different from conventional methods of analysis. The SSL system relies on the propagation of skywaves by the ionosphere. Frequently, this reliance produces *multipath* solutions (Figure 8-37). This means the arriving electromagnetic waves have been propagated at two or more stratums (altitudes) of the ionosphere. The analyst must determine which elevation (or range) is correct. Due to this characteristic of the SSL system, it is important that the DF analyst maintain a close liaison with the traffic analysis (TA) element.

The actual fix point is determined by locating the range along the line of bearing (Figure 8-38). The coordinates are read in the same manner as previously discussed for tactical or strategic analysis.

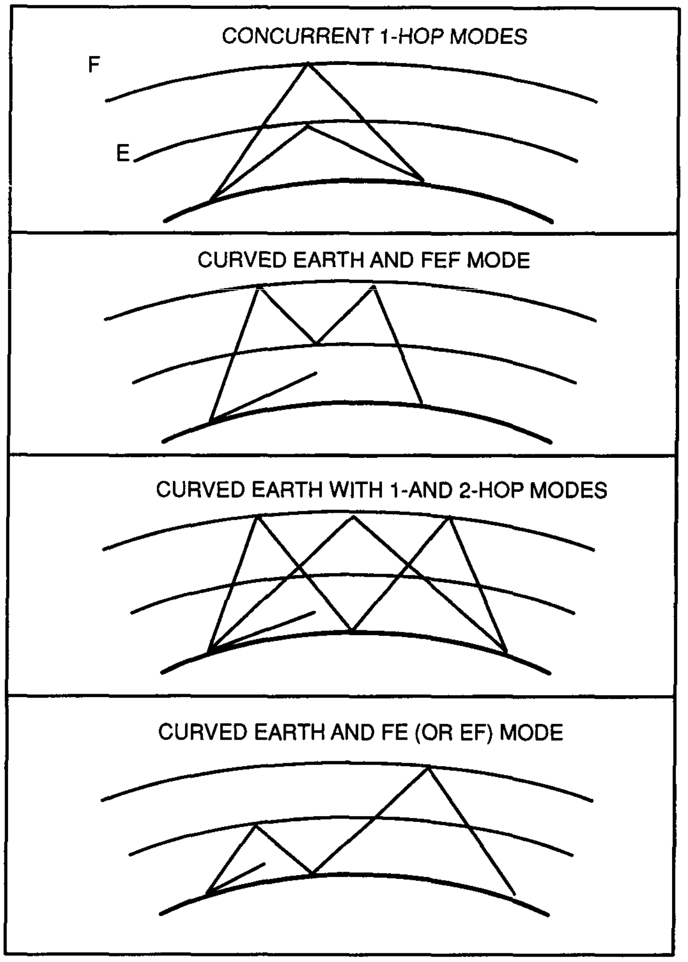


Figure 8-37. Alternative discrete mode propagation paths.

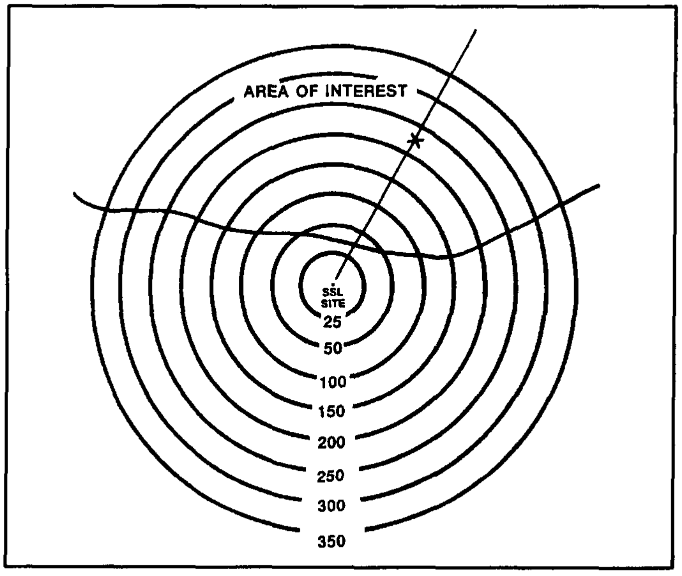


Figure 8-38. Fix point along the line of bearing.

Wild Bearings

In fixes using four or more station's bearings, it may become obvious to the plotter or analyst that a plot contains a *wild* bearing. This is a bearing that shows considerable deviation from the fix created by the other DF stations' bearings. For example, observe the plot illustrated in Figure 8-39. Obviously, site 2 is a wild bearing. In such a situation, the plotter or analyst can disregard the bearing completely when analyzing the fix area.

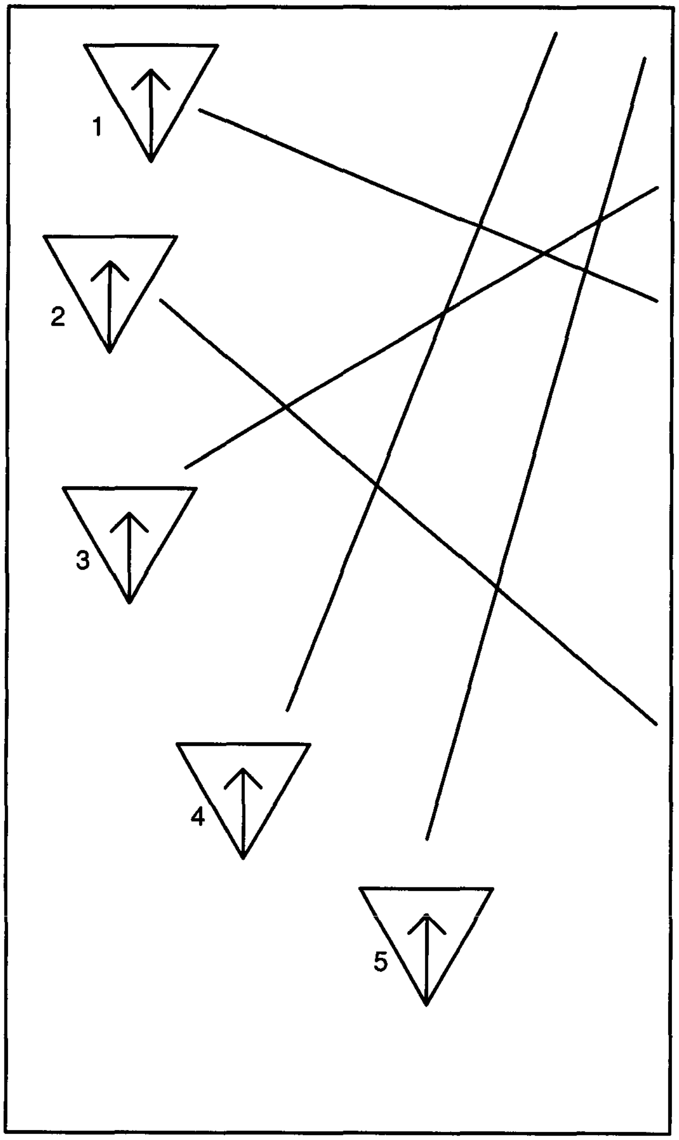


Figure 8-39. Wild bearing.

Radius Determination

A *fix radius* is a circular area wherein there is a high probability **of** a target's location. Radius determination can be used with all plotting or analysis methods and techniques with the exception of SSL plotting or analysis. In the past, the radius was determined by measuring from the fix point to the shortest line which joins the angles of intersection. Using this method, there is only a 25 percent probability that the target will be within the radius. Use of the *longest line* will increase the probability factor from 80 to 90 percent. However, such an enlarged radius diminishes the usefulness of the DF information to the consumer. Therefore, the radius shall include a majority but not all of the bearing intersections, thus providing a 45 to 60 percent probability. The procedure for applying a fix radius to your fix point on a tactical map is as follows:

- Place the length of a piece of paper (or measure with a ruler) along the fix point and the second farthest angle of the geometric figure (Figure 8-40, page 8-20).
- Mark on the paper (or measure) the locations of the fix point and the intersection at the second farthest angle (from the fix point).
- Place the paper (or ruler) on the scale at the bottom of the map to get the actual distance.

This distance, in a circular pattern centered at the fix point, is the fix radius or area of probability.

NOTE: The initial placement of the fix point (.) is the approximate center of geometric error area. The fix point is then moved considerably toward the 90 degree angle which is formed by sites 1 and 2. At their respective distances, sites 1 and 2 have the lowest SD of the three participating sites. The radius is computed to intersection B because a radius applied to B will encompass both intersections A and B, constituting a majority (two of three).

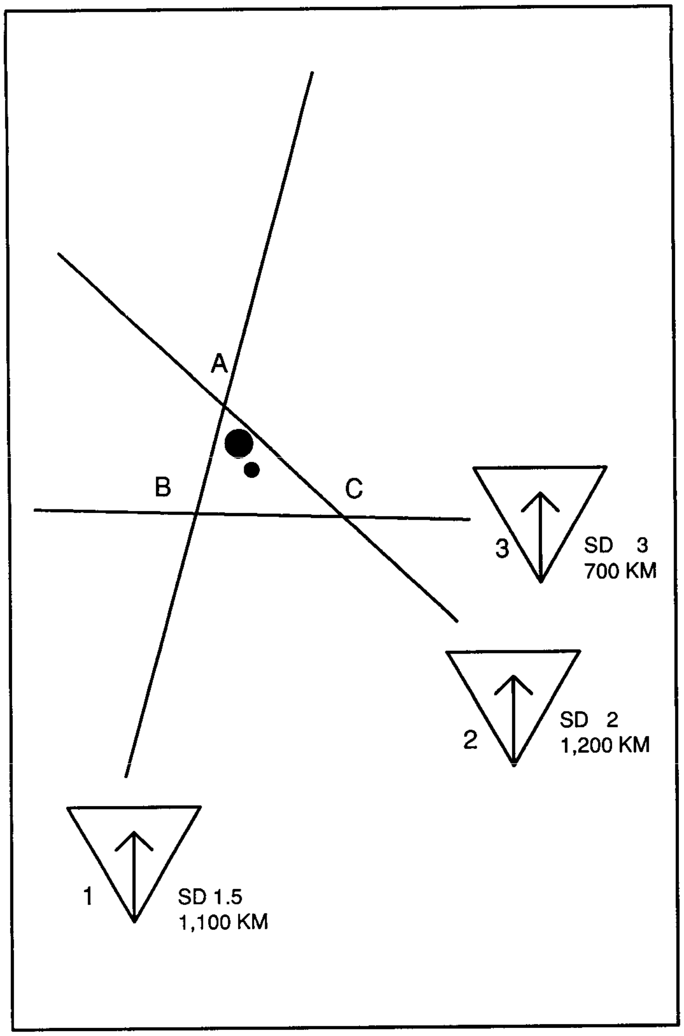


Figure 8-40. Initial placement of a fix.

The procedure for radius determination on gnomonic maps (strategic) is similar to that of UTM maps (tactical). The difference lies in the procedure for measuring the distance of the radius. Instead of equating the length on a tactical map to a given scale, the strategic analyst reads distance directly from the gnomonic map (Figure 8-41). Each square formed from the latitude and longitude lines on the map equates to a distance of 60 Nm. Inside of each square are three rows each of horizontally and vertically oriented dots that are parallel to the latitude and longitude lines. Each dot equates to 15 Nm distance. To determine radius, the length is measured in the same way as on a tactical map. The distance is calculated by placing the paper or ruler in the same area as the fix point, and using the dots inside the square to estimate distance. The paper should be oriented along lines of longitude or latitude, depending on the alignment of the radius measurement. For example, if the line from the fix point to the angle **of** intersection is oriented along an east-west direction, then the distance measurement will be made using the east-west longitudinal dots. If the analyst wishes to convert the radius to statute miles (Sm), the analyst simply multiplies the determined radius in Nm by 1.15.

Some tactical DF systems have computers which will produce a fix point (in UTM or geographic coordinates) and an elliptical error probability (EEP) or circular error probability (CEP) radius. CEP is a radius that encompasses one-half of the errors in a two-dimensional error distribution system. It does not analyze geometric configurations. EEP determines the length (major axis) and width (minor axis) of the geometric figure, producing an elliptical radius that is based on error calculations similar to those in CEP evaluations.

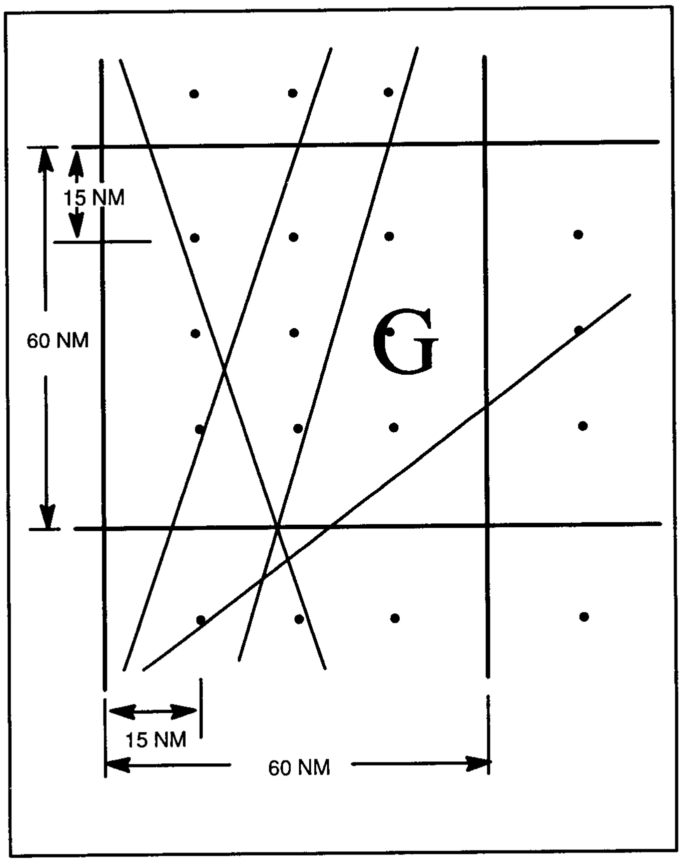


Figure 8-41. Reading distance from the gnomonic map.

Composite Plotting and Analysis

Composite plotting is the process of compiling and averaging bearings obtained over a period of time from a target entity. Composite plotting techniques enable the DF analyst to obtain a more accurate and refined fix area for an emitter under surveillance. The accuracy of the composite plot is also affected by the number of bearings available for averaging. The greater the number of bearings used in the computation, the more accurate the results. The term *composite plotting* is a misnomer. It is used to describe an arithmetic process. After the process is completed, the mean (averaged) bearings are plotted

To make a composite plot, past results are evaluated and **a** mean bearing is computed for each DF site.

The DF analyst first determines the mean bearing grouping (MBG) of the bearing from each DF site. The MBG is the close numeric grouping of bearings. Bearings are examined to determine if any bearing deviates plus or minus 10 degrees from all other bearings in the group. Figure 8-42 and 8-43 illustrate this process. In this example, 42 degrees is removed from the calculation because it has a 12 degree deviation from the outermost bearing limit.

SITE B
17°
17°
18°
42°
17°
17°
18°
19°
18°
20°
18°
20°
22°
27°
25°
30°
28°
20°

Figure 8-42. Compiled list of bearings.

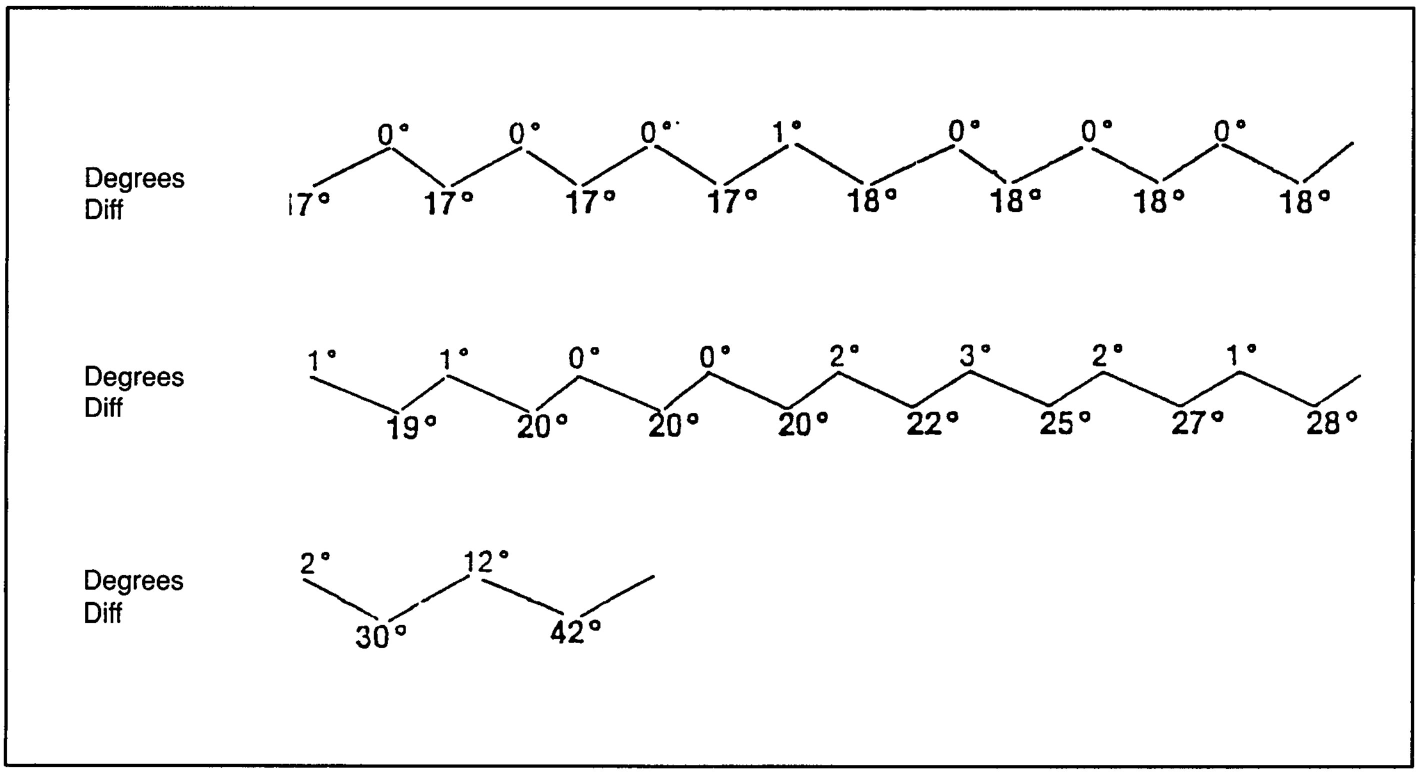


Figure 8-43. MBG determination.

After determining the MBG, the analyst eliminates from the list, any bearings which are more than 10 degrees beyond the upper and lower limits of the MBG. As illustrated in Figure 8-44, the limits of the adjusted MBG are 7 and 40 degrees. Any bearings less than 7 or more than 40 degrees are discarded.

17° (lower limit of MBG)	30° (upper limit of MBG)
–10°	+10°
7°	40°

Figure 8-44. Adjusted MBG.

The analyst now computes an initial mean bearing, as illustrated in Figure 8-45 and Figure 8-46. Studying these lists of bearings, the analyst will eliminate any bearings that are plus or minus 8 degrees from the initial mean bearing resulting in an intermediate mean bearing.

SITE B BEARINGS

17°
17°
18°
17°
17°
18°
19°
18°
\+ 20°
18°
20°
22°
27°
25°
30°
28°
20°

SUM 351°

Figure 8-45. Initial mean bearing.

351 (sum of bearings) ÷ 17 (number of bearings) = ?

```
     20.6     20.6 = 21° (rounded to nearest whole degree)
17) 351.0
    34
     11
      0
    110
    102
      8
```

Figure 8-46. Intermediate mean bearing.

The analyst then recomputes a final mean bearing from the remaining bearings. The analyst repeats the process of eliminating any bearings plus or minus 8 degrees from the intermediate mean bearing. A check of the computations in Figure 8-47 and a check of the list of bearings in Figure 8-48 shows that no bearing needs to be eliminated in the example. Therefore, the mean bearing of 20 degrees (Figure 8-49) is plotted as the final mean bearing for the example DF site. This process must be completed for each DF site.

21° (mean from previous step)	21° (mean from previous step)
–8°	+ 8°
13°	29°

Figure 8-47. Determining bearing limits.

SITE B BEARINGS

17°
17°
18°
17°
17°
18°
19°
18°
\+ 20°
18°
20°
22°
27°
25°
28°
20°

SUM 321°

Figure 8-48. Bearing list.

321 (sum of bearings) ÷ 16 (number of bearings) = ?

```
     20.0     20.0 = 20°
16) 321.0
    32
     01
      0
     10
      0
     10
```

Figure 8-49. Final mean bearing.

Computer Plotting and Analysis

Computerized plotting and analysis of direction finding results is also possible in most strategic DF networks and some tactical systems. The tactical systems with computerized plotting and analysis provide the battalion operations center with near real-time direction finding fix information on targets of interest. In either case, the outstation's bearings are entered into a computer which is programmed to compute the fix location in either geographic or grid coordinates. A fix or no fix of the target transmitter's antenna is quickly determined. The basis for all computer plotting is called the *least square method.*

FFIX is a computer program written in formula translation (FORTRAN) that will compute a fix point and an interval estimate or confidence ellipse when given DF bearings. FFIX is used in all Army strategic DF site computer fix programs. Any other computer programs must be specifically approved by NSA. The input for FFIX consists of the site locations (latitude and longitude) and the SD associated with the respective site. The objective of the algorithm is to identify the largest consistent or cohesive subset of bearings by rejecting wild bearings and then computing the fix point and confidence region for that subset of bearings. (For analytical purposes, the confidence region can be considered the same as a circular radius.) The fix point is computed by the method of maximum likelihood, which is equivalent in this case to the method of least squares.

Currently, the FFIX site look-up table has been programmed for up to 32 or 55 DF sites. The exact number of site inputs depends upon the individual station's requirements. The look-up table stores all pertinent parameters for each site. For the composite fix version, the bearing arrays have been increased to handle 1,000 bearings.

Included in the input data provided to the program are the SD statistics for each site. This SD should represent the SD for targets at a range of 1,000 Nm. This is important because FFIX weighs each site SD as a function of the distance between the site and the fix point. Therefore, if mutually acceptable results are desired among all users of the algorithm, then all users must use the same SD statistics. (It is the National Security Agency's intention to be in a position to provide the DF sites with the appropriate SD statistics.) If desired, such statistics can be obtained individually by developing site SD/distance curves (see Chapter 9).

Two methods of computer plotting are—

- Exhaustive method.
- Sequential method.

Exhaustive Method

The objective of the algorithm is to identify the largest consistent or cohesive subset of bearings and then compute the fix point and ellipse for that subset of data. In doing so, the program employs two methods for identifying the wild bearings to be rejected. The first approach, known as the *exhaustive* method, is used when 10 or less bearings are submitted. This approach begins by examining the consistency of all the submitted bearings. If all the bearings lack sufficient consistency to qualify as a fix, then the program examines all subsets of bearings until an acceptable fix is identified or until a lower limit on the bearing information is reached. In this approach, all combinations of bearings are exhaustively examined to identify the largest subset of consistent bearing information.

Sequential Method

The second approach, known as the *sequential* method, is used when a bearing set contains more than 10 bearings. It begins by examining the consistency of all the bearings. If all of the bearing responses lack sufficient consistency to qualify as a fix, then the bearing that is more inconsistent with the set of bearings is rejected. The remaining set of bearings is then reexamined in the same way to determine if they are sufficiently cohesive to qualify as a fix. In this manner, the most inconsistent and generally the wildest bearings are rejected sequentially. It is impossible to enter the exhaustive mode of bearing rejection once the program is in the sequential mode.

The same method of determining the confidence region is used in the exhaustive method and the sequential method. The determination of the confidence ellipse (similar to a circular radius) is based on the variance of the bearings to the fix point. (Bearing errors and target errors are treated as differentials.) Therefore, the computation of the confidence ellipse is independent of the reported bearings. Further information about the FFIX (and the FORTRAN program) may be obtained by writing to:

National Security Agency/Central Security Service
(NSACSS) ATTN: P38, DDI RNO
Fort George G. Meade, Maryland

ROTATING ROSE PLOTTING

Tactical direction finding equipment will be very mobile in a fluid combat situation. This necessitates an easily adaptable plotting method such as the rotating rose method. The rotating rose method of plotting enables the DF plotter to plot bearings which have been adjusted to true north using a grid map. The intersections of these bearings form a geometric figure on the map where the target emitter's antenna is most probably located. The rotating rose method is used exclusively for tactical plotting on a UTM 1:50,000 map sheet. It is easy to construct and takes a minimum of time and materials. The following materials (Figure 8-50) are needed to construct a rotating rose:

- A 1:50,000 universal transverse mercator map projection.
- Grease pencil.
- Thumbtack.
- Pencil.
- Straightedge.
- Sheet of paper.
- Scotch tape.
- Acetate sheet large enough to cover the map projection.
- True rose (Figure 8-51).

To prepare a UTM 1:50,000 map sheet for rotating rose plotting, first place the map on a smooth, flat surface. Tape it down on all four corners. Ensure the map is stretched as flat as possible, otherwise it could affect the accuracy of the plotting. Once the map is in place, note the latitude-longitude tick marks on each side of the map. They are spaced at 5 degree intervals. There are a total of eight tick marks (Figure 8-52).

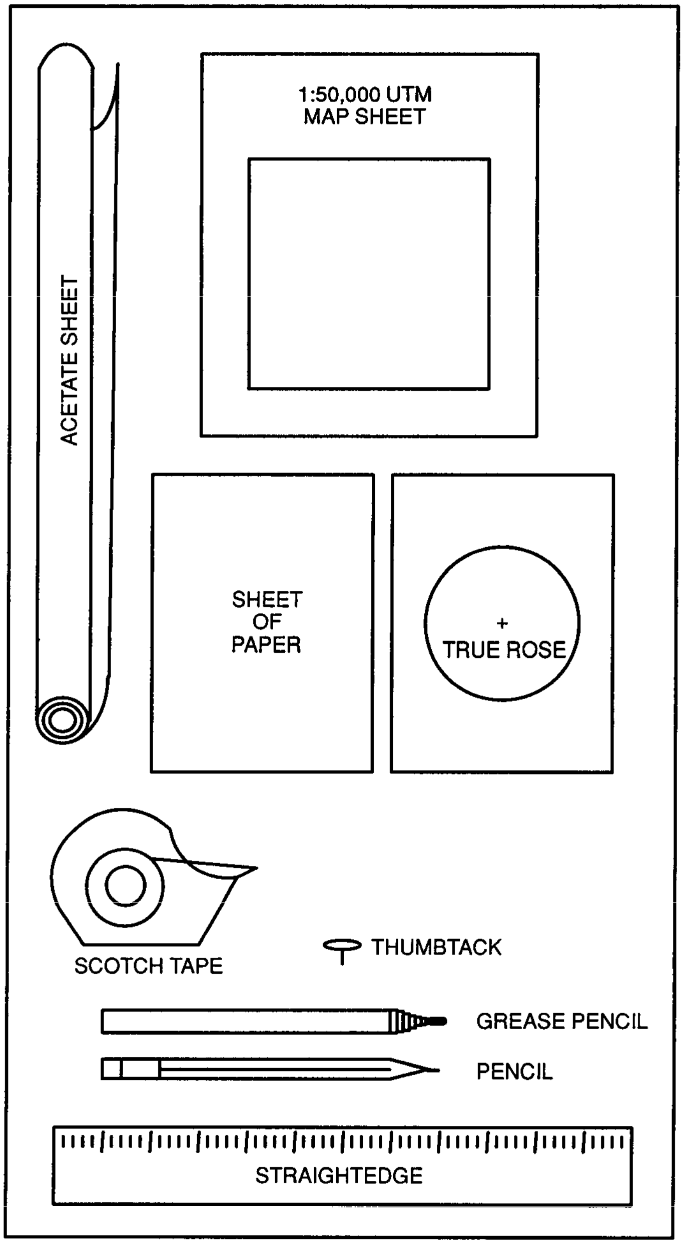


Figure 8-50. Materials needed to construct a rotating rose.

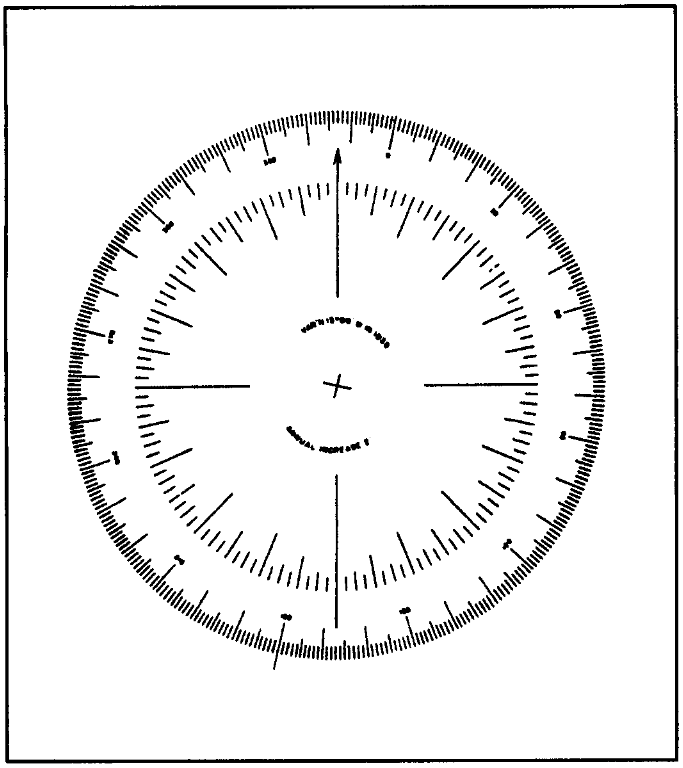


Figure 8-51. True rose.

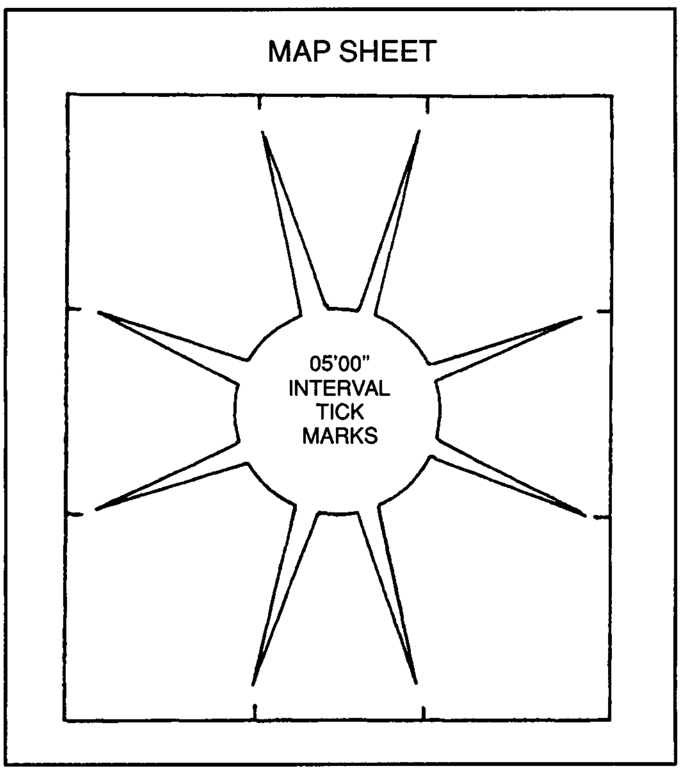


Figure 8-52. Tick marks.

Also note that on a 1:50,000 map sheet there are four cross tick marks-one in each quadrant (Figure 8-53).

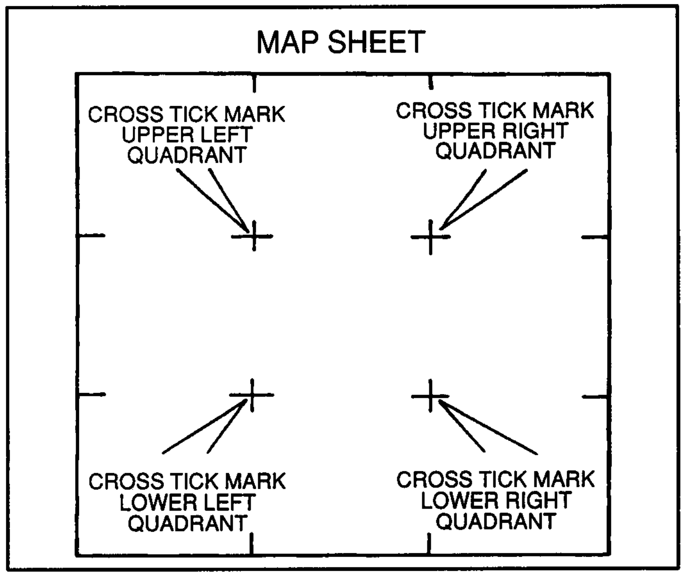


Figure 8-53. Locating the cross tick marks.

These lines indicate where the lines of latitude and longitude cross. Since all lines of longitude are true north-south lines, the latitude-longitude cross tick marks are used to establish a true north-south line on the map. The plotter must construct a true north-south line directly on the map sheet. To do this, use the following steps:

STEP 1. Locate the bottom left-hand tick mark on the map (Figure 8-54).

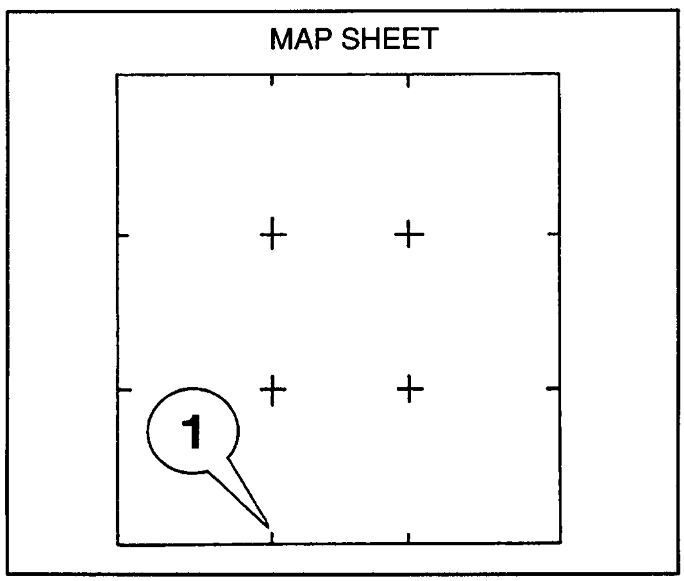


Figure 8-54. Locating tick marks.

STEP 2. Locate the exact center of the cross tick mark in the lower right quadrant of your map. Using a straightedge, draw a connecting diagonal line (Figure 8-55).

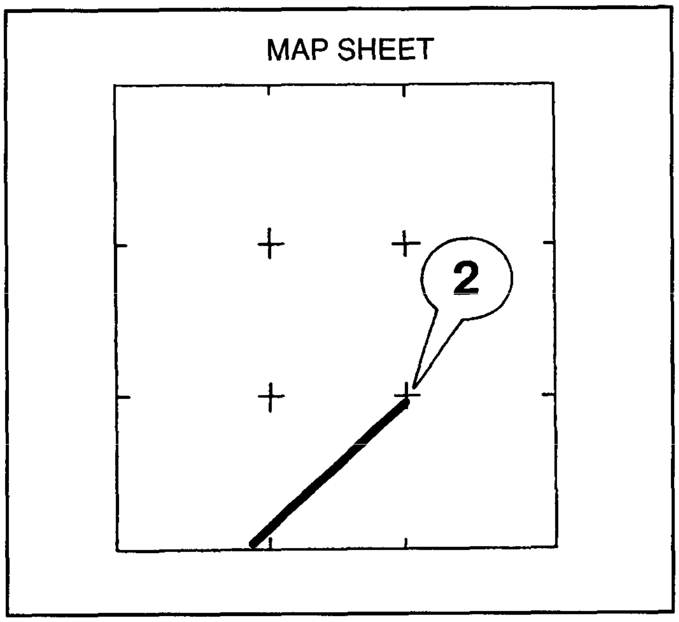


Figure 8-55. Connecting diagonal line.

STEP 3. Locate the exact center of the cross tick mark in the upper left quadrant. Draw a diagonal line connecting it with the center of the cross tick mark in the lower right quadrant (Figure 8-56).

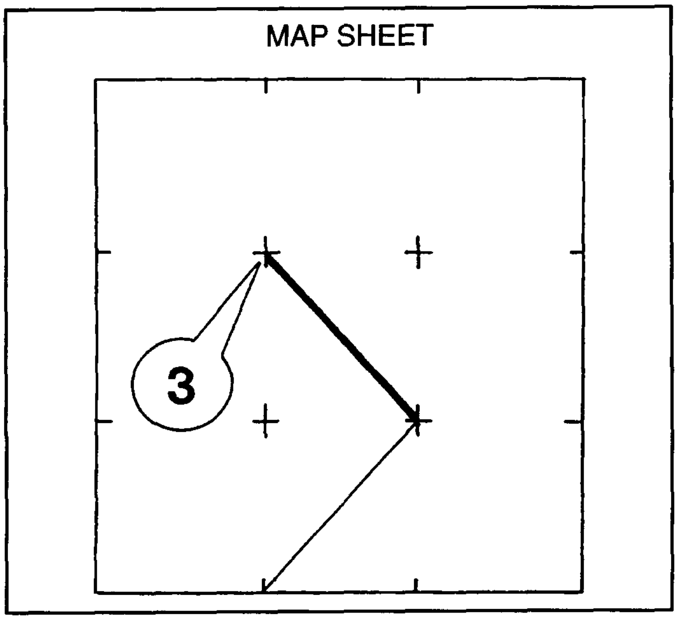


Figure 8-56. Connecting tick marks.

STEP 4. Locate the tick mark in the top right quadrant. Using the straightedge, connect it with the center of the cross tick mark in the upper left quadrant (Figure 8-57). The result is a zigzag pattern which extends the full length of the map.

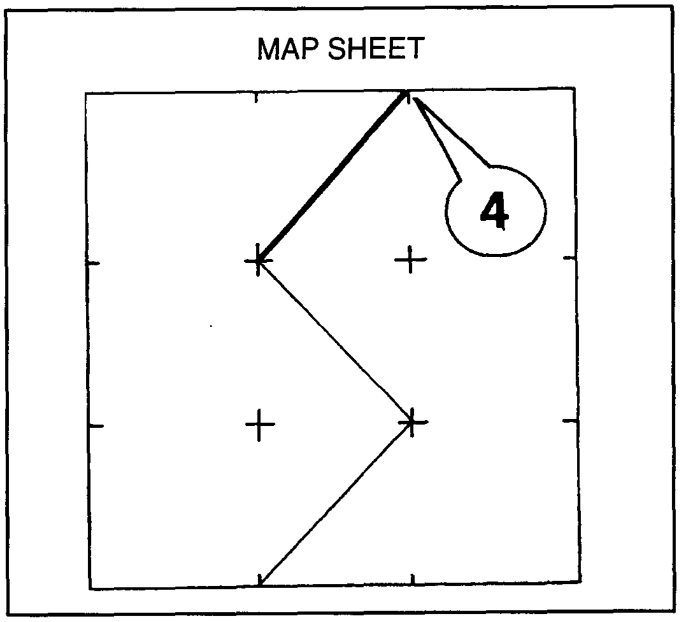


Figure 8-57. Zigzag pattern.

STEP 5. Now repeat the process in reverse. When completed, your map sheet should look the same as Figure 8-58.

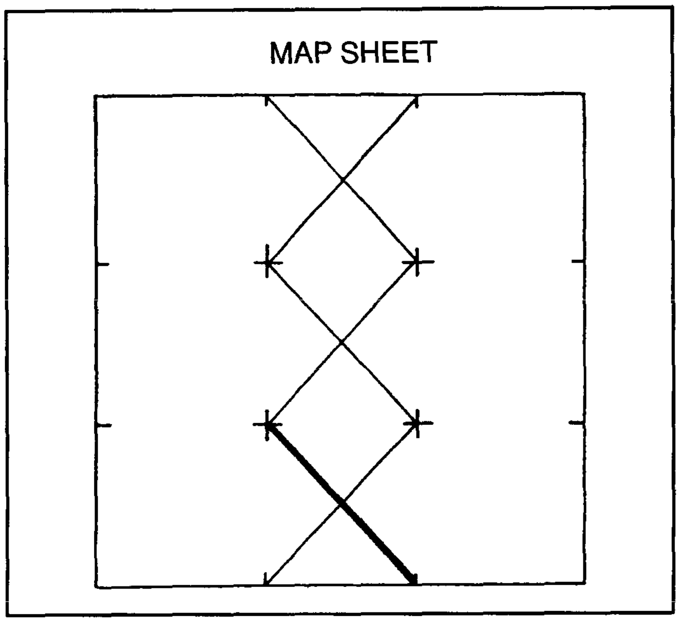


Figure 8-58. Double zigzag pattern.

STEP 6. Align the center points of the Xs with a straightedge and draw a line the complete length of the map (Figure 8-59). This is your true north-south line. Ensure this line is well defined on the map sheet. It will be used for reference when plotting.

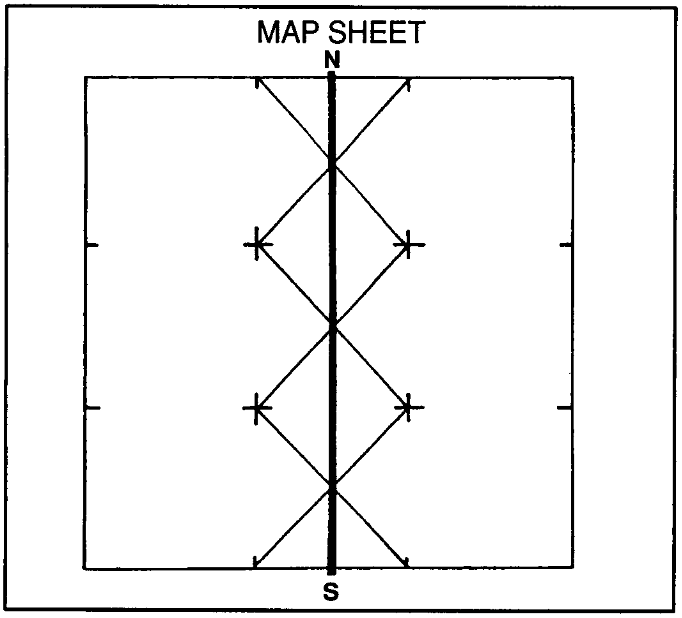


Figure 8-59. True north-south line.

The next step in rotating rose plotting is to locate the DF sites on the map (Figure 8-60). Ensure each site is pinpointed according to it's grid coordinates. Use the following steps:

STEP 1. Identify each site with a letter designation such as site A or site B (Figure 8-60). Use different colored pencils for ease in each site identification.

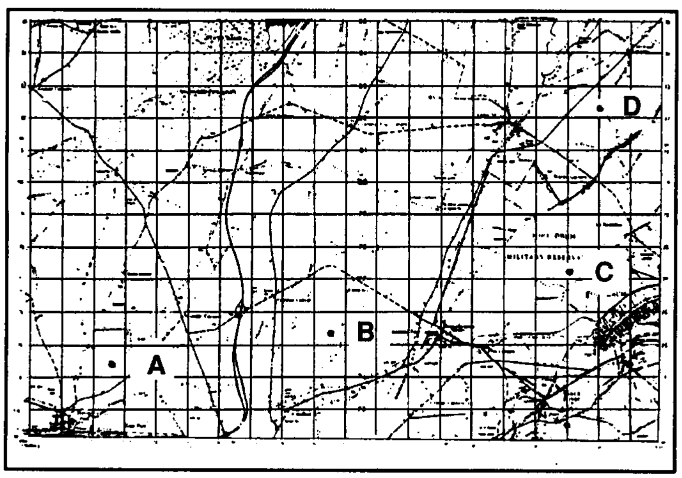


Figure 8-60. Placing DF sites on the map.

STEP 2. Once the sites have been clearly located and marked on your map sheet, lay a piece of acetate over the map (Figure 8-61).

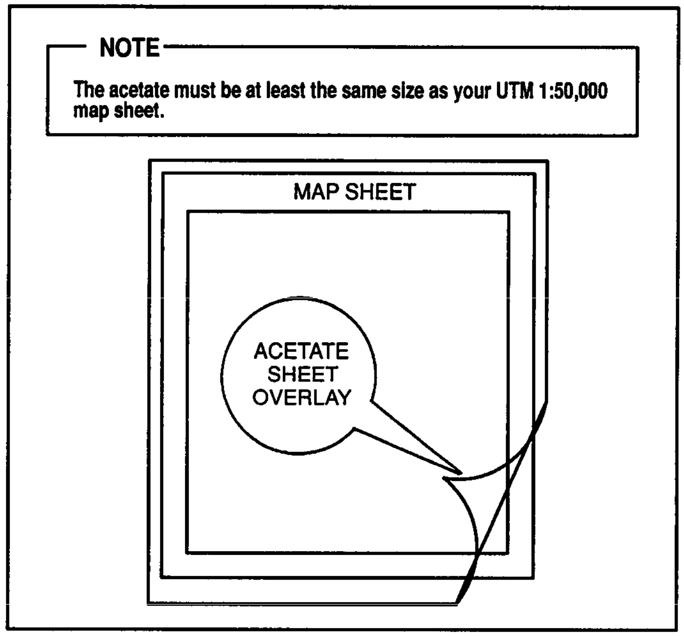


Figure 8-61. Placing acetate over the map.

STEP 3. Place the true rose in the center of your map and tape securely to the acetate (Figure 8-62).

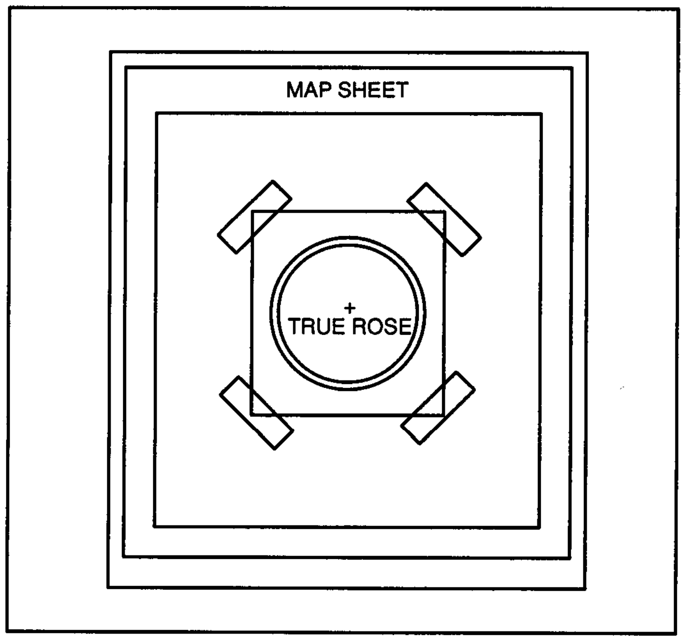


Figure 8-62. Placing the true rose on the map.

STEP 4. Align the 0/360 degree and 180 degree marks of the true rose with the center true north-south line previously drawn on the map (Figure 8-63).

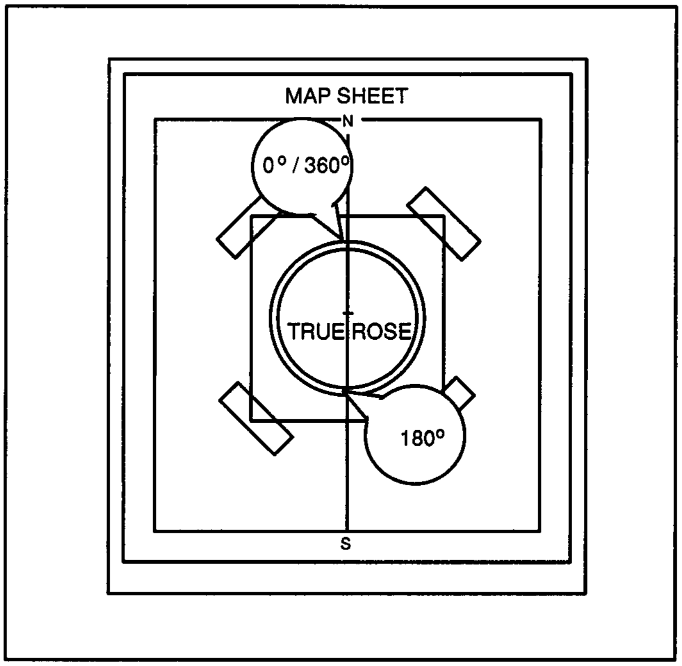


Figure 8-63. Aligning the true rose.

STEP 5. Push a thumbtack through the exact center of the true rose (Figure 8-64). The true rose should now be securely pinned to the map—but free to rotate.

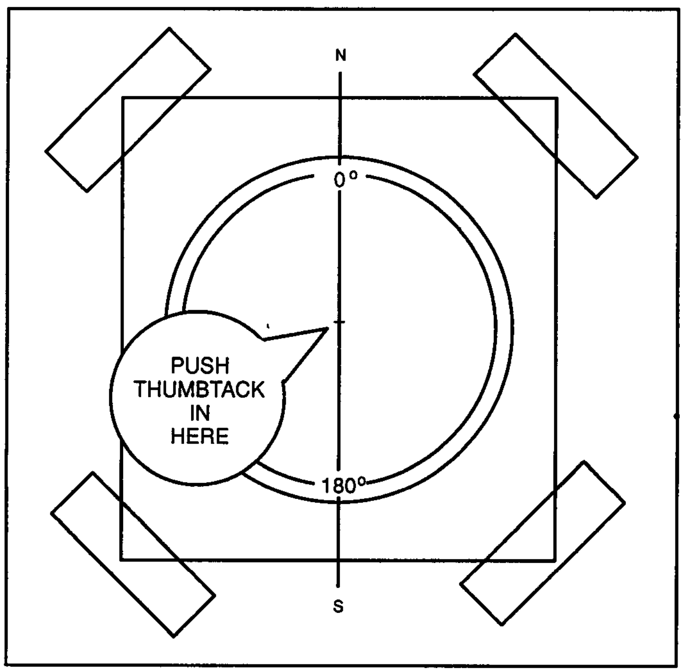


Figure 8-64. Thumbtack placement.

STEP 6. Transfer the locations onto the acetate. However, first ensure the 0/360 degree and 180 degree marks of the true rose are aligned with the true north-south line. Then mark the position of each previously located direction finding site onto the acetate overlay with your grease pencil. To differentiate between the sites marked on your map and those marked on the acetate, circle the letter designations on the acetate (Figure 8-65). The map is now ready to begin plotting.

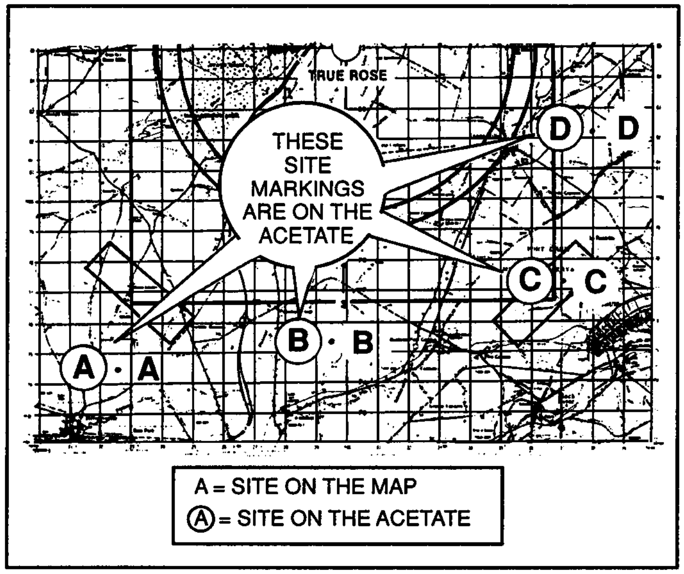


Figure 8-65. Placing DF sites onto the acetate.

To demonstrate how the rotating rose plotting is performed, the following illustrations are provided. Each plotting step is illustrated and is applicable to particular tactical situations. The method remains the same. The difference will be in the—

- Map used.
- Total number of DF sites.
- Site locations.
- Reported bearings.

Assuming that the sites are now clearly marked on the map and acetate as illustrated in Figure 8-65, we will plot the following bearings:

- SITE A - 020°.
- SITE B - 340°.
- SITE C - 290°.
- SITE D - 265°.

Initially, we will start with bearing A to illustrate a step-by-step plotting procedure. The reported bearing is 020 degrees. The following steps are used.

STEP 1. Rotate the compass rose until 020 degrees is aligned with the true north-south line on the map (Figure 8-66).

NOTE

When you do your rotating rose plotting the entire acetate sheet will rotate with the compass rose—they are attached.

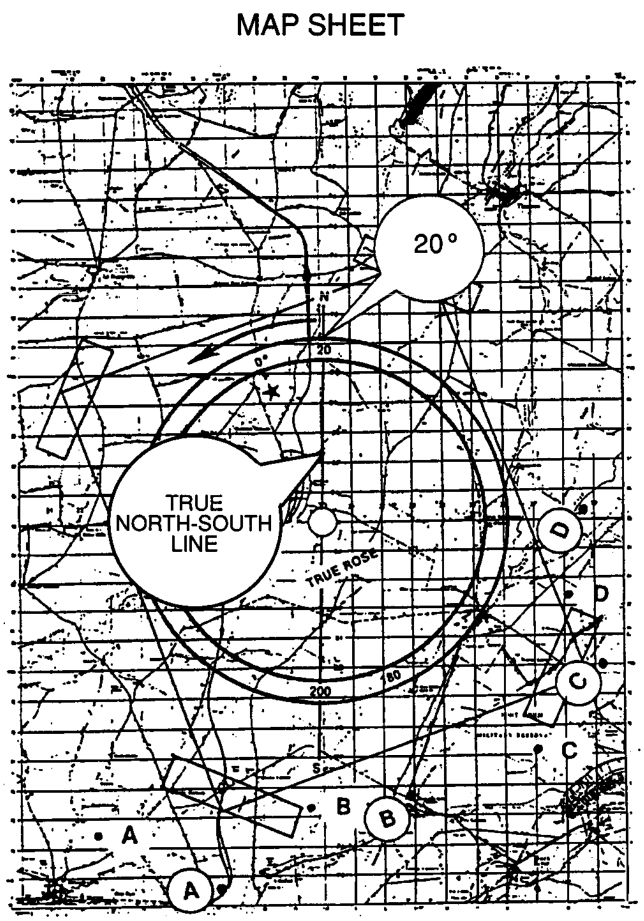


Figure 8-66. Plotting site A's bearing.

STEP 2. Take a sheet of paper and align the long edge with the center true north-south line and the bottom edge with site A on the acetate (Figure 8-67). Make a small tick mark on the bottom edge of the sheet of paper at the point where site A is aligned.

NOTE

When performing rotating rose plotting you will now be working with the site locations made on the acetate rather than those made directly on the map.

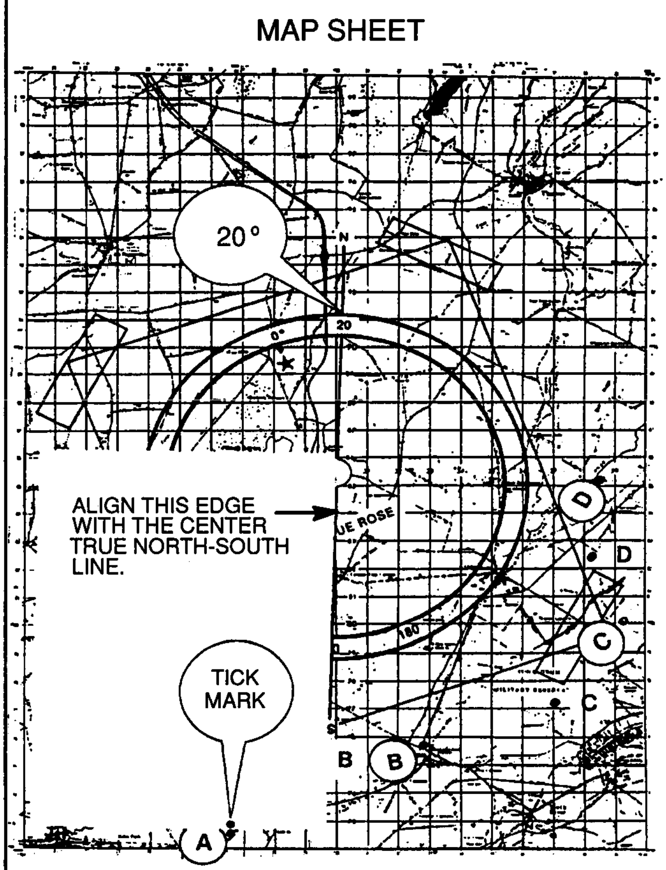


Figure 8-67. Aligning paper with center true north-south line and site A.

STEP 3. Slide the sheet of paper up along the true north-south line until the top edge is aligned with the tip of your map sheet. Ensure the long edge and the center true north-south line are as previously aligned. Place a tick mark on the acetate directly below the tick mark on the bottom edge of the paper (Figure 8-68). This was the tick mark that identified the location of site A.

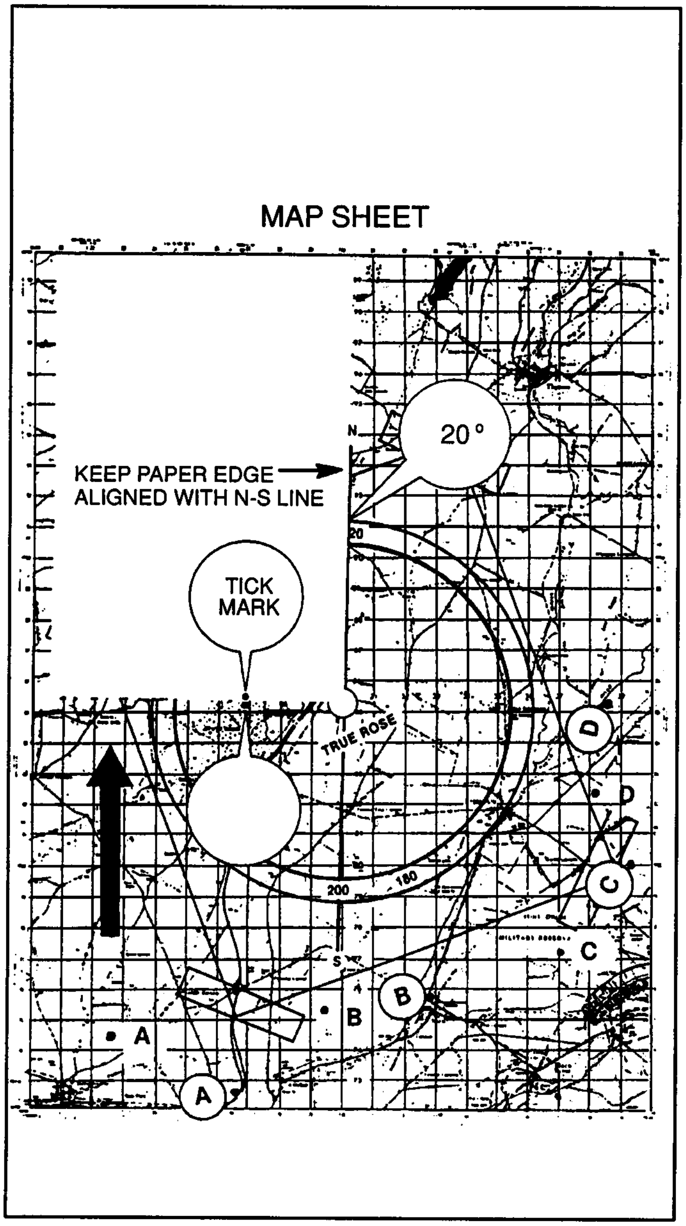


Figure 8-68. Tick mark placement.

STEP 4. Using a straightedge, align the tick mark just made with site A on the acetate. Using a grease pencil, connect these points and extend the line as far as possible (Figure 8-69).

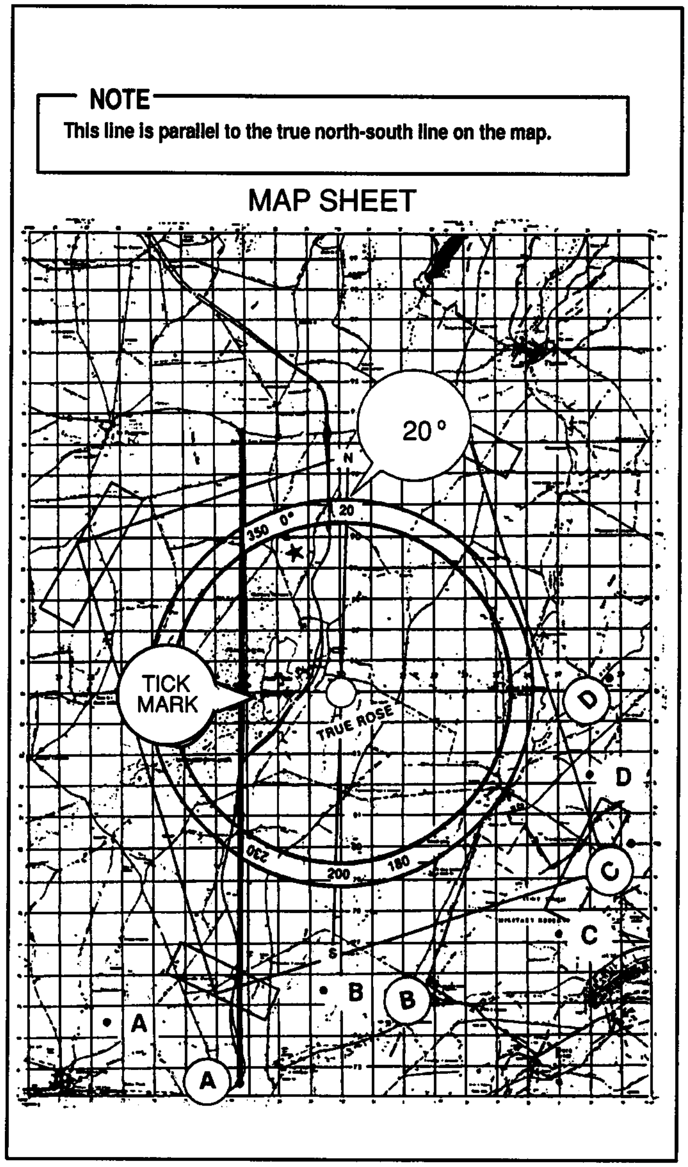


Figure 8-69. Line drawn between site A and tick mark.

STEP 5. Plot the 340 degree bearing for site B. Rotate the true rose to align the 340 degrees with the center true north-south line (Figure 8-70).

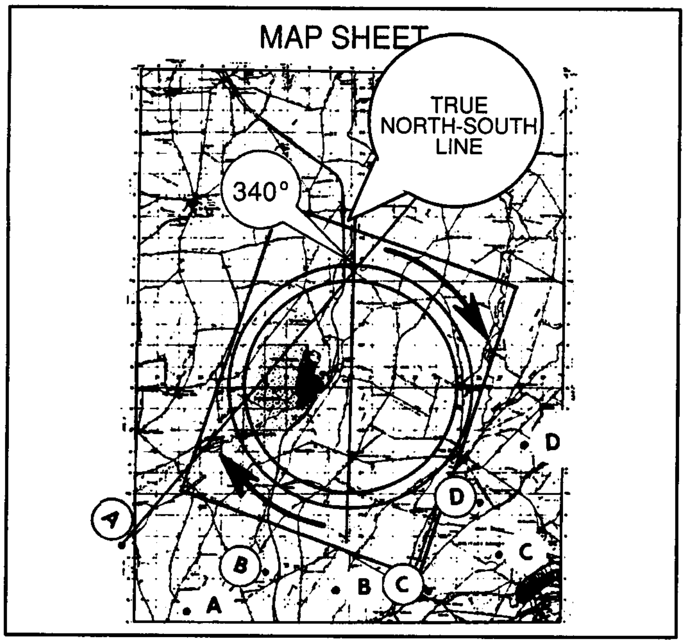


Figure 8-70. Plotting site B's bearing.

STEP 6. Align the long edge of the paper with the true north-south line and the bottom edge of the paper with site B on the acetate. As illustrated in Figure 8-71, make a tick mark on the paper at the point where site B is aligned.

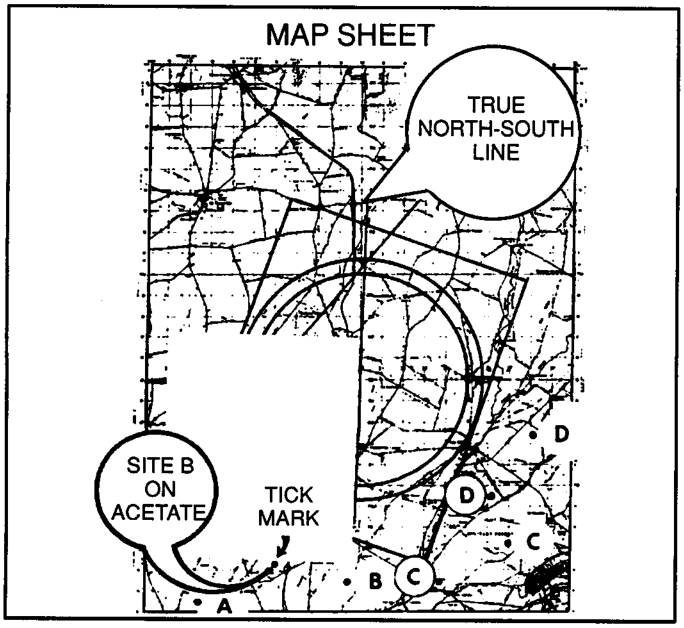


Figure 8-71. Placing tick mark on paper.

STEP 7. Slide the sheet of paper up until the top edge is at the top of the map sheet. Ensure the long edge is aligned with the true north-south line. Place a tick mark precisely below the tick mark on the bottom edge of the paper (Figure 8-72).

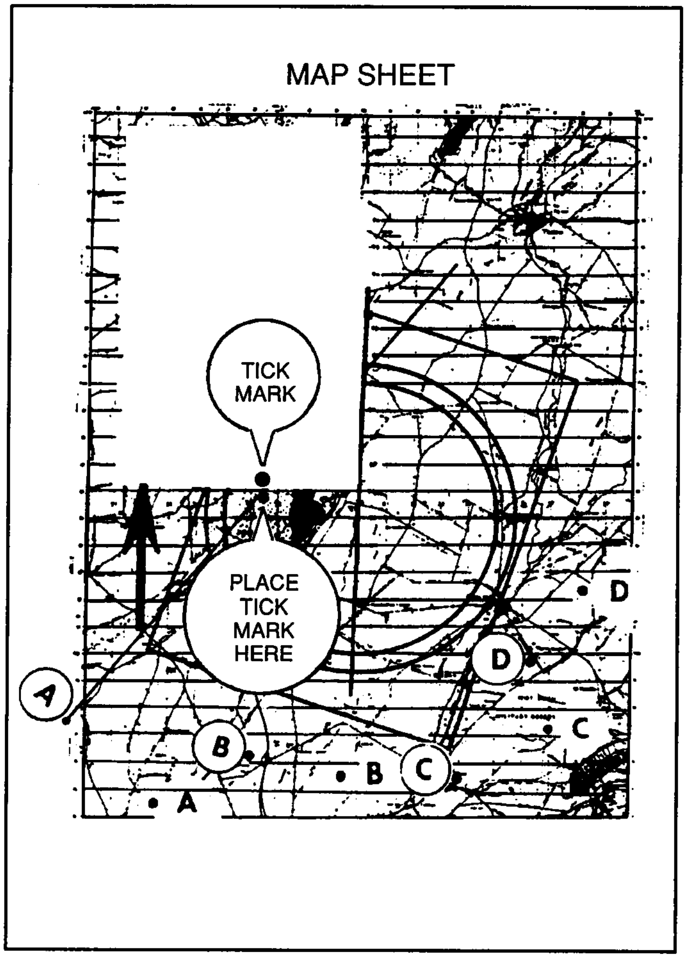


Figure 8-72. Tick mark placement.

STEP 8. Taking a straightedge, align the tick mark just made with site B on the acetate. Draw a line through the two points as far as possible (Figure 8-73).

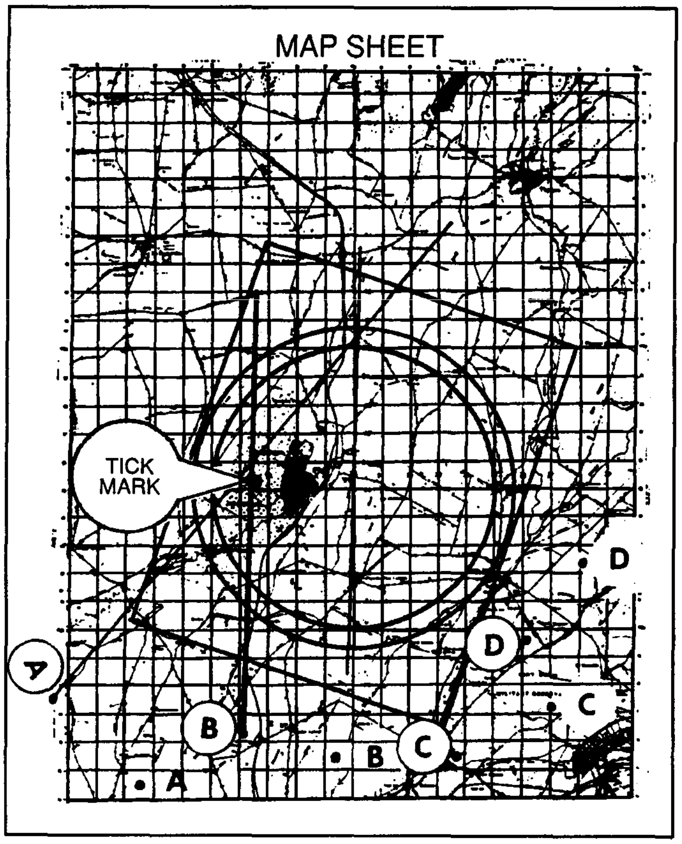


Figure 8-73. Line drawn between site B and tick mark.

Plotting the bearings for sites C and D are completed in exactly the same manner. Once the site C bearing of 290 degrees and site D bearing of 265 degrees are plotted, the acetate will indicate a fix area as illustrated in Figure 8-74. The most probable fix location can then be determined and reported in a 8-digit coordinate. Since the bearings were plotted using a grease pencil, they can now be erased from the acetate and the map is ready to plot the next bearing returns.

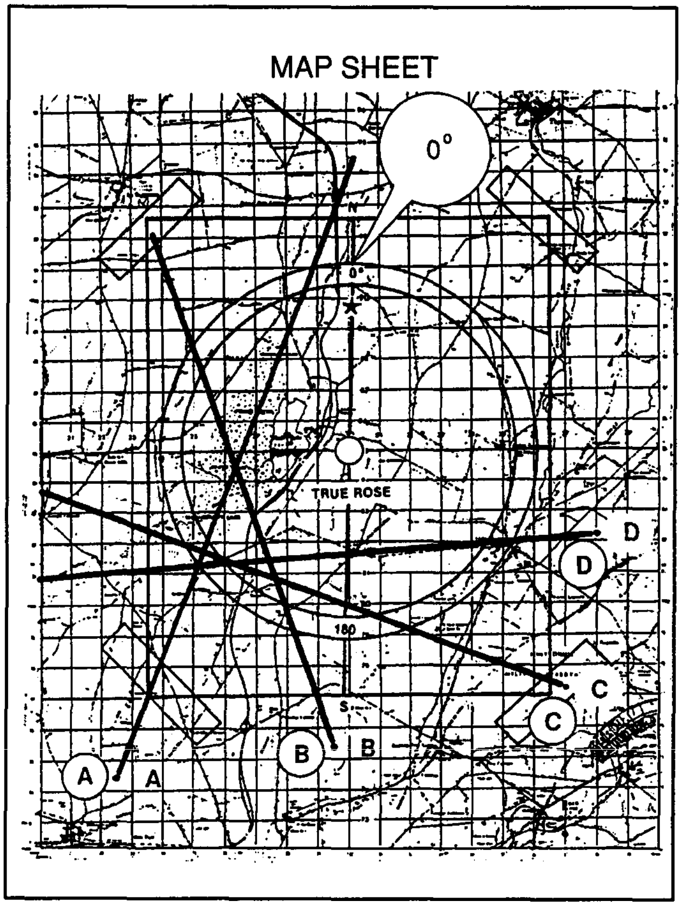


Figure 8-74. The completed plot.

CHAPTER 9

COMPUTATIONS

In Chapter 8, we discussed how maps used in tactical and strategic direction finding operations are developed. Normally, these maps are projected on a plane or a cylinder. Regardless of the projection technique used in developing a map, there will be some distortion. Most strategic DF plotting facilities use mathematical computations to correct this distortion. Tactical plotting operations normally do not compute for map distortion. This is because of the distance from the DF site to the target area (5 to 30 kilometers) and the limited personnel resources and time. It is also not feasible in a tactical environment due to the frequent movement of the DF sites.

We have also discussed how radio waves travel great circle paths. Therefore, using mathematical computations, it is possible to compute the true bearing and distance from a DF site to a known transmitter. These computations are then used to determine the performance of a direction finding site. Normally called statistical analysis, these mathematical computations can reveal DF equipment or operator error. As a management tool, computations can evaluate the DF site as well as the net performance.

MAP DISTORTION CORRECTION TECHNIQUES

The gnomonic projection is the most commonly used map projection for strategic DF plotting (Figure 9-1). It is derived by projecting the surface of the globe, from a center point, upon a planar surface. Its primary characteristic is that all great circles appear as straight lines. This map is particularly useful when plotting across great expanses of ocean. Distortion on the gnomonic projection is minimal at the point of tangency.

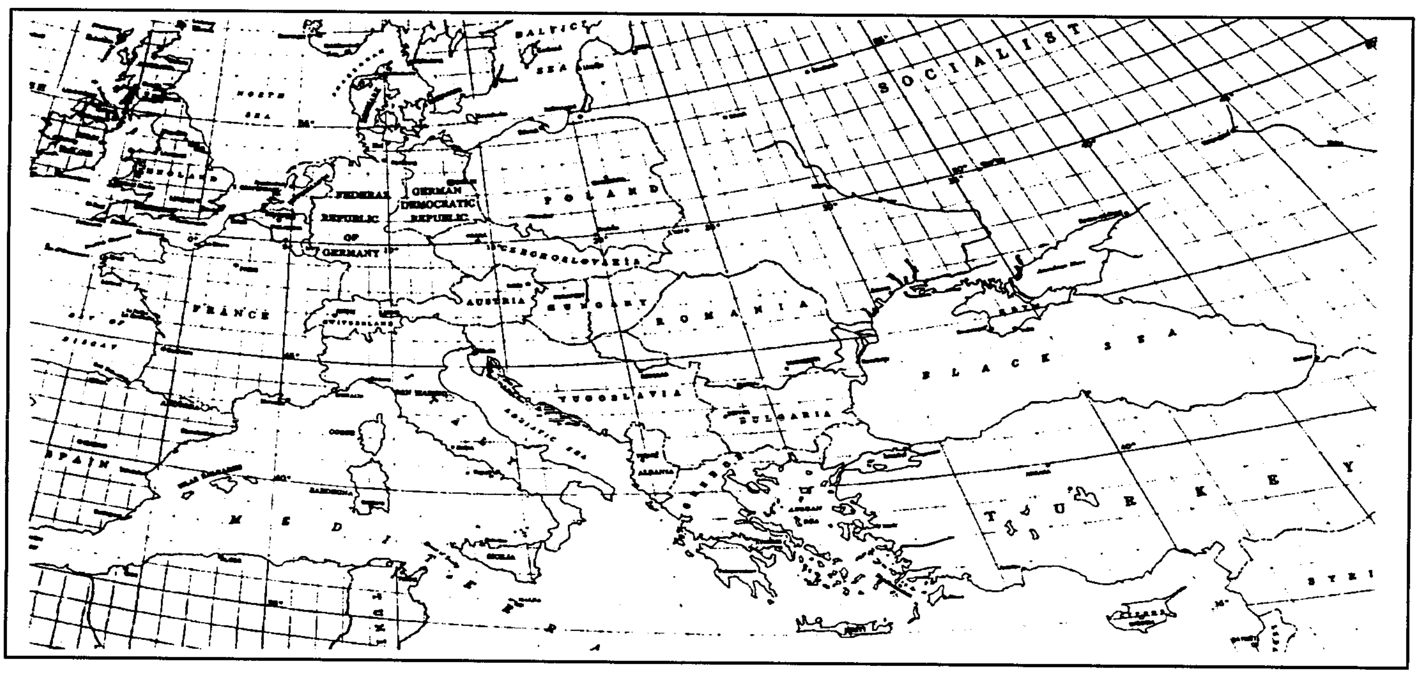


Figure 9-1. Gnomonic projection.

However, distortion increases as the distance from the point of tangency increases. For example, the boundaries near the edge of the map projection are badly distorted and are practically useless for determining true shapes and distances. This distortion does not affect plotting activities if the DF equipment is located within a 4-degree radius from the point of map tangency. Bearings can be plotted to any point on the chart without any appreciable error. However, if the DF station is located outside the 4-degree radius, angular correction must be applied before its bearings can be accurately plotted. The computation methods used to correct this distortion are—

- Border coordinates.
- Corrected compass rose.

Border Coordinates

Border coordinates are used to correct angular distortion on a gnomonic chart. They also provide what is perhaps the most accurate method of manually plotting DF bearings. Border coordinates divide the perimeter of the gnomonic chart into 1,000 equal spaces. The spaces are denoted by tick marks. Every tenth mark is numbered, starting with 00 at the upper left corner and continuing clockwise to 100 (Figure 9-2).

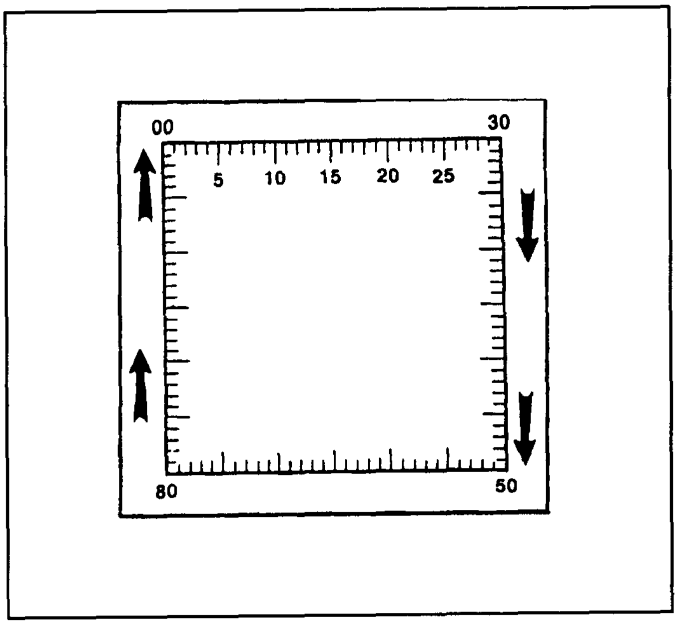


Figure 9-2. Border coordinates.

Border coordinates are constructed on the chart so that 00 through 30 are located on the top border. The numbers 30 through 50 are located on the right border. The bottom border contains 50 through 80. And 80 through 100 are located on the left border. The spaces between the tick marks can be mechanically interpolated into tenths (Figure 9-3).

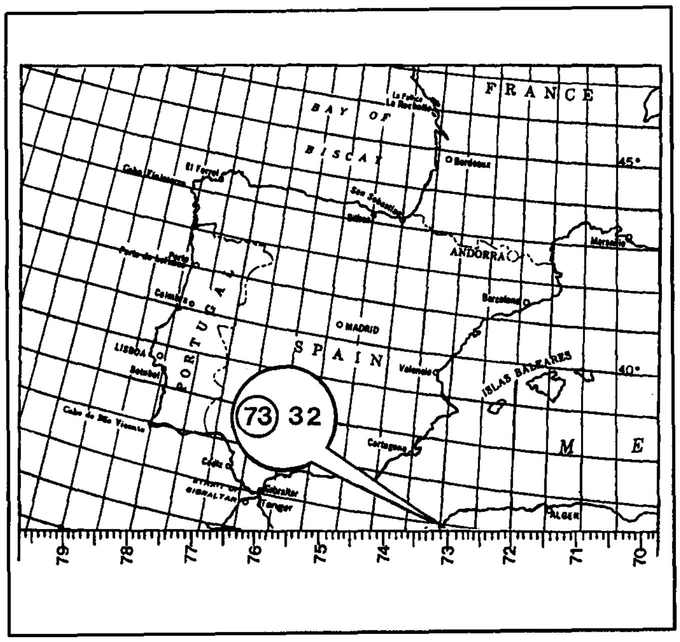


Figure 9-3. Bottom border coordinates.

This provides a total of 10,000 coordinates for plotting purposes (Figure 9-4).

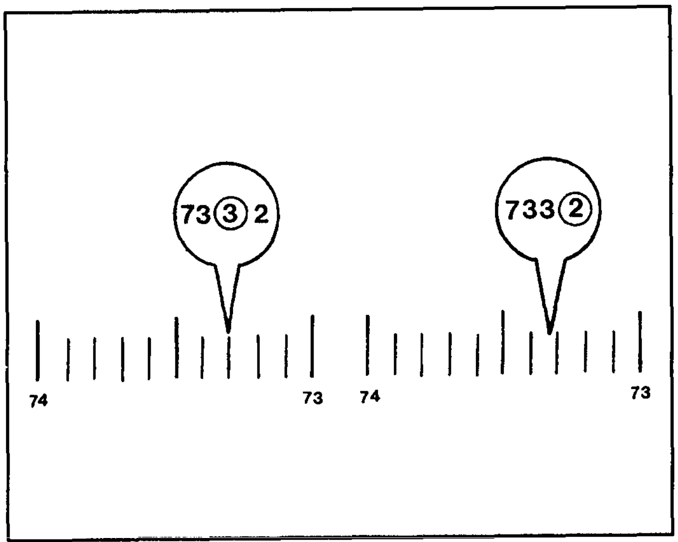


Figure 9-4. Interpolation.

Tables are constructed for each DF site, providing coordinates for all azimuths. When a bearing is reported by a DF site, it is converted to border coordinates. It is then plotted on the gnomonic chart by drawing a line between the coordinate and the DF site. Border coordinates and conversion tables are machine computed. They may be obtained on request from the National Security Agency/Central Security Service. The applicable gnomonic chart number and the exact latitude and longitude of each DF site located must be included in the request.

Corrected Compass Rose

A corrected compass rose is nothing more than a compass rose which has been corrected or expanded to compensate for angular distortion. In other words, the degree marks have been placed close together or moved apart. This is done according to the amount of map distortion present (Figure 9-5).

When situated on the gnomonic plotting chart, the CCR must have its center exactly over the DF site location. Bearings can then be plotted from the CCR. If desired, the rose can be extended to a line around the edge of the map. This is accomplished in the same manner as border coordinates. A corrected compass rose is constructed using the right-triangle method.

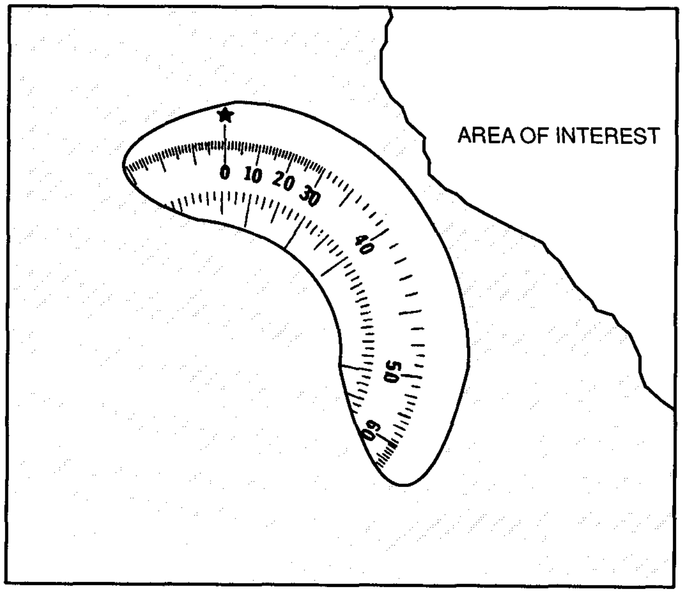


Figure 9-5. Corrected compass rose.

Right-Triangle Method. Constructing a CCR by the right-triangle method entails the computation of mathematical formulas. It is time consuming. However, this is compensated by the high degree of accuracy and reliability it provides. Since radio waves follow great circle paths, the right-triangle method of error correction is concerned with spherical trigonometry. Under theoretical conditions, the equator and the selected meridian would intersect at a right angle (Figure 9-6).

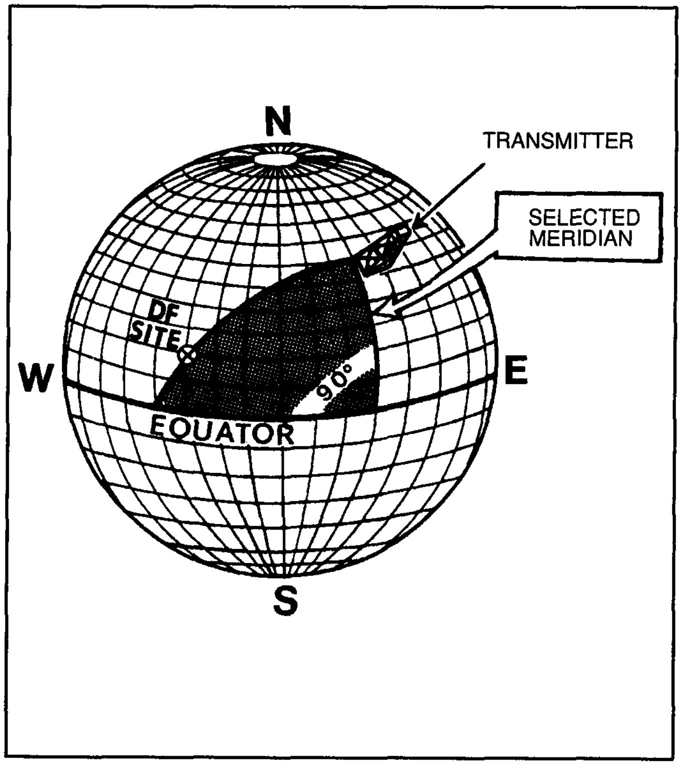


Figure 9-6. Spherical right triangle.

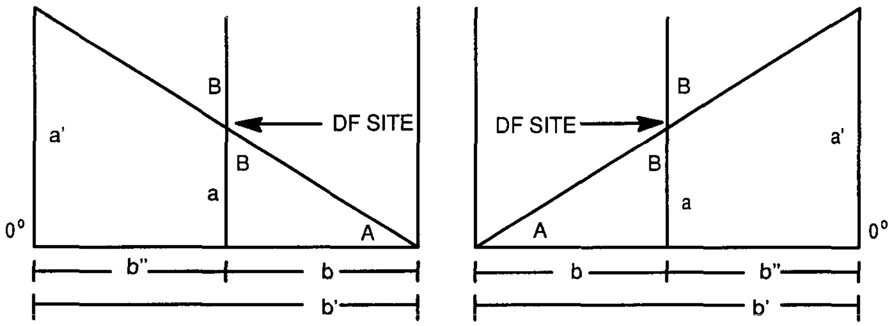
The azimuth from the DF site would intersect both the equator and the selected meridian. This forms a right triangle. A common logarithm of functions of angles in degrees and minutes table (Appendix A) is used to solve the unknown quantities of a spherical right triangle. For additional information on the principles and application of logarithms, refer to TM 11-684. The three known factors of the computation are the—

- Latitude and longitude of the DF site.
- Longitude of the selected meridian.
- Desired azimuth.

Right-Triangulation Computation Work Sheet. The selected meridian used during the computation should be in the approximate center of the area of interest. It also should be noted that one single meridian need not be used for the computation of the entire CCR. Figure 9-7 illustrates the formula used in the right-triangle method of computation.

NOTE

The use of a calculator containing logarithmic/trigonometric functions would decrease the time needed to construct CCR. However, for instructional purposes, the tables contained in Appendix A are used.



B = ____________ a = ____________ b" = ____________ b = ____________

a' = ____________ A = ____________ b' = ____________

(log tan b) = (log sin a) – (log cot B)

log sin a: ____________

log cot B: ____________

Diff: ____________ = log tan b   b = __________

(log cos A) = (log cos a) + (log sin B)

log cos a: ____________

log sin B: ____________

Sum: ____________ = log cos A   A = __________

(log tan a') = (log sin b') – (log cot A)

log sin b': ____________

log cot A: ____________

Diff: ____________ = log tan a'   a' = __________

Figure 9-7. Right-triangle computation work sheet.

An explanation of the right-triangle computation work sheet is as follows:

- The bottom line, marked 0 degrees, represents the equator.
- Line a is the distance in degrees and minutes from the equator to the DF site or the latitude of the site.
- Angle B is the desired azimuth which is to be corrected for angular map distortion.
- Angle A is the angle the desired azimuth makes at the equator.

Note: Angles A and B do not total 90 degrees as in a true right triangle. This is because the right-triangle method deals with a right triangle only in theory. The functions are computed by spherical trigonometry.

- Line b is the distance in degrees and minutes of the difference in longitude between the DF site and the intersection of the azimuth with the equator.
- Line b“ is the distance in degrees and minutes from the DF site to the selected meridian.
- Line b’ is the difference in longitude of the intersection of the azimuth with the equator and the selected meridian. (Line b’ is the sum of lines b and b“.)
- The value of a’ represents the latitude at which the bearing will intersect the selected meridian.

Common Logarithms of Functions of Angles in Degrees and Minutes Table. The table is used in solving the unknown quantities of a spherical right triangle. This information is used to construct a corrected compass rose. The use of common logarithms of functions of angles in degrees and minutes table is as follows:

- **Degrees.** Each page of the table in Appendix A is computed for eight different angles. Four are indicated in the upper left corner and four in the lower right comer. The fact that one page is sufficient for the functions of eight different angles is a result of the properties of trigonometric functions. For example, the sine of O degrees is numerically equal to the sine of 180 degrees. The cosine of 90 degrees is equal to the cosine of 270 degrees (Figure 9-8).

- **Minutes.** The minutes for each angle are found in the columns headed by the mathematical sign for minutes (’) (Figure 9-9, page 9-6).

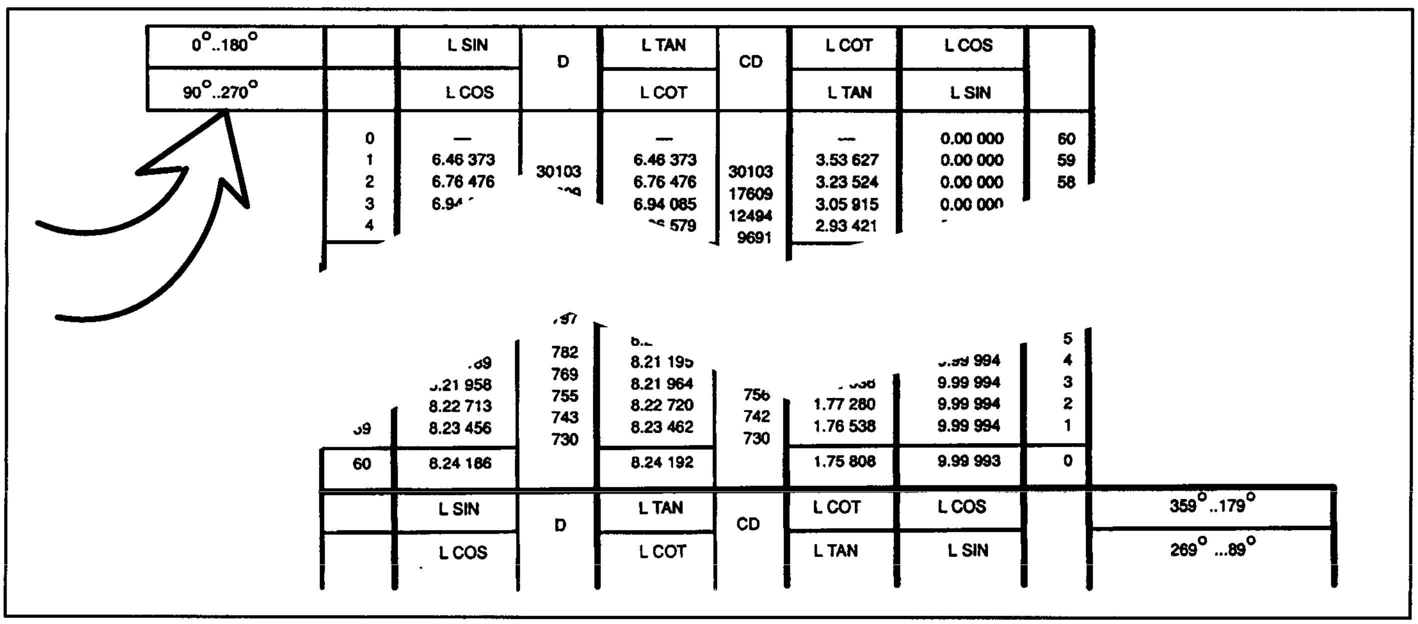


Figure 9-8. Properties of trigonometric functions.

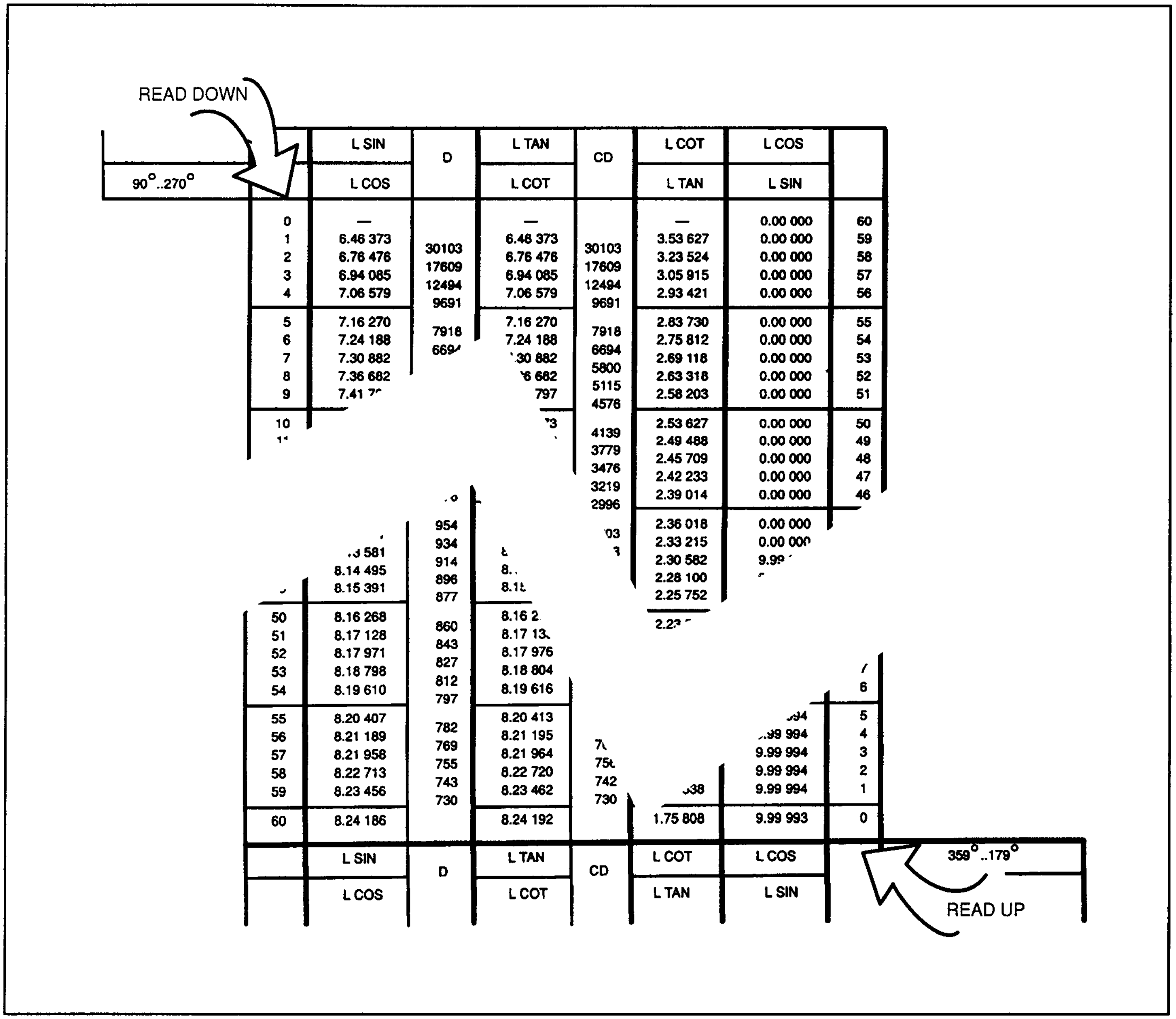


Figure 9-9. Minutes.

The minutes for the angles in the upper left corner are read *down* the left minute column. The minutes for the angles in the lower right corner are read *up* the right

use the following steps (Figure 9-10):

STEP 1. Locate the page containing the angle of the trigonometric function (Figure 9-10 ①).

STEP 2. Follow the angle's minute column either up or down until the exact minute reading is located (Figure 9-10 ②).

STEP 3. Determine which function is appropriate by consulting the legend. Check both the top and the bottom of the table (Figure 9-10 ③). Angle functions are *opposite* each angle or degree reading. The number found at the intersection of the function column and the logarithm row opposite the minute column is the logarithm of that angle.

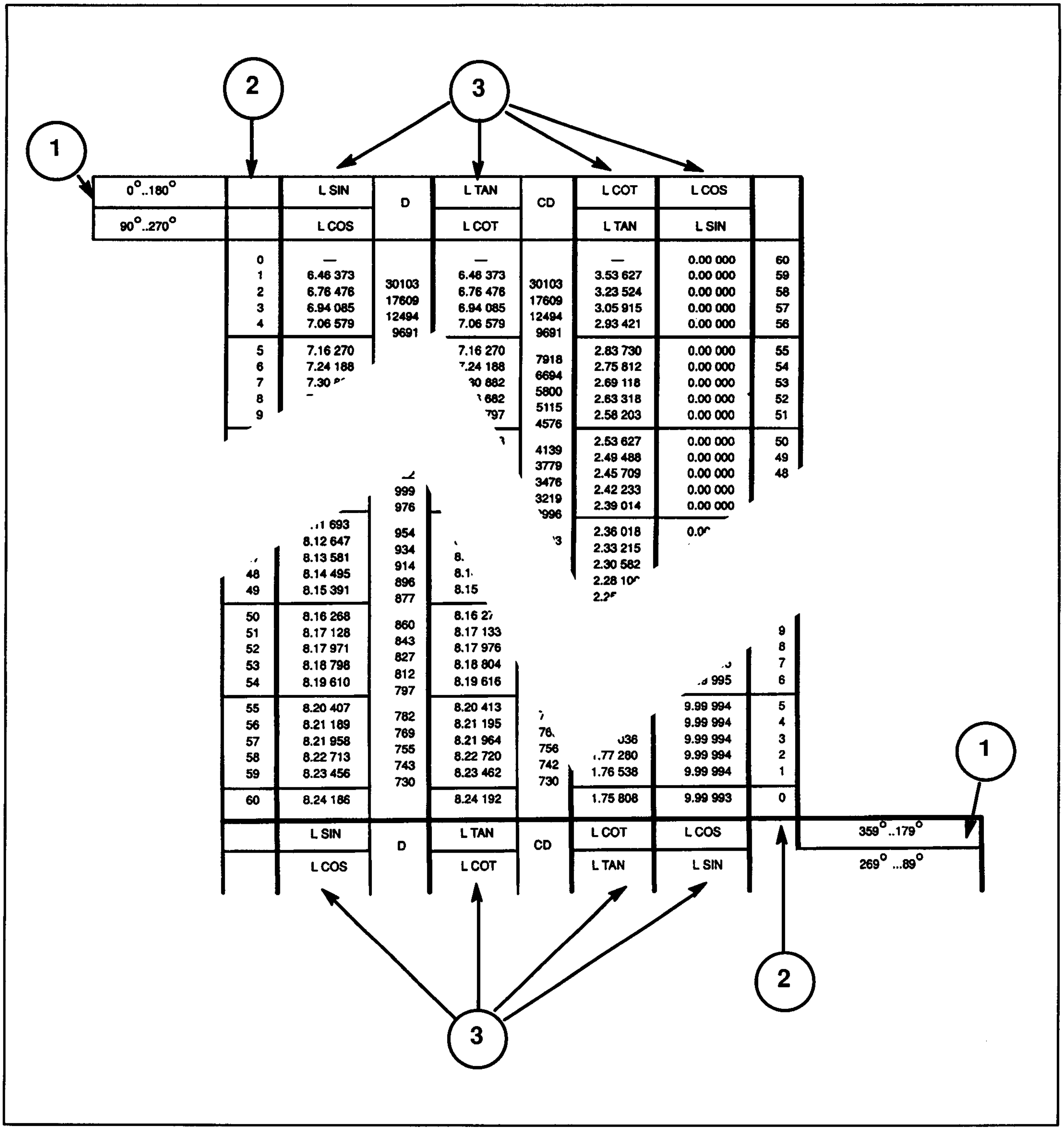


Figure 9-10. Use of the tables.

To determine the angle of a logarithm, use the following steps (Figure 9-11):

STEP 1. Locate the logarithm which is *nearest* the given logarithm in the appropriate function column (Figure 9-11 (1)).

STEP 2. The minute value will be selected from either the corresponding number in the left minute column or the right minute column (Figure 9-11 (2)).

STEP 3. Note the corresponding angles of the function column, top left comer and bottom right comer. Select the *lowest* of the four angles (Figure 9-11(3)). If the selected angle is at the top of the page, read the minute value from the left minute column. However, if the selected angle is taken from the bottom of the page, read the minute value from the right minute column.

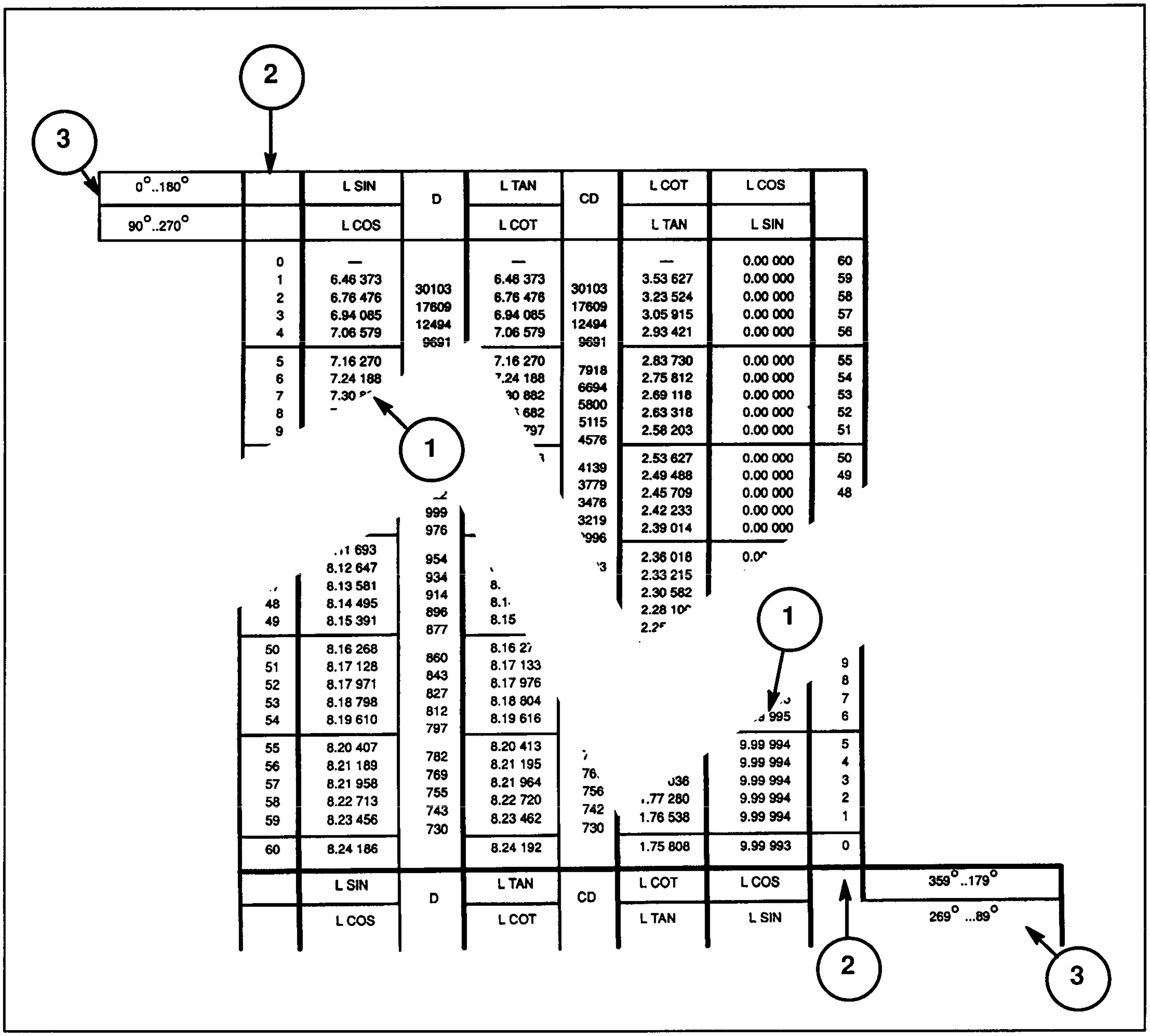


Figure 9-11. Determining the angle of a logarithm.

Right-Triangle Method Example. The desired azimuth (or angle B) which is to be corrected for angular distortion is 10 degrees. The latitude of the DF site (or line a) is 36 degrees. The difference in longitude between the DF site and selected meridian (or b“) is 5 degrees. (Refer to Appendix A for logarithm table.)

STEP 1. Find b:

(log sin a) - (log cot B) = (log tan b)
Log sin 36 degrees = 9.76922-10 (Figure 9-12)
Log cot 10 degrees = 0.75368 (Figure 9-13)

36°...216° / 126°...306°		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	
	0	9.76 922	17	9.86 126	27	0.13 874	9.90 796	9	60
		9.76 939	18	9.86 153	26	0.13 847	9.90 787	10	59
		9.76 957	17	9.86 179	27	0.13 821	9.90 777	9	58
		9.76 974	17	9.86 206	26	0.13 794	9.90 768	9	57
	4	9.76 991	18	9.86 232	27	0.13 768	9.90 759	9	56
	5	9.77 009	17	9.86 259	26	0.13 741	9.90 750	9	55
	6	9.77 026	17	9.86 285	27	0.13 715	9.90 741	10	54
	7	9.77 043	18	9.86 312	26	0.13 688	9.90 731	9	53
	8	9.77 061	17	9.86 338	27	0.13 662	9.90 722	9	52
	9	9.77 078	17	9.86 365	27	0.13 635	9.90 713	9	51

Figure 9-12. Log sin 36 degrees.

10°..190° / 100°.280°		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	
	0	9.23 967	72	9.24 632	74	0.75 368	9.99 335	60
	1	9.24 039	71	9.24 706	73	0.75 294	[illegible]	59
	2	9.24 110	71	9.24 779	74	0.75 221	[illegible]	58
	3	9.24 181	72	9.24 853	73	0.75 147	[illegible]	[illegible]
	4	9.24 253	71	9.24 926	74	0.75 074	9.99 326	[illegible]
	5	9.24 324	71	9.25 000	73	0.75 000	9.99 324	[illegible]
	6	9.24 395	71	9.25 073	73	0.74 927	9.99 322	54
	7	9.24 466	70	9.25 146	73	0.74 854	9.99 319	53
	8	9.24 536	71	9.25 219	73	0.74 781	9.99 317	52
	9	9.24 607	70	9.25 292	73	0.74 708	9.99 315	51

Figure 9-13. Log cot 10 degrees.

Log diff = 9.01554-10
Log tan b = 9.01554-10
b = 5 degrees 55 minutes (Figure 9- 14)

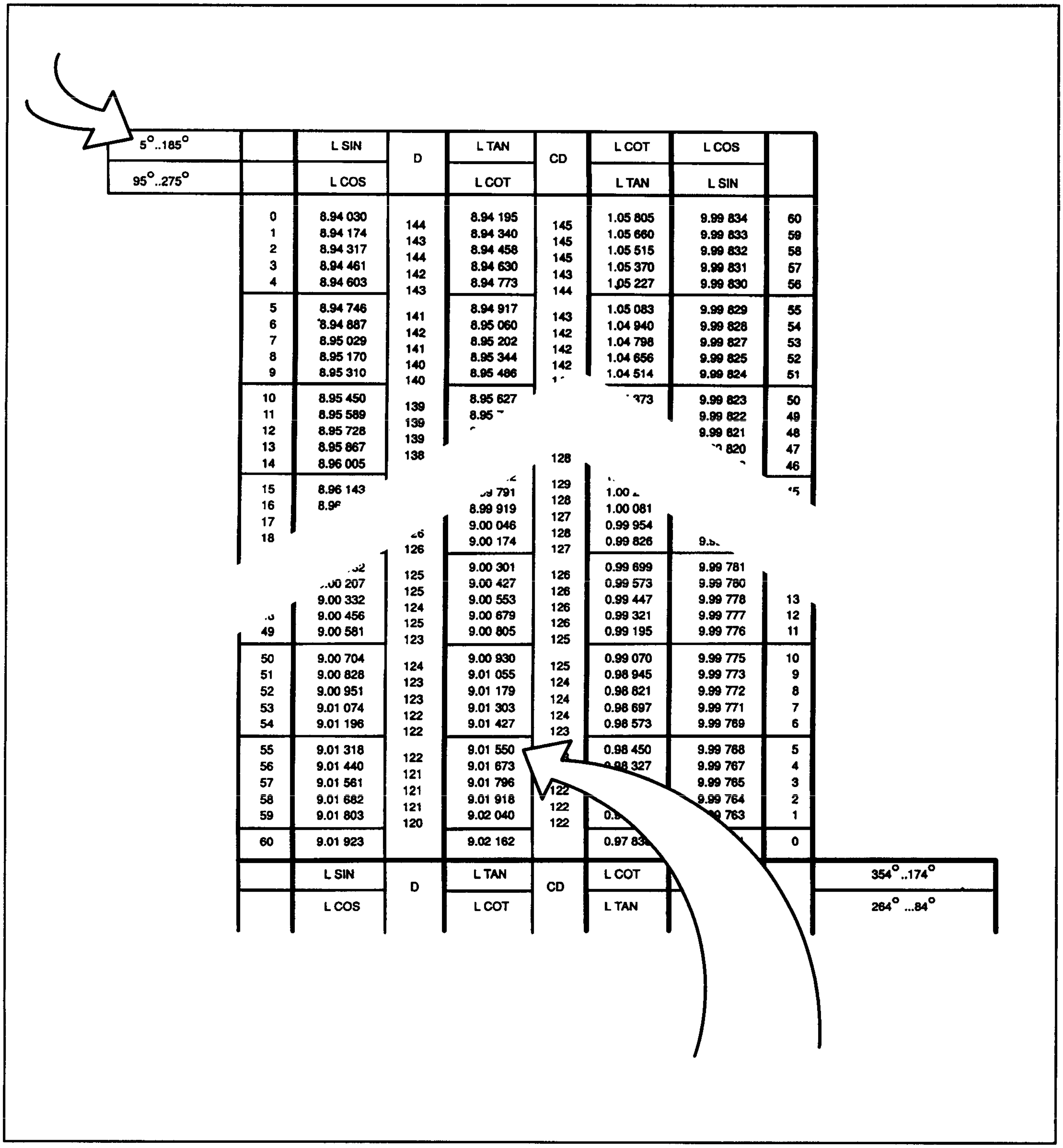


Figure 9-14. Determining the angle of log tan b (9.01554-10).

STEP 2. Find b':

(b") + (b)= (b')

b" = 5 degrees

b = 5 degrees 55 minutes

b' = 10 degrees 55 minutes

NOTE: Always select the lowest degree and minute reading.

STEP 3. Find A:

(log cos a) + (log sin B) = (log cos A)

Log cos 36 degrees = 9.90796-10 (Figure 9-15)

Log sin 10 degrees = 9.23967-10 (Figure 9-16)

36°...216°		L SIN	D	L TAN	CD	L COT	L COS	D	
126°...306°		L COS		L COT		L TAN	L SIN		
	0	9.76 922	17	9.86 126	27	0.13 874	9.90 796	9	60
	1	9.76 939	18	9.86 153	26	0.13 847	9.90 787	10	59
	2	9.76 957	17	9.86 179	27	0.13 821	9.90 777	9	58
	3	9.76 974	17	9.86 206	26	0.13 794	9.90 768	9	57
	4	9.76 991	18	9.86 232	27	0.13 768	9.90 759	9	56
	5	9.77 009	17	9.86 259	26	0.13 741	9.90 750	9	55
	6	9.77 026	17	9.86 285	27	0.13 715	9.90 741	10	54
	7	9.77 043	18	9.86 312	26	0.13 688	9.90 731	9	53
	8	9.77 061	17	9.86 338	27	0.13 662	9.90 722	9	52
	9	9.77 078	17	9.86 365	27	0.13 635	9.90 713	9	51

Figure 9-15. Log cos 36 degrees.

10°..190°		L SIN	D	L TAN	CD	L COT	L COS	
100°.280°		L COS		L COT		L TAN	L SIN	
	0	9.23 967	72	9.24 632	74	0.75 368	9.99 335	60
		9.24 039	71	9.24 706	73	0.75 294	9.99 333	59
		9.24 110	71	9.24 779	74	0.75 221	9.99 331	58
	3	9.24 181	72	9.24 853	73	0.75 147	9.99 328	57
	4	9.24 253	71	9.24 926	74	0.75 074	9.99 326	56
	5	9.24 324	71	9.25 000	73	0.75 000	9.99 324	55
	6	9.24 395	71	9.25 073	73	0.74 927	9.99 322	54
	7	9.24 466	70	9.25 146	73	0.74 854	9.99 319	53
	8	9.24 536	71	9.25 219	73	0.74 781	9.99 317	52
	9	9.24 607	70	9.25 292	73	0.74 708	9.99 315	51

Figure 9-16. Log sin 10 degrees.

Log sum = 19.14763-20
Log cos A = 9.14763-10 (Figure 9-17)
A = 81 degrees 55 minutes

8°..188°		L SIN	D	L TAN	CD	L COT	L COS	
98°..278°		L COS		L COT		L TAN	L SIN	
	0	9.14 356	89	9.14 780	92	0.85 220	9.99 575	60
	1	9.14 445	90	9.14 872	91	0.85 128	9.99 574	59
	2	9.14 535	89	9.14 963	91	0.85 037	9.99 572	58
	3	9.14 624	90	9.15 054	91	0.84 946	9.99 570	57
	4	9.14 714	89	9.15 145	91	0.84 855	9.99 568	56
	5	9.14 803	88	9.15 236	91	0.84 764	9.99 566	55
	6	9.14 891	89	9.15 327	90	0.84 673	9.99 565	54
	7	9.14 980	89	9.15 417	91	0.84 583	9.99 563	53
	8	9.15 069	88	9.15 508	90	0.84 492	9.99 561	52
	9	9.15 157	88	9.15 598	[illegible]	0.84 402	9.99 559	51
	10	9.15 245	88	9.15 68[illegible]		[illegible]	9.99 557	50
	11	9.15 333	88	[illegible]			9.99 556	49
	12	9.15 421					9.99 554	48
	13	9.15 50[illegible]					[illegible] 552	47
	14	[illegible]						46

	L SIN	D	L TAN	CD	L COT	L COS		
				84	[illegible]			
			9.18 728	84	0.81 272			
		81	9.18 812	84	0.81 188			
	[illegible]	82	9.18 896	83	0.81 104	[illegible]		
	9.18 465	82	9.18 979	84	0.81 021	9.99 [illegible]		
49	9.18 547	81	9.19 063	83	0.80 937	9.99 484		
50	9.18 628	81	9.19 146	83	0.80 854	9.99 482	10	
51	9.18 709	81	9.19 229	83	0.80 771	9.99 480	9	
52	9.18 790	81	9.19 342	83	0.80 688	9.99 478	8	
53	9.18 871	81	9.19 395	83	0.80 605	9.99 476	7	
54	9.18 952	81	9.19 478	83	0.80 522	9.99 474	6	
55	9.19 033	80	9.19 561	82	0.80 439	9.99 472	5	
56	9.19 113	80	9.19 643	82	0.80 357	9.99 470	4	
57	9.19 193	80	9.19 725	82	0.80 275	9.99 468	3	
58	9.19 273	80	9.19 807	82	0.80 193	9.99 466	2	
59	9.19 353	80	9.19 889	82	0.80 111	9.99 464	1	
60	9.19 433		9.19 971		0.80 029	9.99 462	0	
	L SIN	D	L TAN	CD	L COT	L COS		351°..171°
	L COS		L COT		L TAN	L SIN		261° ...81°

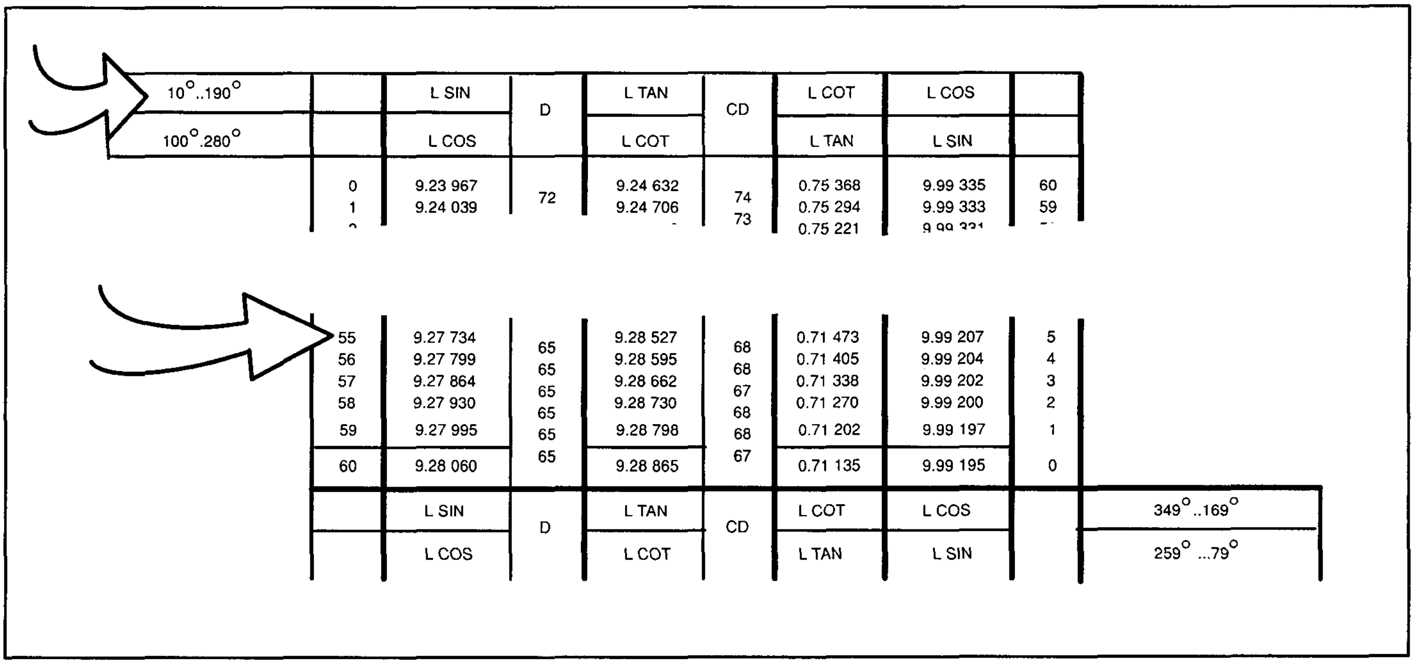
Figure 9-17. Determining the angle of log cos 9.14763-10.

STEP 4. Find a':

(log sin b') - (log cot A)= (log tan a')

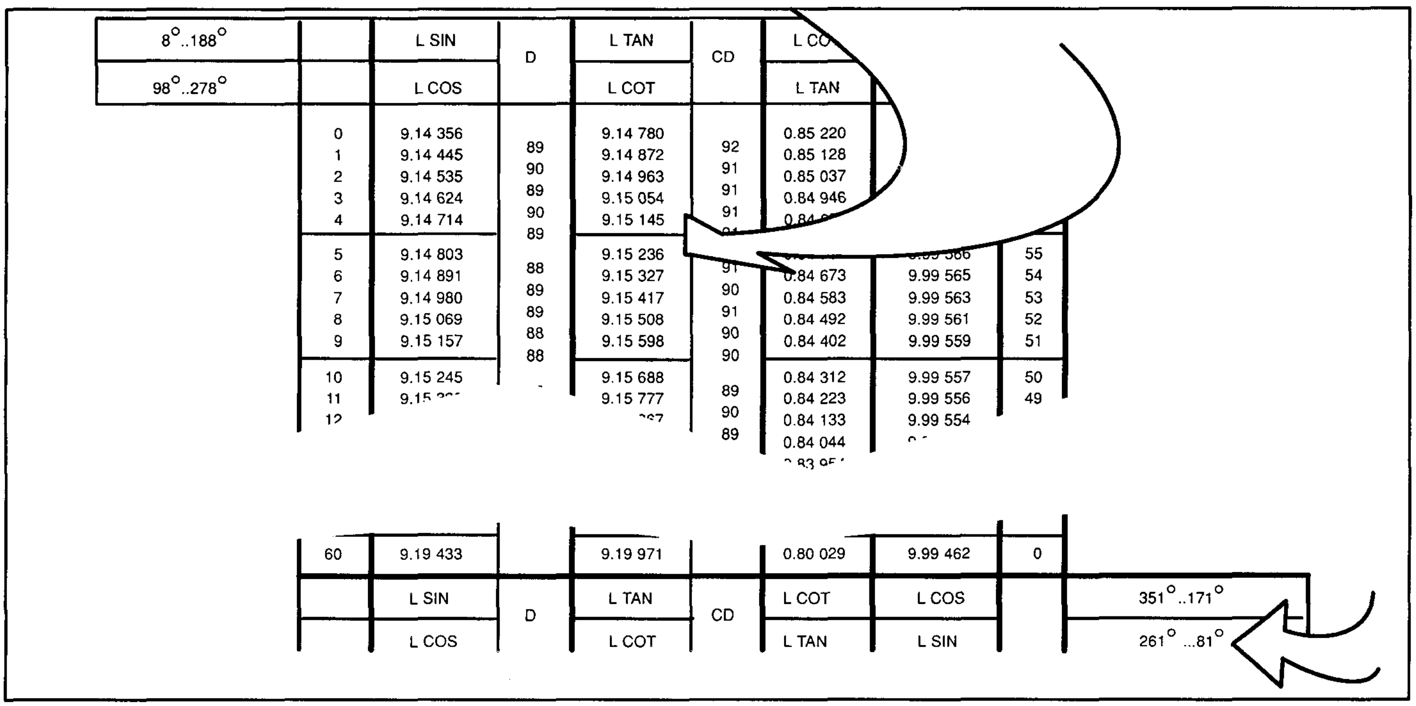
Log sin 10 degrees 55 minutes = 9.27734-10 (Figure 9-18)

Log cot 81 degrees 55 minutes =9.15236-10 (Figure 9-19)



10°..190° / 100°.280°		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	
	0	9.23 967	72	9.24 632	74	0.75 368	9.99 335	60
	1	9.24 039		9.24 706	73	0.75 294	9.99 333	59
	[illegible]					0.75 221	[illegible]	[illegible]
	55	9.27 734	65	9.28 527	68	0.71 473	9.99 207	5
	56	9.27 799	65	9.28 595	68	0.71 405	9.99 204	4
	57	9.27 864	65	9.28 662	67	0.71 338	9.99 202	3
	58	9.27 930	65	9.28 730	68	0.71 270	9.99 200	2
	59	9.27 995	65	9.28 798	68	0.71 202	9.99 197	1
	60	9.28 060	65	9.28 865	67	0.71 135	9.99 195	0
		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	349°..169° / 259° ...79°

Figure 9-18. Log sin 10 degrees 55 minutes.



8°..188° / 98°..278°		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	
	0	9.14 356	89	9.14 780	92	0.85 220	[illegible]	[illegible]
	1	9.14 445	90	9.14 872	91	0.85 128	[illegible]	[illegible]
	2	9.14 535	89	9.14 963	91	0.85 037	[illegible]	[illegible]
	3	9.14 624	90	9.15 054	91	0.84 946	[illegible]	[illegible]
	4	9.14 714	89	9.15 145	[illegible]	[illegible]	[illegible]	[illegible]
	5	9.14 803	88	9.15 236	91	[illegible]	[illegible]	55
	6	9.14 891	89	9.15 327	90	0.84 673	9.99 565	54
	7	9.14 980	89	9.15 417	91	0.84 583	9.99 563	53
	8	9.15 069	88	9.15 508	90	0.84 492	9.99 561	52
	9	9.15 157	88	9.15 598	90	0.84 402	9.99 559	51
	10	9.15 245		9.15 688	89	0.84 312	9.99 557	50
	11	[illegible]		9.15 777	90	0.84 223	9.99 556	49
	12	[illegible]		[illegible]	89	0.84 133	9.99 554	
						0.84 044		
	60	9.19 433		9.19 971		0.80 029	9.99 462	0
		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	351°..171° / 261° ...81°

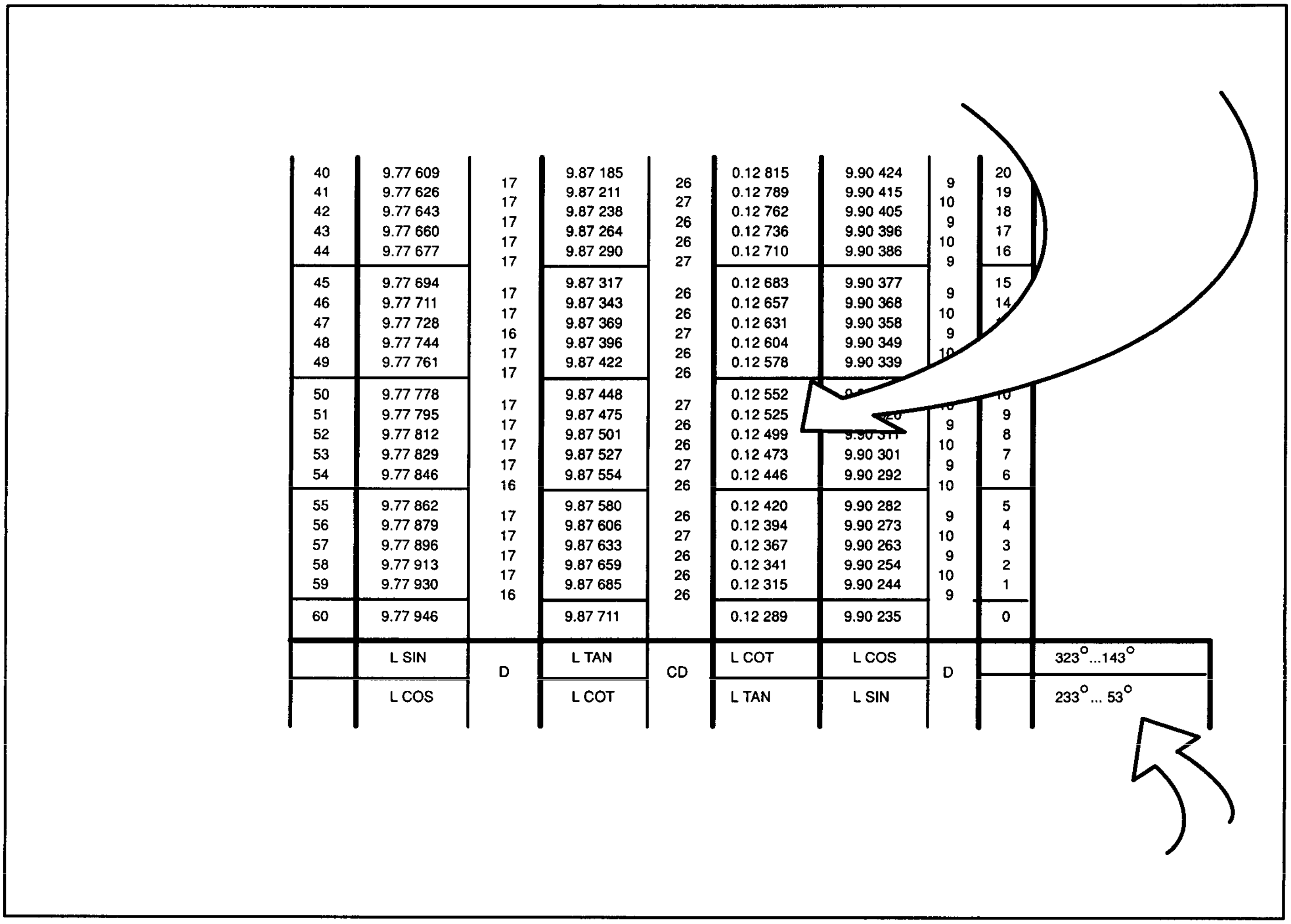
Figure 9-19. Log cot 81 degrees 55 minutes.

Log diff = 0.12498
Log tan a' = 0.12498
a' = 53 degrees 08 minutes (Figure 9-20)

STEP 5. A straightedge aligned with 53 degrees and 8 minutes latitude on the selected meridian indicates the corrected azimuth for 10 degrees. When constructing a corrected compass rose, a tick mark should be placed on the compass rose and numbered 10 degrees. Or a tick mark should be placed on the edge of the plotting chart and numbered 10 degrees.

A problem area may arise when computing desired azimuths around 90 or 270 degrees. To eliminate confusion, subtract the value of b from 90 degrees and complete the computations. This procedure should also be used approximately 5 degrees on either side of the 90 or 270 degree azimuth. This ensures standard accuracy.

NOTE: It is apparent that logarithm tables are constructed in such a manner so the area from 0 to 90 degrees represents the entire 360 ***degrees. Any computation using X degrees east as the selected meridian will also be correct for X degrees west and both reciprocals. Therefore, any single computation will yield four azimuths. Ninety computations are required to complete the entire compass rose.***



40	9.77 609	17	9.87 185	26	0.12 815	9.90 424	9	20	
41	9.77 626	17	9.87 211	27	0.12 789	9.90 415	10	19	
42	9.77 643	17	9.87 238	26	0.12 762	9.90 405	9	18	
43	9.77 660	17	9.87 264	26	0.12 736	9.90 396	10	17	
44	9.77 677	17	9.87 290	27	0.12 710	9.90 386	9	16	
45	9.77 694	17	9.87 317	26	0.12 683	9.90 377	9	15	
46	9.77 711	17	9.87 343	26	0.12 657	9.90 368	10	14	
47	9.77 728	16	9.87 369	27	0.12 631	9.90 358	9	[illegible]	
48	9.77 744	17	9.87 396	26	0.12 604	9.90 349	[illegible]	[illegible]	
49	9.77 761	17	9.87 422	26	0.12 578	9.90 339	[illegible]	[illegible]	
50	9.77 778	17	9.87 448	27	0.12 552	[illegible]	[illegible]	[illegible]	
51	9.77 795	17	9.87 475	26	0.12 525	[illegible]	9	9	
52	9.77 812	17	9.87 501	26	0.12 499	[illegible]	10	8	
53	9.77 829	17	9.87 527	27	0.12 473	9.90 301	9	7	
54	9.77 846	16	9.87 554	26	0.12 446	9.90 292	10	6	
55	9.77 862	17	9.87 580	26	0.12 420	9.90 282	9	5	
56	9.77 879	17	9.87 606	27	0.12 394	9.90 273	10	4	
57	9.77 896	17	9.87 633	26	0.12 367	9.90 263	9	3	
58	9.77 913	17	9.87 659	26	0.12 341	9.90 254	10	2	
59	9.77 930	16	9.87 685	26	0.12 315	9.90 244	9	1	
60	9.77 946		9.87 711		0.12 289	9.90 235		0	
	L SIN	D	L TAN	CD	L COT	L COS	D		323°...143°
	L COS		L COT		L TAN	L SIN			233°... 53°

Figure 9-20. Log tan a' 0.12498 angle.

GREAT CIRCLE AZIMUTH AND DISTANCE

Radio waves follow great circle paths between the transmitting and receiving antennas. When the exact location of the signal source is known, it is possible to compute the true or great circle azimuth and distance (GCAD). This can be computed from the point of signal origin to any other point receiving the signal on the surface of the earth. The computations of great circle azimuths are based on spherical trigonometry (Figure 9-21). They may be computed using the dead-reckoning altitude and azimuth table in Appendix B. This method is simpler and much faster than using other logarithmic methods. It is accurate to within one half a minute. Greater accuracy is possible by interpolating between table functions.

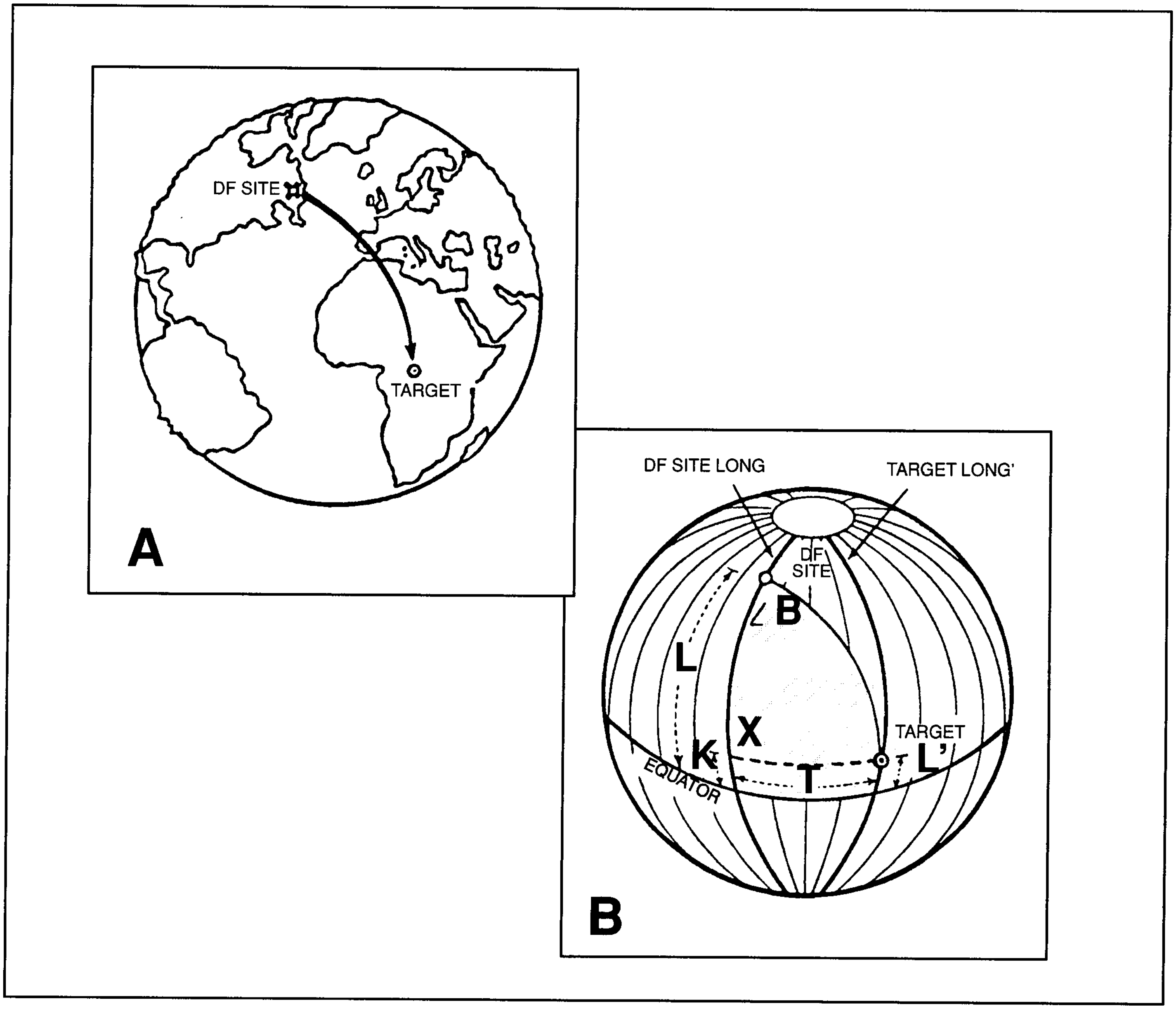


Figure 9-21. Spherical trigonometry.

Dead-Reckoning Altitude and Azimuth Table

The dead-reckoning altitude and azimuth table (Figure 9-22) is arranged in parallel *A* and *B* columns. The *A* columns contain log cosecants multiplied by 100,000. The *B* columns contain log secants also multiplied by 100,000. The *A* columns decrease in value from the front of the table toward the rear. The *B* columns increase in value from the front of the table to the rear.

When determining degrees and minutes from the top of the table, read the minutes from the *left* column (Figure 9-22 (1)). However, when reading the degrees and minutes from the bottom of the table, read the minutes from the *right* column (Figure 9-22 (2)). If the desired degrees and minutes exceed 180 degrees, subtract 180 degrees before entering the table.

1

	0°00'	0°30'	1°00'	1°30'	2°00'	
	A B	A B	A B	A B	A B	
0	———.....0.0	205916.....1.7	175814.....6.6	158208....14.9	145718....26.5	30
	383730.....0.0	205198.....1.7	175454.....6.7	157967....15.1	145538....26.7	
1	353627.....0.0	204492.....1.8	175097.....6.8	157728....15.2	145358....26.9	29
	336018.....0.0	203797.....1.8	174742.....7.0	157490....15.4	145179....27.1	
2	323524.....0.0	203113.....1.9	174391.....7.1	157254....15.6	145000....27.3	28
	313833.....0.0	202440.....1.9	174042.....7.2	157019....15.7	144823....27.6	
3	305915.....0.0	201777.....2.0	173696.....7.3	156784....15.9	144646....27.8	27
	299221.....0.0	201124.....2.1	173352.....7.4	156552....16.1	144470....28.0	
4	293421.....0.0	200480.....2.1	173012.....7.5	156320....16.2	144295....28.3	26
	288306.....0.0	199846.....2.2	172674.....7.6	156090....16.4	144120....28.5	
5	283730.....0.0	199221.....2.3	172339.....7.8	155861....16.6	143946....28.7	25
	279591.....0.1	198605.....2.3	172006.....7.9	155633....16.8	143773....28.9	
6	275812.....0.1	197998.....2.4	171676.....8.0	155406....16.9	143600....29.2	24
	272336.....0.1	197399.....2.4	171348.....8.1	155180....17.1	143428....29.4	
7	269118.....0.1	196808.....2.5	[illegible].....8.2	154956....17.3	143257....29.6	23
	266121.....0.1	196225.....2.6	[illegible]	154733....17.5	143086....29.9	
8	263318.....0.1			154511....17.6	142916....30.1	[illegible]
	[illegible]			[illegible]		
		[illegible]	161463....[illegible]		[illegible]	
[illegible]	215607.....1.1	180390.....5.4	161204....13.0	147945....23.9	137804....38.1	6
	214711.....1.1	179990.....5.5	160946....13.1	147755....24.1	137653....38.4	
25	213834.....1.1	179593.....5.6	160690....13.3	147566....24.3	137504....38.6	5
	212974.....1.2	179200.....5.7	160435....13.4	147377....24.5	137354....38.9	
26	212130.....1.2	178810.....5.8	160182....13.6	147190....24.7	137205....39.2	4
	211303.....1.3	178424.....5.9	159930....13.8	147003....24.9	137057....39.4	
27	210491.....1.3	178042.....6.0	159680....13.9	146817....25.2	136909....39.7	3
	209695.....1.4	177663.....6.1	159431....14.1	146632....25.4	136761....40.0	
28	208912.....1.4	177287.....6.2	159184....14.2	146448....25.6	136615....40.3	2
	208143.....1.5	176914.....6.3	158938....14.4	146264....25.8	136468....40.5	
29	207388.....1.5	176544.....6.4	158693....14.6	146081....26.0	136322....40.8	1
	206646.....1.6	176178.....6.5	158450....14.7	145899....26.2	136177....41.1	
30	205916.....1.7	175814.....6.6	158208....14.9	145718....26.5	136032....41.4	0
	A B	A B	A B	A B	A B	
	179°30'	179°00'	178°30'	178°00'	177°30'	

2

Figure 9-22. Dead-reckoning altitude and azimuth table.

Great Circle Azimuth and Distance Computation

Great circle azimuth and distance computations are based on spherical trigonometry. A terrestrial triangle has curved sides and is commonly referred to as a spherical triangle. Refer to Figure 9-21 Ⓑ, page 9-15. The shaded portion of the illustration is a spherical triangle. The determination of the true azimuth and distance is reduced to simply completing the work sheet (Figure 9-23) using the dead-reckoning altitude and azimuth table.

FROM: ______________ TO: ______________

LAT: ______________ LAT': ______________

LONG: ______________ LONG': ______________

T is determined by the following conditions: If long and long' are the same name SUBTRACT. If long and long' are different names ADD.

T ______________

DEGREES/MINUTES	COL-1 (ADD)	COL-2 (SUBTRACT)	COL-3 (ADD)	COL-4 (SUBTRACT)
T: ______	A: ______			
L': ______	B: ______	A: ______		
	A: ______	B: ______	B: ______	A: ______
K: ______		A: ______		
L: ______				
KL: ______			B: ______	
D ARC: ______			B: ______	A: ______
60 X DEGREES ______				A: ______
+ MINUTES + ______				<B ______
TOTAL ______				
TRUE AZIMUTH ______				

If other logarithm tables are used instead of dead-reckoning altitude and azimuth tables, column A equates to log cosecant, and column B equates to log secant.

Figure 9-23. GCAD computation work sheet.

Specific formula symbols used in the GCAD formula (Figure 9-24) are as follows:

- L or lat is the latitude of the initial position or the DF site.
- L' or lat' is the latitude of the final position or the check station.
- ∠ B is the great circle azimuth from the check station to the DF site.
- D arc is the great circle distance, in minutes of arc, between the target and the DF site. (One minute of arc equals one nautical mile.)
- X is the factor introduced to simplify the computation. It represents that point at which a great circle constructed perpendicular to the target's meridian crosses the meridian of the DF site.
- K is the latitude of point X or the arc from X to the equator (assumes the name of the latitude of the final position).
- KL is the difference between K and L.
- Long is the longitude of the DF site.
- Long' is the longitude of the check station.
- T is the distance from the target longitude to the line of longitude of the DF site.

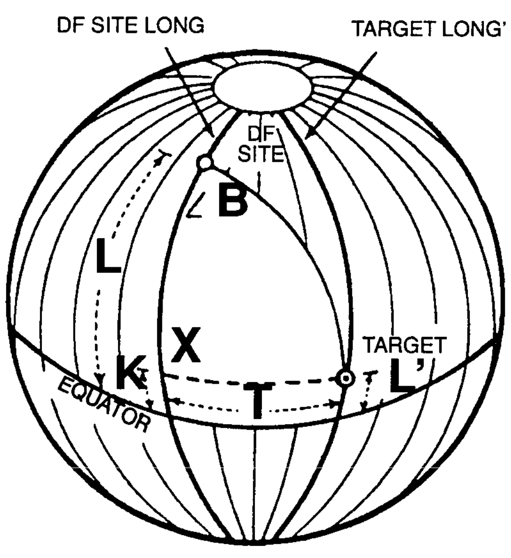


Figure 8-24. Spherical triangle symbols.

Special Rules. The fact that D arc maybe greater than 90 degrees has necessitated the following rules:

Rule 1. When L and L' are the same name (north or south), the following procedures are applicable:

a. When T is *greater* than 90 degrees, select the K value from the bottom of the dead-reckoning altitude and azimuth table. When T is *less* than 90 degrees, select the K value from the top of the table.

b. Record ∠ B from the top of the table when K is *greater* than L. When K is *less* than L select ∠ B from the bottom of the table.

c. D arc is recorded from the top of the table *except* when T and KL are *both greater* than 90 degrees.

Rule 2. When L and L' are different names, the following procedures are applicable:

a. When T is *greater* than 90 degrees, select the K value from the bottom of the table. When T is *less* than 90 degrees, select the K value from the top of the table.

b. Record ∠ B from the bottom of the table except when KL is *greater* than 180 degrees.

c. D arc is recorded from the bottom of the table *except* when T and KL are both *less* than 90 degrees.

d. When KL exceeds 180 degrees, subtract 180 degrees before making a table computation.

Rule 3. Computation of ∠ B.

a. When the initial position is in the *Northern Hemisphere* and is *west* of the final position, ∠ B is the true bearing. If the initial position is *east* of the final position, ∠ B is subtracted from 360 degrees to obtain the true bearing.

b. When the initial position is in the *Southern Hemisphere* and is *west* of the final position, subtract ∠ B from 180 degrees. If the initial position is *east* of the final position, add 180 degrees to ∠ B to obtain the true bearing.

Great Circle Azimuth and Distance Work Sheet

To facilitate the computation process, a GCAD work sheet is illustrated in Figure 9-25. It is divided into a heading and the step-by-step procedure for determining true azimuth and distance. An explanation of the work sheet and the GCAD formula follows.

The heading contains the latitude and longitude of the direction finding site and the selected check station, containing abbreviations—

- FROM: The name of the DF site.
- LAT or L: The latitude of the DF site.
- LONG: The longitude of the DF site.
- TO: The name of the target station.
- LAT' or L': The latitude of the target station.
- LONG': The longitude of the target station.
- T : To determine T, one of the following two rules is applicable and must be followed.

Rule 1. If LONG and LONG' are in the same hemisphere (same names), *subtract* to determine the T value.

Rule 2. If LONG and LONG' are in different hemispheres (different names), *add* to determine the T value.

FROM: name of DF site TO: name of Target Station

LAT: DF site Latitude LAT': Target Station Latitude

LONG: DF site Longitude LONG': Target Station Longitude

T is determined by the following conditions: If long and long' are the same name SUBTRACT. If long and long' are different names ADD.

T ____

DEGREES/MINUTES	COL-1 (ADD)	COL-2 (SUBTRACT)	COL-3 (ADD)	COL-4 (SUBTRACT)
T:	A:			
L':	B:	A:		
	A:	B:	B:	A:
K:		A:		
L:				
KL:			B:	
D ARC:			B:	A:
60 X DEGREES				A:
+ MINUTES +				<B
TOTAL				
TRUE AZIMUTH				

If other logarithm tables are used instead of dead-reckoning altitude and azimuth tables, column A equates to log cosecant, and column B equates to log secant.

Figure 9-25. GCAD work sheet explanation.

The remainder of the work sheet is divided into the degrees/minutes column and column-1 through column-4. The mathematical function is indicated at the top of each column. Logarithms are entered at the spaces ***A*** and ***B*** beginning with column-1 and the appropriate function performed. If other logarithm tables are used instead of the dead-reckoning altitude and azimuth table, column A will equate to the log cosecant. Column B will equate to the log secant. Prior to beginning the computation, enter the T value in the appropriate space under the degrees/minutes column. Complete the work sheet as follows:

COL-1.

- Locate the T value in the dead-reckoning altitude and azimuth table (Appendix B). Enter the figure found under the corresponding A column in the appropriate space under COL-1.
- Enter L' in the appropriate space under the DEGREES/MINUTES column.
- Locate the L' value in the table. Enter the corresponding B column number in the appropriate space under COL-1.
- Add the COL-1 A and B values. Enter the results under the final A space in COL-1.

COL-2.

- Locate the L' value in the table. Enter the corresponding A column figure in the appropriate space under COL-2.
- Locate the COL-1 final A value in the table. Enter the corresponding B figure in the appropriate space under COL-2.
- Subtract the COL-2 B value from the COL-2 value. The result is entered as the final COL-2 A value.
- Locate the final COL-2 A value in the table. The corresponding degrees and minutes will be entered as the K value under the DEGREES/MINUTES column.

NOTE:
Before the K value is determined, refer to special rules 1 or 2. Determine which rule is applicable to the GCAD computation.

COL-3.

- The first COL-3 B value is a repeat of the COL-2 B value.
- Enter the L or LAT in the appropriate space under the DEGREES/MINUTES column.
- Determine the KL value under the DEGREES/MINUTES column. *Subtract* the L or LAT value from the K value if they are the same name. If they are different names, *add K and L*
- Locate the KL value in the table. Enter the corresponding B column value in the appropriate COL-3 space.

NOTE:
If rule 2 is applicable to the computation, and the KL value exceeds 180 degrees, subtract 180 degrees before entering the table.

- Add the COL-3 values. Enter the result as the final COL-3 B value.
- Locate the final COL-3 B value in the table. Enter the corresponding degrees and minutes as the D arc value under the DEGREES/MINUTES column.

NOTE:
Refer to applicable rule to determine if the D arc value is taken from the top or the bottom of the table.

COL-4.

- The first COL-4 A value is a repeat of the final COL-1 A value.
- Locate the final COL-3 B value in the table. Enter the corresponding A value **in** the **appropriate** COL-4 A space.
- Subtract the COL-4 A values and enter the difference in the space provided.
- Locate the final COL-4 A value in the table. Enter the corresponding degrees and minutes as the COL-4 ∠ B value.

NOTE:
Again refer to the applicable rule. Determine if ∠ B is taken from the top or the bottom of the table. Determine if that value is the true azimuth.

Distance. To compute the great circle azimuth distance—

- Multiply the number of D arc degrees by 60.
- Add the D arc minutes to the result. The sum indicates the distance in nautical miles. To obtain statute miles, multiply the nautical miles by 1.15.

Great Circle Azimuth and Distance Example. Determine the great circle azimuth and distance from Needham's Villa, USA, to London, England. The necessary coordinates are in Figure 9-26. Before beginning the computation, determine which rule is applicable. Since LONG and LONG' are the same name—west—rule 1 applies.

STEP 1. Determine the T value. Since LONG and LONG' are the same name—west—subtract to find the difference.

Needham's Villa LONG:	71° 36'
London, England LONG':	00° 05'
T	71° 31'

STEP 2. Locate the T value, 71 degrees 31 minutes, in the dead-reckoning altitude and azimuth table. The corresponding COL-1 A value from the table is 2300 (Figure 9-27).

FROM: Needham's Villa TO: London, England

LAT: 42° 33' North LAT': 51° 32' North

LONG: 71° 36' West LONG': 00° 05' West

T is determined by the following conditions: If long and long' are the same name SUBTRACT. If long and long' are different names ADD.

T 71° 31'

Figure 9-26. Entering initial information on work sheet.

	70°00' A B	70°30' A B	71°00' A B	71°30' A B	72°00' A B	
0	2701.....46595	2565.....47650	2433.....48736	2304.....49852	2179.....51002	30
	2699.....46612	2563.....47668	2431.....48754	2302.....49871	2177.....51021	
1	2697.....46630	2561.....47686	[illegible]	2300.....49890	2175.....51041	29
	2694.....46647	2559.....47704	[illegible]	2298.....49909	2173.....51060	
2	2692.....46664	[illegible]	[illegible]	2296.....49928	2171.....51080	28
	2690.....46682	[illegible]	[illegible]	2294.....49947	2169.....51099	
3	2688.....46699	[illegible]	2420.....48846	2292.....49966	2167.....51119	27
	[illegible]	[illegible]	2418.....48864	2290.....49985	2165.....51138	
4	[illegible]	[illegible]	2416.....48883	2287.....50004	2163.....51158	26
	[illegible]	[illegible]	2413.....48901	2285.....50023	2161.....51177	
5	[illegible]	[illegible]	2411.....48920	2283.....50042	2159.....51197	25
	[illegible]	[illegible]	2409.....48938	2281.....50061	2157.....51216	
6	[illegible]	[illegible]	2407.....48957	2279.....50080	2155.....51236	24

Figure 9-27. *A* value for 71 degrees 31 minutes.

STEP 3. Locate the L' value, 51 degrees 32 minutes, in the table. The corresponding COL-1 B value is 20617 (Figure 9-28).

STEP 4. Add COL-1 A and B values (Figure 9-29). The result or 22917 is the final COL-1 A value.

A: 2300
B: + 20617
22917

	50°00' A B	50°30' A B	51°00' A B	51°30' A B	A	
0	11575....19193	11259....19649	10950....20113	10646....20585	10347..	
	11569....19201	11254....19657	10945....20121	10640....20593	10342..	
1	11564....19208	11249....19664	10939....20128	10635....20601	1033	
	11559....19216	11244....19672	10934....20136	10630....20609		
2	11553....19223	11239....19680	10929....20144	10625....20617	10327....21098	28
	11548....19231	11233....19687	10924....20152	10620....20625	10322....21106	
3	11543....10238	11228....19695	10919....20160	10615....20633	10317....21114	27
	11537....19246	11223....19703	10914....20167	10610....20641	10312....21122	
4	11532....19253	11218....19710	10909....20175	10605....20649	10307....21131	26
	11527....19261	11213....19718	10904....20183	10600....20657	10302....21139	
5	11522....19269	11207....19726	10899....20191	10595....20665	10298....21147	25
	11516....19276	11202....19733	10894....20199	10590....20672	10293....21155	
6	11511....19284	11197....19741	10888....20207	10585....20680	10288....21163	24
	11506....19291	11192....19749	10883....20214	10580....20688	10283....21171	
7	11501....19299	11187....19756	10878....20222	10575....20696	10278....21179	23
	11495....19306	11181....19764	10873....20230	10570....20704	10273....21187	
8	11490....19314	11176....19772	10868....20238	10565....20712	10268....21195	22
	11485....19321	11171....19779	10863....20246	10560....20720	10263....21204	
9	11479....19329	11166....19787	10858....20254	10555....20728	10258....21212	21
	11474....19337	11161....19795	10853....20261	10550....20736	10253....21220	
10	11469....19344	11156....19803	10848....20269	10545....20744	10248....21228	20
	11464....19352	11150....19810	10843....20277	10540....20752	10243....21236	

Figure 9-28. *B* value for 51 degrees 32 minutes.

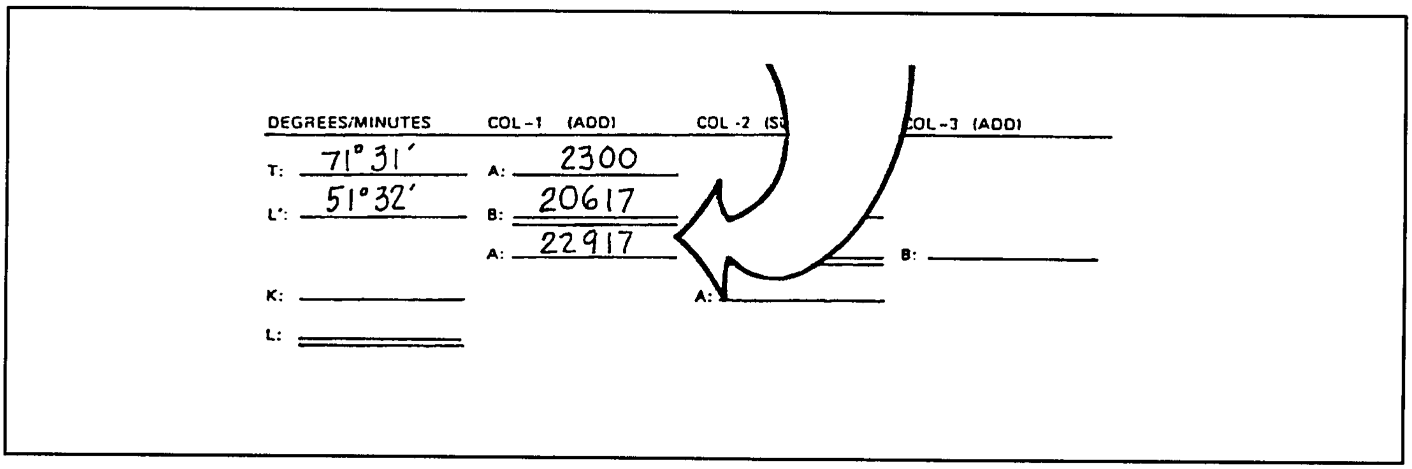
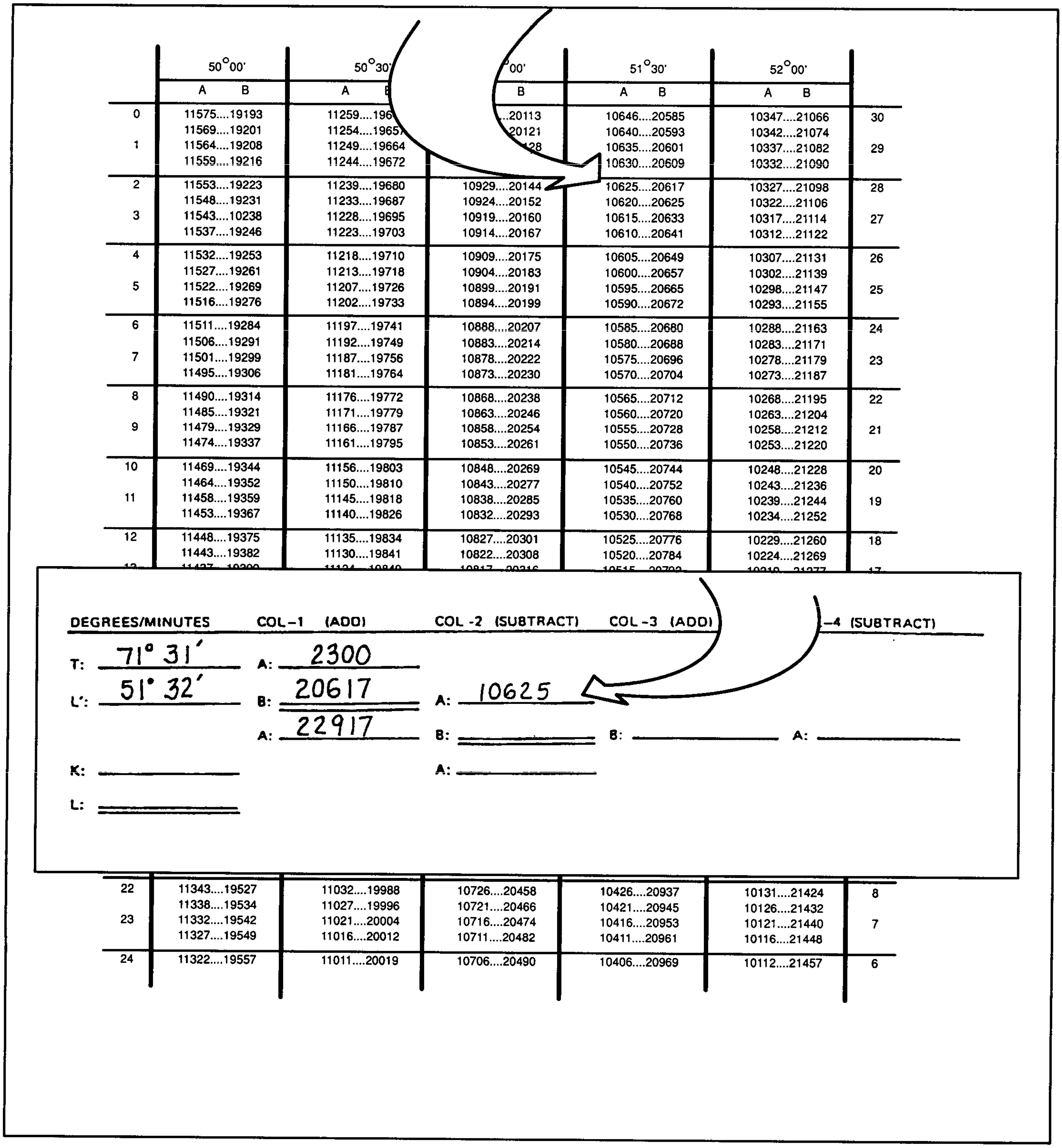


Figure 9-29. Final COL-1 *A* value.

STEP 5. Locate the L' value, 51 degrees 32 minutes, in the table (Figure 9-30). The corresponding COL-2 A value is 10625.



	50°00' A B	50°30' A B	51°00' A B	51°30' A B	52°00' A B	
0	11575....19193	11259....196	..20113	10646....20585	10347....21066	30
	11569....19201	11254....1965	20121	10640....20593	10342....21074	
1	11564....19208	11249....19664	28	10635....20601	10337....21082	29
	11559....19216	11244....19672		10630....20609	10332....21090	
2	11553....19223	11239....19680	10929....20144	10625....20617	10327....21098	28
	11548....19231	11233....19687	10924....20152	10620....20625	10322....21106	
3	11543....10238	11228....19695	10919....20160	10615....20633	10317....21114	27
	11537....19246	11223....19703	10914....20167	10610....20641	10312....21122	
4	11532....19253	11218....19710	10909....20175	10605....20649	10307....21131	26
	11527....19261	11213....19718	10904....20183	10600....20657	10302....21139	
5	11522....19269	11207....19726	10899....20191	10595....20665	10298....21147	25
	11516....19276	11202....19733	10894....20199	10590....20672	10293....21155	
6	11511....19284	11197....19741	10888....20207	10585....20680	10288....21163	24
	11506....19291	11192....19749	10883....20214	10580....20688	10283....21171	
7	11501....19299	11187....19756	10878....20222	10575....20696	10278....21179	23
	11495....19306	11181....19764	10873....20230	10570....20704	10273....21187	
8	11490....19314	11176....19772	10868....20238	10565....20712	10268....21195	22
	11485....19321	11171....19779	10863....20246	10560....20720	10263....21204	
9	11479....19329	11166....19787	10858....20254	10555....20728	10258....21212	21
	11474....19337	11161....19795	10853....20261	10550....20736	10253....21220	
10	11469....19344	11156....19803	10848....20269	10545....20744	10248....21228	20
	11464....19352	11150....19810	10843....20277	10540....20752	10243....21236	
11	11458....19359	11145....19818	10838....20285	10535....20760	10239....21244	19
	11453....19367	11140....19826	10832....20293	10530....20768	10234....21252	
12	11448....19375	11135....19834	10827....20301	10525....20776	10229....21260	18
	11443....19382	11130....19841	10822....20308	10520....20784	10224....21269	
22	11343....19527	11032....19988	10726....20458	10426....20937	10131....21424	8
	11338....19534	11027....19996	10721....20466	10421....20945	10126....21432	
23	11332....19542	11021....20004	10716....20474	10416....20953	10121....21440	7
	11327....19549	11016....20012	10711....20482	10411....20961	10116....21448	
24	11322....19557	11011....20019	10706....20490	10406....20969	10112....21457	6

Figure 9-30. ***A*** **value for 51 degrees 32 minutes.**

STEP 6. Locate the COL-1 final A value, 22917, in the table (Figure 9-3 1). The corresponding COL-2 B value is 9292.

STEP 7. Subtract the COL-2 B value, 9292, from the COL-2 A value—10625. The remainder is 1333 and the final COL-2 A value (Figure 9-32).

A: 10625
B: – 9292
1333

	35°00'	35°30'	36°00'	36°30'	37°00'	
	A B	A B	A B	A B	A B	
0	24141.....8663	23605.....8931	23078.....9204	22561....9482	22054....9765	30
	24132.....8668	23596.....8936	23069.....9209	22553....9487	22045....9770	
1	24123.....8672	23587.....8940	23061.....9213	22544....9492	22037....9775	29
	24114.....8677	23578.....8945	23052.....9218	22536....9496	22029....9779	
2	24105.....8681	23569.....8949	23043.....9223	22527....9501	22020....9784	28
	24096.....8686	23560.....8954	23035.....9227	22519....9505	22012....9789	
3	24087.....8690	23551.....8958	23026.....9232	25510....9510	22003....9794	27
	24078.....8694	23543.....8963	23017.....9236	22501....9515	21995....9798	
4	24069.....8699	23534.....8967	23009.....9241	22493....9520	21987....9803	26
	24060.....8703	23525.....8972	23000.....9246	22484....9524	21978....9808	
5	24051.....8708	23516.....8976	22991.....9250	22476....9529	21970....9813	25
	24042.....8712	23507.....8981	22983.....9255	22467....9534	21962....9818	
6	24033.....8717	23498.....8986	22974.....9259	22459....9538	21953....9822	24
	24024.....8721	23490.....8990	22965.....9264	22450....9543	21945....9827	
7	24015.....8726	23481.....8995	29957.....9269	22442....9548	21937....9832	23
	24006.....8730	23472.....8999	22948.....9273	22433....9552	21928....9837	
8	23997.....8734	23463.....9004	22939.....9278	22425....9557	21920....9841	22
	23988.....8739	23454.....9008	22931.....9282	22416....9562	21912....9846	
9	23979.....8743	23446.....9013	22922.....9287	22408....9566	21903....9851	21
	23970.....8748	23437.....9017	22913.....9292	22399....9571	21895....9856	
10	23961.....8752	2342[illegible]	22905.....9296	22391....9576	21887....9861	20
	23952.....8757	23[illegible]6	22896.....9301	22382....9581	21878....9865	
11	23943.....8761	2[illegible]1	22887.....9305	22374....9585	21870....9870	19
	23934.....8766	2[illegible]5	22879.....9310	22366....9590	21862....9875	
12	23925.....8770	23[illegible]	22870.....9315	22357....9595	21853....9880	18
	23916.....8775	233[illegible]	22862.....9319	22349....9599	21845....9885	

Figure 9-31. *A* value of 22917.

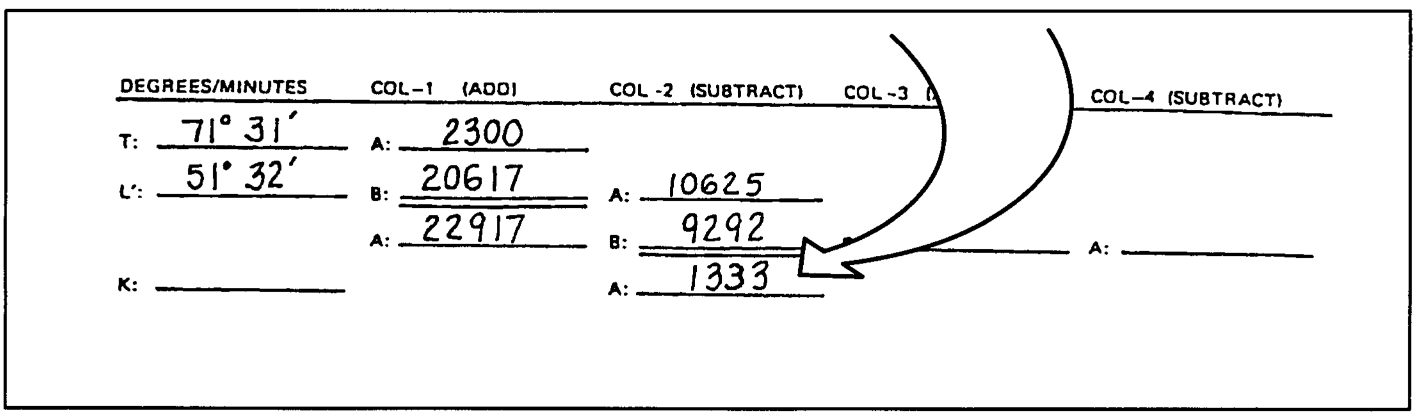


Figure 9-32. Final COL-2 *A* value.

STEP 8. Locate the final COL-2 A value, 1333, in the table. The corresponding degrees and minutes, 75 degrees 52 minutes 30 seconds, represents the K value (Figure 9-33).

NOTE:
Refer to rule 1a to determine if K is selected from the top or the bottom of the table.

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	75°00'	75°30'	76°00'	76°30'	77°00'	
	A B	A B	A B	A B	A B	
0	1506.....58700	1406.....60140	1310.....61632	1217.....63181	1128.....64791	30
	1504.....58724	1404.....60164	1308.....61658	1215.....63208	1126.....64819	
1	1502.....58748	1403.....60189	1306.....61683	1214.....63234	1125.....64846	29
	1500.....58771	1401.....60213	1305.....61709	1212.....63260	1123.....64873	
2	1499.....58795	1399.....60238	1303.....61734	1211.....63287	1122.....64901	28
	1497.....58818	1398.....60262	1301.....61759	1209.....63313	1120.....64928	
3	1495.....58842	1396.....60287	1300.....61785	1208.....63340	1119.....64956	27
	1494.....58866	1394.....60311	1299.....61810	1206.....63366	1117.....64983	
14	1459.....59366	1360.....60830	1266.....62348	1175.....63925	1087.....65564	16
	1457.....593[illegible]	1359.....60855	1264.....62374	1173.....63952	1086.....65592	
15	1455	[illegible]	[illegible]	63978	1084.....65620	
19					10[illegible]	
20	1439.....[illegible]	1341.....61129	1247.....62659	1157.....64248	1070.....65900	10
	1437.....59679	1340.....61154	1246.....62685	1155.....64275	1069.....65928	
21	1435.....59703	1338.....61179	1244.....62711	1154.....64302	1067.....65957	9
	1434.....59727	1336.....61204	1243.....62737	1152.....64329	1066.....65985	
22	1432.....59751	1335.....61229	1241.....62763	1151.....64356	1064.....66013	8
	1430.....59775	1333.....61254	1240.....62789	1150.....64383	1063.....66041	
23	1429.....[illegible]	1332.....61279	1238.....62815	1148.....64410	1061.....66069	7
	142[illegible]	1330.....61304	1237.....62841	1147.....64437	1060.....66098	
24	142[illegible]	1329.....61330	1235.....62867	1145.....64464	1059.....66126	6
	142[illegible]	1327.....61355	1234.....62893	1144.....64491	1057.....66154	

DEGREES/MINUTES	COL-1 (ADD)	COL-2 (SUBTRACT)	COL-3 (ADD)	COL-4 (SUBTRACT)
T: 71° 31'	A: 2300			
L': 51° 32'	B: 20617	A: 10625		
	A: 22917	B: 9292	B:	A:
K: 75° 52' 30"		A: 1333		
L:				

Figure 9-33. Determining *K* value.

STEP 9. Record the first COL-3 B value as 9292 (Figure 9-34 ①). It is a repeat of the COL-2 B value.

STEP 10. Enter the value for LAT, or 42 degrees 33 minutes, under the DEGREES / MINUTES column in the appropriate space (Figure 9-34 ②).

STEP 11. Determine the value for KL by subtracting LAT, 42 degrees 33 minutes, from the K value of 75 degrees 52 minutes 30 seconds. The remainder is 33 degrees 19 minutes 30 seconds (Figure 9-34③).

K:	75 degrees 52 minutes 30 seconds
L:	– 42 degrees 33 minutes
KL	= 33 degrees 19 minutes 30 seconds

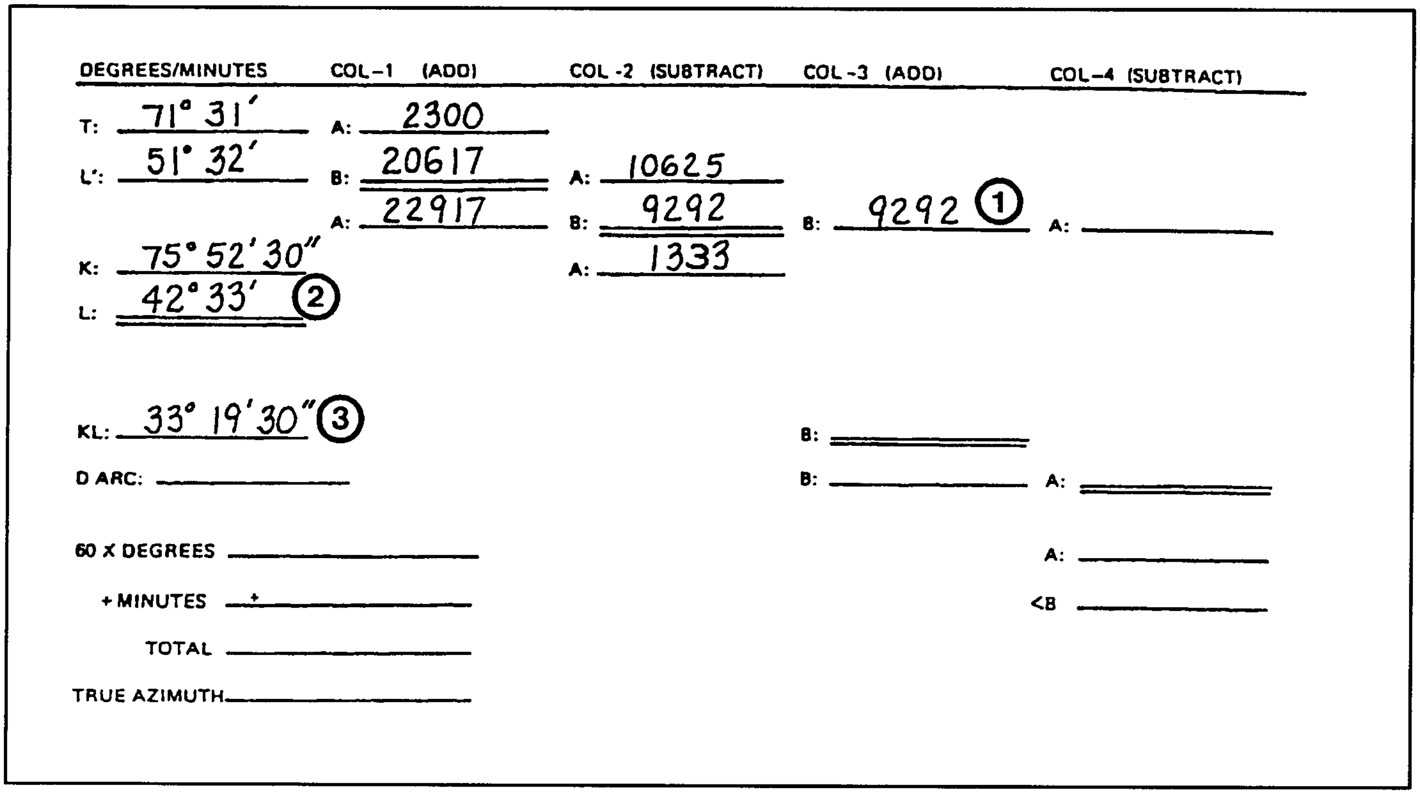
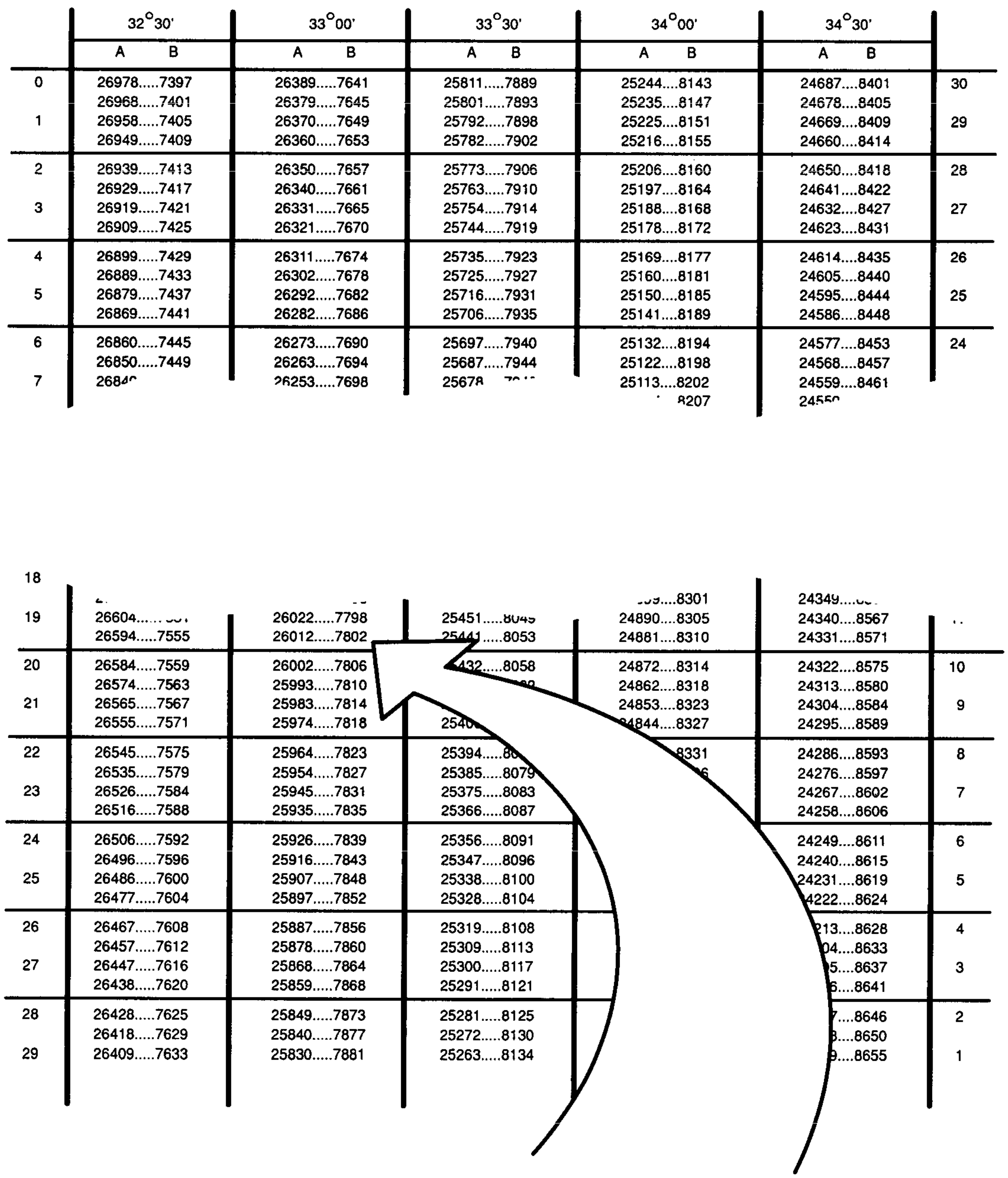


Figure 9-34. Work sheet entries.

STEP 12. Locate the KL value, 33 degrees 19 minutes 30 seconds, in the table. The corresponding B value is 7802 (Figure 9-35).



	32°30' A B	33°00' A B	33°30' A B	34°00' A B	34°30' A B	
0	26978.....7397	26389.....7641	25811.....7889	25244....8143	24687....8401	30
	26968.....7401	26379.....7645	25801.....7893	25235....8147	24678....8405	
1	26958.....7405	26370.....7649	25792.....7898	25225....8151	24669....8409	29
	26949.....7409	26360.....7653	25782.....7902	25216....8155	24660....8414	
2	26939.....7413	26350.....7657	25773.....7906	25206....8160	24650....8418	28
	26929.....7417	26340.....7661	25763.....7910	25197....8164	24641....8422	
3	26919.....7421	26331.....7665	25754.....7914	25188....8168	24632....8427	27
	26909.....7425	26321.....7670	25744.....7919	25178....8172	24623....8431	
4	26899.....7429	26311.....7674	25735.....7923	25169....8177	24614....8435	26
	26889.....7433	26302.....7678	25725.....7927	25160....8181	24605....8440	
5	26879.....7437	26292.....7682	25716.....7931	25150....8185	24595....8444	25
	26869.....7441	26282.....7686	25706.....7935	25141....8189	24586....8448	
6	26860.....7445	26273.....7690	25697.....7940	25132....8194	24577....8453	24
	26850.....7449	26263.....7694	25687.....7944	25122....8198	24568....8457	
7	[illegible]	26253.....7698	[illegible]	25113....8202	24559....8461	
				[illegible]8207	[illegible]	
18				[illegible]8301	[illegible]	
19	[illegible]	26022.....7798	[illegible]	24890....8305	24340....8567	
	26594.....7555	26012.....7802	[illegible]8053	24881....8310	24331....8571	
20	26584.....7559	26002.....7806	[illegible]432.....8058	24872....8314	24322....8575	10
	26574.....7563	25993.....7810	[illegible]	24862....8318	24313....8580	
21	26565.....7567	25983.....7814	[illegible]	24853....8323	24304....8584	9
	26555.....7571	25974.....7818	[illegible]	[illegible]844....8327	24295....8589	
22	26545.....7575	25964.....7823	[illegible]	[illegible]8331	24286....8593	8
	26535.....7579	25954.....7827	25385.....807[illegible]	[illegible]	24276....8597	
23	26526.....7584	25945.....7831	25375.....8083		24267....8602	7
	26516.....7588	25935.....7835	25366.....8087		24258....8606	
24	26506.....7592	25926.....7839	25356.....8091		24249....8611	6
	26496.....7596	25916.....7843	25347.....8096		24240....8615	
25	26486.....7600	25907.....7848	25338.....8100		24231....8619	5
	26477.....7604	25897.....7852	25328.....8104		[illegible]4222....8624	
26	26467.....7608	25887.....7856	25319.....8108		[illegible]13....8628	4
	26457.....7612	25878.....7860	25309.....8113		[illegible]04....8633	
27	26447.....7616	25868.....7864	25300.....8117		[illegible]5....8637	3
	26438.....7620	25859.....7868	25291.....8121		[illegible]6....8641	
28	26428.....7625	25849.....7873	25281.....8125		[illegible]7....8646	2
	26418.....7629	25840.....7877	25272.....8130		[illegible]....8650	
29	26409.....7633	25830.....7881	25263.....8134		[illegible]....8655	1

Figure 9-35. *B* value for 33 degrees 19 minutes 30 seconds.

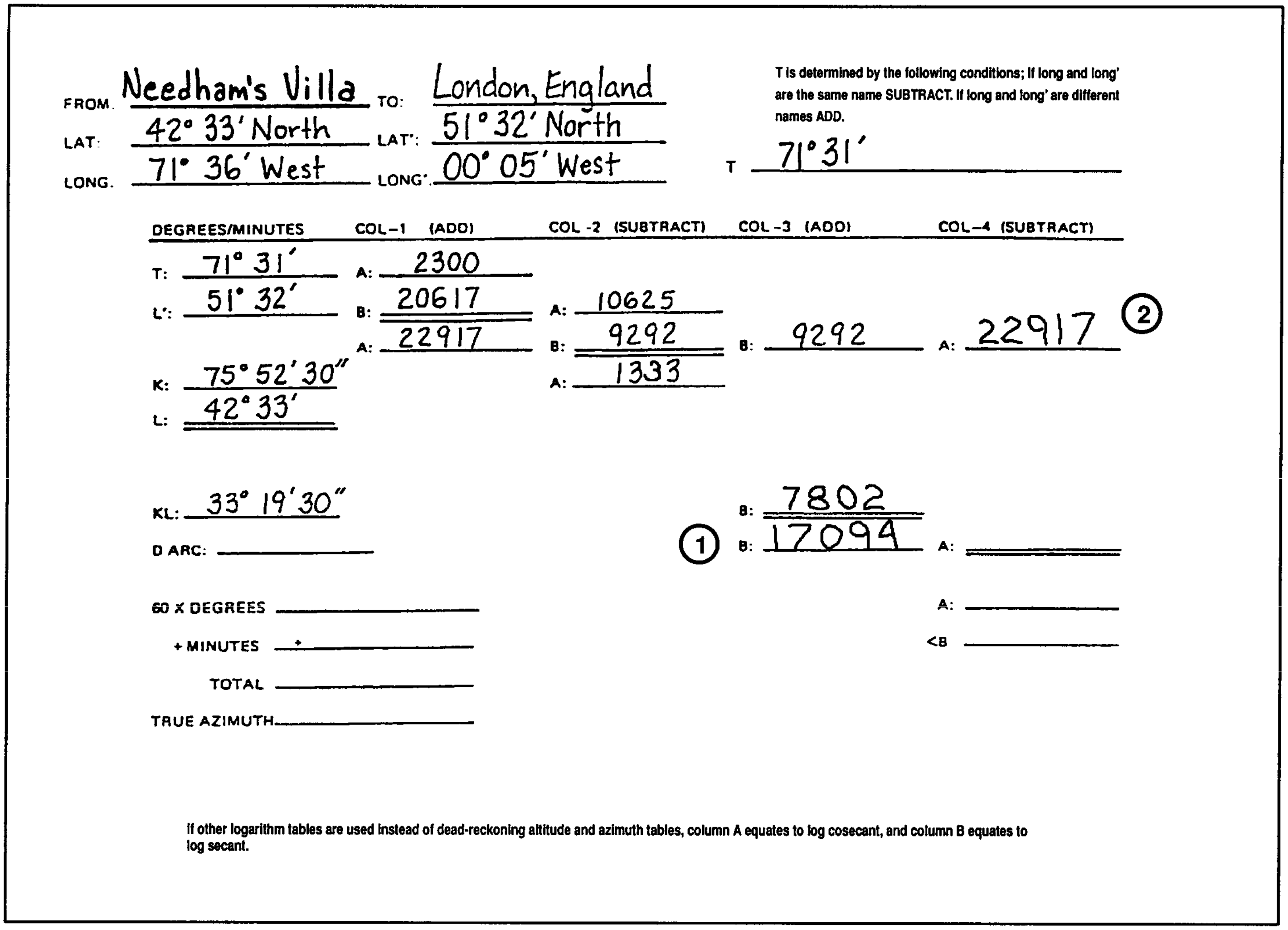
STEP 13. Add the COL-3 B values. The sum and final B value is 17094 (Figure 9-36 ①).

B: 9292

B: + 7802

B =17094

STEP 14. Record the first COL-4 A value as 22917 (Figure 9-36 ②). It is a repeat of the final COL-1 A value.



FROM: Needham's Villa TO: London, England

LAT: 42° 33' North LAT': 51° 32' North

LONG: 71° 36' West LONG': 00° 05' West

T is determined by the following conditions; If long and long' are the same name SUBTRACT. If long and long' are different names ADD.

T 71° 31'

DEGREES/MINUTES	COL-1 (ADD)	COL-2 (SUBTRACT)	COL-3 (ADD)	COL-4 (SUBTRACT)
T: 71° 31'	A: 2300			
L': 51° 32'	B: 20617	A: 10625		
	A: 22917	B: 9292	B: 9292	A: 22917 ②
K: 75° 52' 30"		A: 1333		
L: 42° 33'				
KL: 33° 19' 30"			B: 7802	
D ARC:			① B: 17094	A:
60 X DEGREES				A:
+ MINUTES +				<B
TOTAL				
TRUE AZIMUTH				

If other logarithm tables are used instead of dead-reckoning altitude and azimuth tables, column A equates to log cosecant, and column B equates to log secant.

Figure 9-36. GCAD work sheet entries.

STEP 15. Locate the COL-3 final B value, 17094, in the table (Figure 9-37 (1)). The corresponding COL-4 A value is 13185.

STEP 16. Subtract the COL-4 A value, 13185 (Figure 9-37 (2)), from the 22917. The final COL-4 value is 9732 (Figure 9-37 (3)).

A:		22917
A:	–	13185
A	=	9732

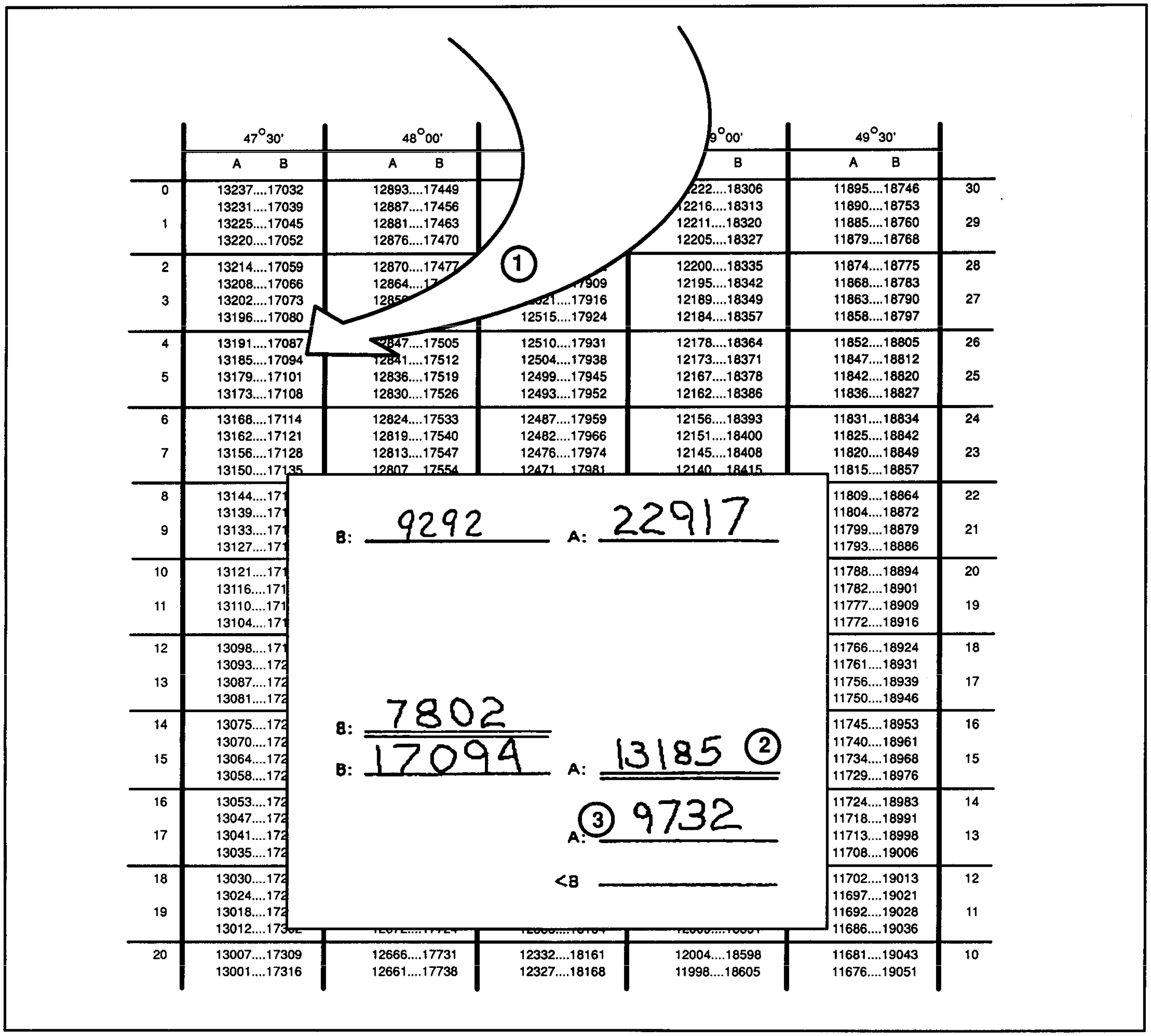


Figure 9-37. Determining COL-4 entries.

STEP 17. Locate the COL-4 final A value, 9732, in the table (Figure 9-38). Again refer to rule 1 and determine if ∠ B is taken from the top or the bottom of the table. Since K is greater than L, ∠ B is selected from the top of the table. Therefore, ∠B or the true azimuth from Needham's Villa to London, England, is 53 degrees 03 minutes 30 seconds. Refer to rule 3 and determine if ∠ B is the true bearing. The initial position is west of the final position. Therefore, 53 degrees 03 minutes 30 seconds is the true azimuth.

	52°30' A B	53°00' A B	53°30' A B	54°00' A B	54°30' A B	
0	10053....21555	9765.....22054	9482.....22561	9204.....23078	8931.....23605	30
	10049....21563	9760.....22062	9477.....22570	9200.....23087	8927.....23613	
1	10044....21572	9756.....22070	9473.....22578	9195.....23095	8922.....23622	29
	10039....21580	9751.....22079	9468.....22587	9190.....23104	8918.....23631	
2	10034....21588	9746.....22087	9463.....22595	9186.....23113	8913.....23640	28
	10029....21596	9741.....22096	9459.....22604	9181.....23122	8909.....23649	
3	10024....21605	9737.....22104	9454.....22612	9177.....23130	8904.....23658	27
	10019....21613	9732.		9172.....23139	8900.....23667	
4	10015....21621	9727.			8895.....23675	26
	10010....21629	9722.....	9440.....		8891.....23684	
5	10005....21638	9718.....22138	9435.....22647		8886.....23693	25
	10000....21646	9713.....22146	9431.....22655		8882.....23702	
6	9995.....21654	9708.....22154	9426.....22664		77.....23711	24
	9990.....21662	9703.....22163	9421.....22672		23720	
7	9986.....21671	9699.....22171	9417.....22681		23729	23
	9981.....21679	9694.....22180	9412.....22690		23738	
8	9976.....21687	9689.....22188	9407.....22698		23747	22
	9971.....21696	9684.....22197	9403.....22707		23755	
9	9966.....21704	9680.....22205	9398.....22715		0.....23764	21
	9962.....21712	9675.....22213				
10	9957.....21720	9670.....22222				
	9952.....21729	9665.....22230				
11	9947.....21737	9661.....22239				
	9942.....21745	9656.....22247				
12	9937.....21754	9651.....22256				
	9933.....21762	9647.....22264				
13	9928.....21770	9642.....22272				
	9923.....21778	9637.....22281				
14	9918.....21787	9632.....22289				
	9913.....21795	9628.....22298				
15	9909.....21803	9623.....22306				
	9904.....21812	9618.....22315				
16	9899.....21820	9614.....22323				
	9894.....21828	9609.....22332				
17	9889.....21837	9604.....22340				
	9885.....21845	9599.....22349				
18	9880.....21853	9595.....22357				
	9875.....21862	9590.....22366				
19	9870.....21870	9585.....22374				
	9865.....21878	9581.....22382	9301.....22896	9026.....23419	8757.....23952	
20	9861.....21887	9576.....22391	9296.....22905	9022.....23428	8752.....23961	10
	9856.....21895	9571.....22399	9292.....22913	9017.....23437	8748.....23970	
21	9851.....21903	9566.....22408	9287.....22922	9013.....23446	8743.....23979	9
	9846.....21912	9562.....22416	9282.....22931	9008.....23454	8739.....23988	

B: 7802
B: 17094
A: 13185
A: 9732
<B 53° 03'30"

Figure 9-38. Determining ∠ B.

STEP 18. To determine D arc, locate the final COL-3 B value, 17094, in the table (Figure 9-39 (1)). Refer to rule 1 to determine if D arc is taken from the top or the bottom of the table. Since T and KL are both less than 90 degrees, D arc is taken from the top of the table. It is 47 degrees 34 minutes 30 seconds (Figure 9-39 (2)).

STEP 19. To compute the distance from the initial to the final position in nautical miles, multiply D arc by 60. To obtain statute miles, multiply the total nautical miles by 1.15.

D arc = 47 degrees 34 minutes 30 seconds

47 × 60 = 2820 (Figure 9-39 (3))

\+ 34.5 (Figure 9-39 (4))

Total nautical miles = 2854.5 (Figure 9-39 (5))

× 1.15

142725

28545

28545

Total statute miles = 3282.675

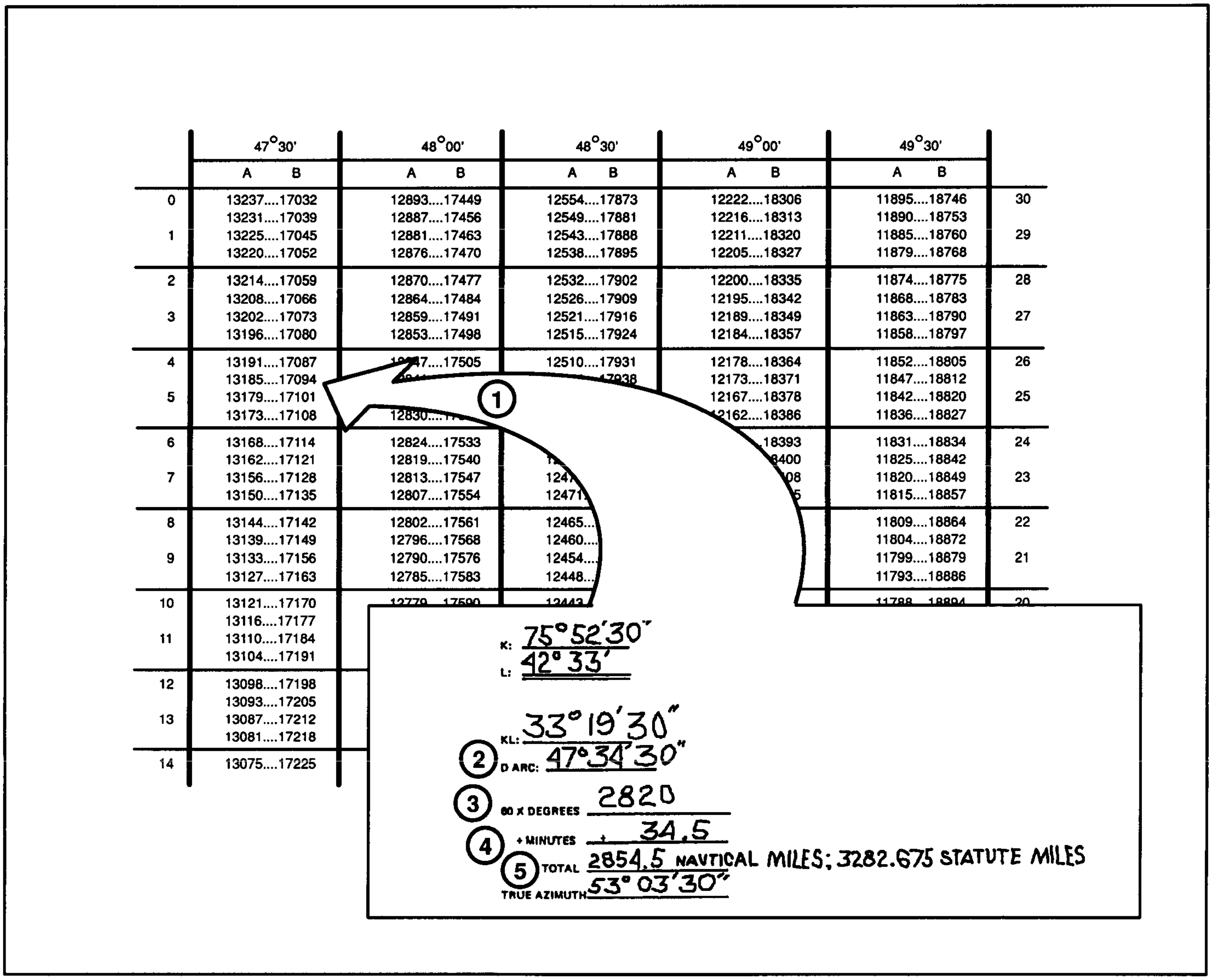


Figure 9-39. Determining D arc and total distance.

STATISTICAL FACTORS

Statistical analysis is an invaluable management tool for measuring direction finding performance. An estimate of the amount of error found in individual bearings is provided through the proper application of statistics. The probable amount of error of the DF site or even the complete DF net can also be determined. Normally, plotting and evaluation centers are responsible for performing accuracy studies. However, direction finding supervisors and analysts must be knowledgeable of statistical analysis procedures. They must be able to compute the analytical computations outlined in this section.

Systematic Error

Systematic error represents the difference between the true bearing and the mean bearing of a transmitter. The true bearing is determined by computing a great circle azimuth from the DF site to the selected target station. The average bearing is determined by taking a large number of bearings on the selected transmitter-a minimum of 200-and computing the average or mean bearing of the sample.

The following criteria is considered when selecting a check station:

- The frequency should be compatible with operational targets.
- The location should be within the area of interest or within a very close proximity.
- The distance should not be significantly different from that of operational targets.

The following definitions are used:

- Bearing mean (BM) is the mean bearing between the DF site and the selected check station.
- Bearing true (BT) is the true bearing between the DF site and the selected check station.

NOTE: Systematic error is computed using the formula:

SE= BM minus BT

The following steps outline the procedure for computing the systematic error:

STEP 1. Visually inspect the reported bearings. Eliminate the wild bearings. (A wild bearing is considered plus or minus 8 degrees from the *true* bearing.)

STEP 2. Mathematically compute the mean bearing from the remaining bearings.

STEP 3. Determine the difference between the mean and true bearings. The difference is the systematic error.

NOTE: Systematic error must always be expressed as a negative or positive error. If the mean bearing is smaller than the true bearing, the error is negative. However if the mean bearing is larger than the true bearing, the error is positive.

The following example illustrates the computation of systematic error using the formula **SE = BM - BT.** The true azimuth of the check station is 029 degrees. The following bearings were observed on the selected check station: 028, 034, 013, 023, 029, 036, 058, 029, 032, 035, 033, 038, 021, 028, 031, 027, and 031 degrees.

NOTE: In practical applications, at least 200 bearings must be obtained on the selected check station.

STEP 1. Inspect all reported bearings to ensure there are no wild bearings. In this example, 013, 038, and 058 degrees are wild; they are removed from our computation.

STEP 2. Compute the mean bearing.

028°	033°
034°	0210
023°	028°
029°	031°
036°	027°
029°	<u>031°</u>
032°	417° divided by 14 = 29.7857 degrees
035°	

STEP 3. Determine the difference between the mean and true bearings. The difference is the systematic error.

SE = BM-BT
SE = 029.79 -029.0 degrees
SE = +0.79 degrees

Variance

Variance is used as a reliability factor and indicates the quality of bearings used in the computation of the mean bearing. Variance provides the measure of spread or the dispersion of bearings around the mean bearing. The analysis of either site or individual operator variance on selected check stations provides the supervisor with an additional management tool for evaluating efficiency. The formula for computing variance is:

- σ^2 is the symbol for variance.
- Σ indicates the algebraic sum.
- $(BM - BO)^2$ is the bearing observed (BO) subtracted from the mean bearing. The difference or remainder is then squared.
- N is the total number of bearings within plus or minus 8 degrees of the mean bearing.

The following steps outline the procedure for computing variance:

STEP 1. Visually inspect all reported bearings and eliminate the obvious wild bearings.

STEP 2. Mathematically compute the mean bearing from the remaining bearings.

STEP 3. Eliminate any of the remaining bearings which deviate more than plus or minus 8 degrees from the computed mean bearing.

STEP 4. Recompute the mean bearing, if necessary.

STEP 5. Determine the deviation of each observed bearing from the mean bearing. Square each deviation.

STEP 6. Add the squared deviations. Divide the sum by the total number of bearings used. The result is the variance.

NOTE: Due to the squaring process in step 5, the negative sign no longer applies.

For example, the following bearings were observed on a selected check station: 330, 326, 333, 334, 325, 331, 330,329,328, and 334 degrees.

NOTE: In practical applications, at least 200 bearings must be obtained on the selected check station.

STEP 1. A visual inspection proves there are no obvious wild bearings.

STEP 2. Compute the mean bearing.

STEPS 3 and 4. Since there are no bearings which deviate over plus or minus 8 degrees from the computed mean, proceed to step 5.

STEP 5. Determine the deviation of each observed bearing from the mean bearing. Square each deviation.

BM	BO	Remainder		Squared
330° –	330°	0°	=	0
330° –	326°	4°	=	16
330° –	333°	–3°	=	9
330° –	334°	–4°	=	16
330° –	325°	–5°	=	25
330° –	3310	–1°	=	1
330° –	330°	0°	=	0
330° –	329°	1°	=	1
330° –	328°	2°	=	4
330° –	334°	-4°	=	16

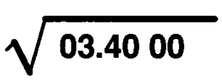
STEP 6. Add the squared deviations and divide by the number of bearings used. The result is the variance.

0
16
9
16
25
1
0
1
4
16
88÷10=8.8
The variance is 8.8

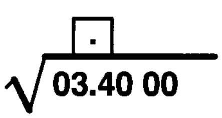
Square Root

Although standard deviation is another direction finding statistical factor, before it can be addressed, it is necessary to be able to manually compute square root. Pocket calculators and other machine aids can perform this function much faster. However, the need for manual computation of square root may arise. The following steps outline the procedure for obtaining the square root of the number 3.4:

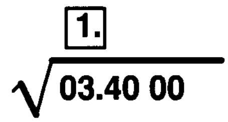
STEP 1. Starting at the decimal point, mark off the digits in pairs in both directions. Add zeros, as necessary.



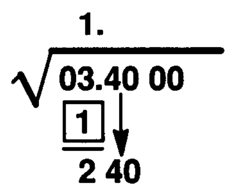
STEP 2. Place the decimal point for the answer directly above the decimal point that appears under the radical sign.



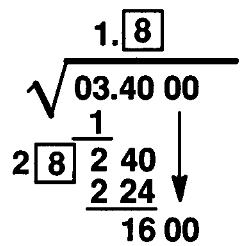
STEP 3. Determine by inspection the largest number that can be squared without exceeding the first pair of digits-03. The answer is 1. This is because the square of any number larger than 1 will be greater than 03, Place the 1 above the first pair of digits.



STEP 4. Multiply 1 by itself. This equals 1. Place the 1 under the 03. Subtract 1 from 03. This equals 2. Then bring down the next pair of digits.



STEP 5. Double the answer or quotient of 1 (1 doubled equals 2). Place the 2 to the immediate left of 240. Determine the number that can be multiplied by 2 and that same number, but do not exceed 240. The answer is 8 since 28 x 8 = 224. (The number 9 would prove to be too large since 29 x 9 = 261.) Place the number 8 to the right of the decimal in the quotient. Subtract the 224 from 240 and bring down the next pair of numbers-00.



STEP 6. Disregarding the decimal point, double the quotient 18, obtaining 36. Place the 36 to the left of the 1600. Determine the number that can be multiplied by 36 and that same number, but do not exceed 1600. The answer is 4 as 364 X 4 = 1456. (The number 5 would be too large since 365 x 5 = 1825.) Place the 4 above the second pair of digits.

```
          1. 8 [4]
       √ 03.40 00
          1
   28     2 40
          2 24
 36[4]      16 00
            14 56
             1 44
```

Depending on the degree of accuracy desired, you can continue the process indefinitely by adding zeros. For direction finding purposes, two places to the right of the decimal are sufficient. The square root of 3.40 is 1.84 or $1.84^2 = 3.3856$.

Standard Deviation

Standard deviation is perhaps the best statistical method of evaluating direction finding site performance. Systematic error is indicative of average error. Standard deviation is a representative of site reliability. Standard deviation is a probability figure which indicates the spread of bearings on one or more targets. In this respect, the smaller the number or SD, the greater the reliability that is attributed to the direction finding site. Standard deviation is computed using the formula:

- BT is the true bearing between the DF site and the selected check station.
- BO is the observed bearing of the selected check station,
- N is the total number of bearings, within plus or minus 8 degrees of the mean bearing, used in the computation.
- $(SE)^2$ is the systematic error squared.

The following steps outline the procedure for computing the standard deviation:

STEP 1. Compute the SE of a selected check station using a minimum of 200 bearings.

STEP 2. For each observed bearing, determine the deviation in degrees from the true bearings. (If the true bearing on the selected check station is not known, a great circle azimuth must be computed.)

STEP 3. Square each deviation.

STEP 4. Add the squared deviations. Divide the sum by the total number of bearings used in the computation, within plus or minus 8 degrees of the mean bearing. This step satisfies the $\frac{(BT-BO)^2}{N}$ portion of the formula.

STEP 5. Square the SE obtained in step 1. Subtract the $(SE)^2$ from the number obtained in step 4.

STEP 6. Compute the square root of the number obtained in step 5. The square root represents the standard deviation of the direction finding site.

The following example illustrates the computation of standard deviation. To prevent a lengthy illustration, only 10 bearings are used. The following information is provided:

SE = -001 degree

BT = 031 degrees

The following bearings were observed on the selected check station: 029, 025, 032, 029, 034, 032, 030, 028, 034, and 027 degrees.

STEP 1. An SE of -001 degree is provided.

STEP 2. Subtract the BO from the BT.

BT	BO		Remainder
0310	– 029°	=	2°
0310	– 025°	=	6°
031°	– 032°	=	–1°
031°	– 029°	=	2°
0310	– 034°	=	-3°
031°	– 032°	=	-10
0310	– 030°	=	1°
031°	– 028°	=	3°
031°	– 034°	=	–3°
031°	– 027°	=	4°

STEP 3. Square the remainder obtained in step 2.

Remainder	Squared
2°	4
6°	36
–10	1
2°	4
–3°	9
–10	1
1°	1
3°	9
–3°	9
4°	16

STEP 4. Add the squared deviations and divide by the total number of bearings used in the computation.

4
36
1
4
9
1
1
9
9
<u>16</u>
90÷10=9

This step satisfies $\frac{(BT-BO)^2}{N}$ portion of the formula.

STEP 5. Square the SE and subtract the result from the number obtained in step 4.

$$\sqrt{9-(SE)^2}$$

$$\sqrt{9-(-001)^2}$$

$$\sqrt{9-1}$$

$$\sqrt{8}$$

STEP 6. Compute the square root.

$$\sqrt{8}$$

```
             2.  8  2
          ____________
         √ 08. 00 00
            4
            -
   48       4 00
            3 84
           -----
  562          16 00
               11 24
               -----
                4 76
```

The standard deviation is 2.82

Standard Deviation/Distance Curve

It is difficult to visualize the effect that distance has on bearings without periodically computing a SD/distance curve for each DF site within the net (Figure 9-40). The SD/distance curve for the SSL varies from those of conventional DF systems because the SSL has a better ability to discriminate against the effects of multipath propagation (Figure 9-4 1). Therefore, at distances beyond 1,000 km (below 10 MHz) and 100 Nm (above 10 MHz), the curve for the SSL continues in a straight line and has no further deviation. The primary reason for the SD/distance curve is to show accurate SD information at the various ranges from each DF site.

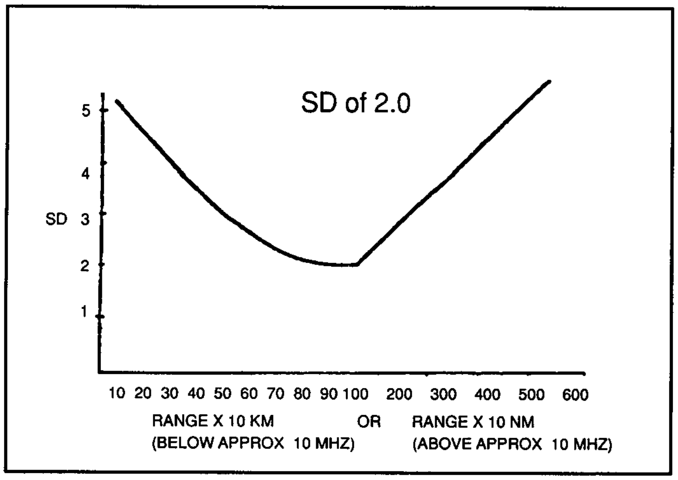


Figure 9-40. SD/distance curve for conventional DF systems.

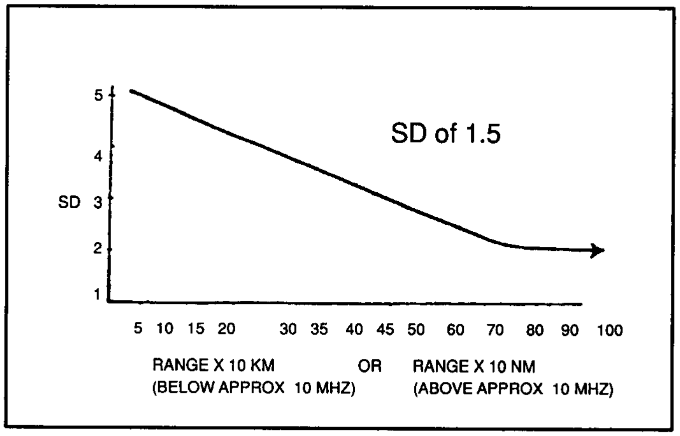


Figure 9-41. SD/distance curve for SSL.

The following formulas are variations taken from the FFIX computer algorithm and should be used to compute SD/distance tables for each site.

For frequencies less than approximately 10 MHz:

SD (.285714 + .714256 R)= range weighted SD where R is greater than or equal to 10.

SD (3 - .402R + .204 R^2) = range weighted SD where R is less than 10.

R is distance in 100 km units.

For frequencies above approximately 10 MHz, use the same formulas and change R to be the distance in 100 Nm units.

Standard Deviation Probability Graph

As stated previously, the statistical measure of SD is dependant on the number and quality of bearings used in the formula (expressed as BM and N). The standard deviation probability graph (Figure 9-42, page 9-38) can be used to calculate the probable accuracy of any data set where the number of bearings (samples) are 1,000 or less. This chart is useful in determining how close an estimated SD will be to the true SD of the site. The vertical axis of the graph represents the total number of samples used to compute the mean bearing (BM). The horizontal axis represents the percentage of accuracy of the BM from the true bearing (BT). The diagonal line represents the percentage of time that the BM will be within the percentage of accuracy which is required.

For example, assume you are working at a site which requires the BM to be accurate to within plus or minus 10 percent of the BT, 80 percent of the time. Locate the accuracy requirement of 10 percent on the bottom horizontal line of the graph. Follow that line upward until it intersects with the diagonal line (Y = .80). This indicates the percentage of time. Now look to the left along the vertical line of the graph and you will see that for such accuracy requirements, a minimum of 90 bearings (samples) must be used in the computation of the BM.

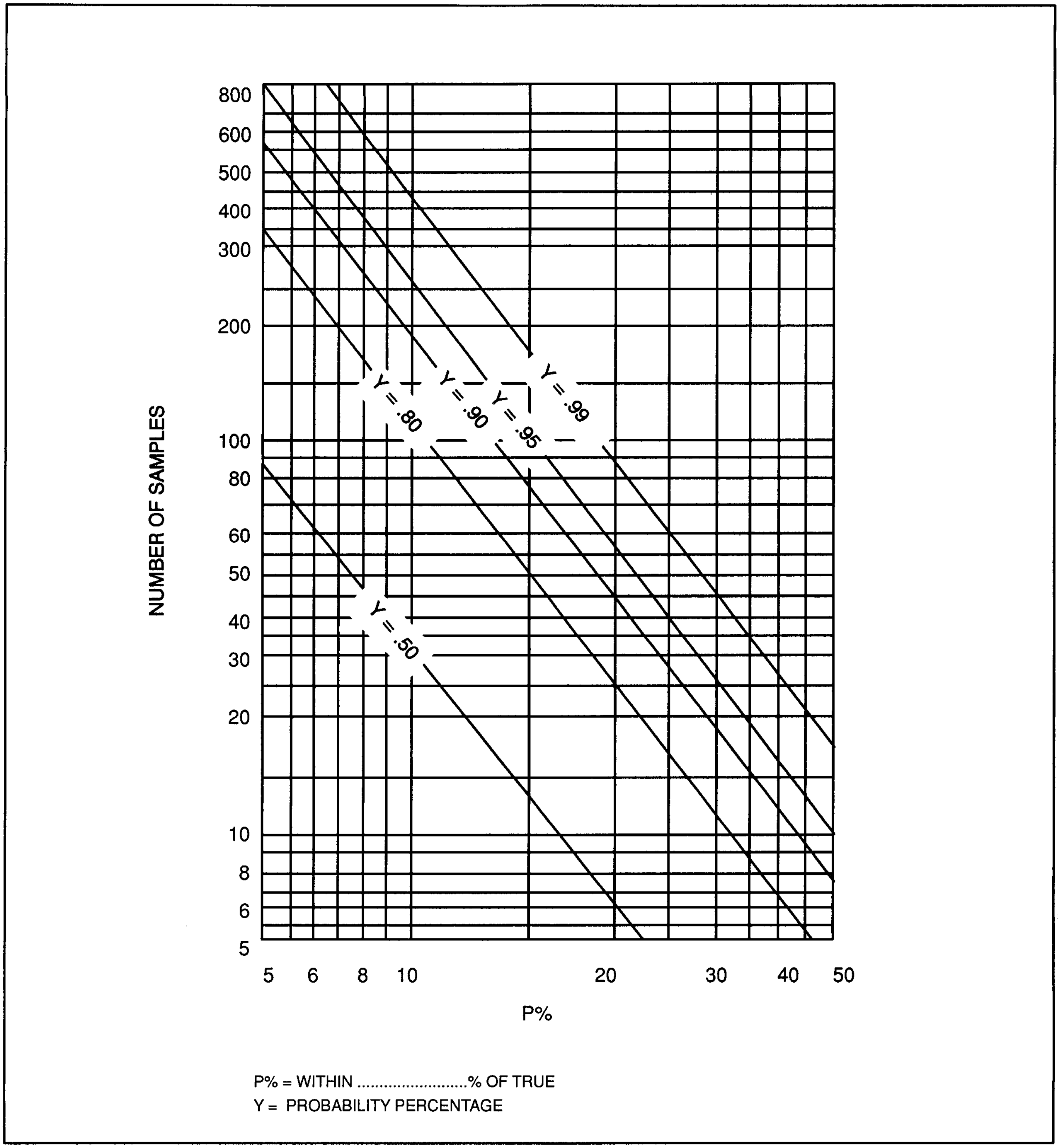


Figure 9-42. SD probability graph.

APPENDIX A

COMMON LOGARITHMS OF FUNCTIONS OF ANGLES IN DEGREES AND MINUTES TABLE

0°..180°	L SIN	D	L TAN	CD	L COT	L COS	
90°..270°	L COS		L COT		L TAN	L SIN	
0	—		—		—	0.00 000	60
1	6.46 373	30103	6.46 373	30103	3.53 627	0.00 000	59
2	6.76 476	17609	6.76 476	17609	3.23 524	0.00 000	58
3	6.94 085	12494	6.94 085	12494	3.05 915	0.00 000	57
4	7.06 579	9691	7.06 579	9691	2.93 421	0.00 000	56
5	7.16 270	7918	7.16 270	7918	2.83 730	0.00 000	55
6	7.24 188	6694	7.24 188	6694	2.75 812	0.00 000	54
7	7.30 882	5800	7.30 882	5800	2.69 118	0.00 000	53
8	7.36 682	5115	7.36 682	5115	2.63 318	0.00 000	52
9	7.41 797	4576	7.41 797	4576	2.58 203	0.00 000	51
10	7.46 373	4139	7.46 373	4139	2.53 627	0.00 000	50
11	7.50 512	3779	7.50 512	3779	2.49 488	0.00 000	49
12	7.54 291	3476	7.54 291	3476	2.45 709	0.00 000	48
13	7.57 767	3218	7.57 767	3219	2.42 233	0.00 000	47
14	7.60 985	2997	7.60 986	2996	2.39 014	0.00 000	46
15	7.63 982	2802	7.63 982	2803	2.36 018	0.00 000	45
16	7.66 784	2633	7.66 785	2633	2.33 215	0.00 000	44
17	7.69 417	2483	7.69 418	2482	2.30 582	9.99 999	43
18	7.71 900	2348	7.71 900	2348	2.28 100	9.99 999	42
19	7.74 248	2227	7.74 248	2228	2.25 752	9.99 999	41
20	7.76 475	2119	7.76 476	2119	2.23 524	9.99 999	40
21	7.78 594	2021	7.78 595	2020	2.21 405	9.99 999	39
22	7.80 615	1930	7.80 615	1931	2.19 385	9.99 999	38
23	7.82 545	1848	7.82 546	1848	2.17 454	9.99 999	37
24	7.84 393	1773	7.84 394	1773	2.15 606	9.99 999	36
25	7.86 166	1704	7.86 167	1704	2.13 833	9.99 999	35
26	7.87 870	1639	7.87 871	1639	2.12 129	9.99 999	34
27	7.89 509	1579	7.89 510	1579	2.10 490	9.99 999	33
28	7.91 088	1524	7.91 089	1524	2.08 911	9.99 999	32
29	7.92 612	1472	7.92 613	1473	2.07 387	9.99 998	31
30	7.94 084	1424	7.94 086	1424	2.05 914	9.99 998	30
31	7.95 508	1379	7.95 510	1379	2.04 490	9.99 998	29
32	7.96 887	1336	7.96 889	1336	2.03 111	9.99 998	28
33	7.98 223	1297	7.98 225	1297	2.01 775	9.99 998	27
34	7.99 520	1259	7.99 522	1259	2.00 478	9.99 998	26
35	8.00 779	1223	8.00 781	1223	1.99 219	9.99 998	25
36	8.02 002	1190	8.02 004	1190	1.97 996	9.99 998	24
37	8.03 192	1158	8.03 194	1159	1.96 806	9.99 997	23
38	8.04 350	1128	8.04 353	1128	1.95 647	9.99 997	22
39	8.05 478	1100	8.05 481	1100	1.94 519	9.99 997	21
40	8.06 578	1072	8.06 581	1072	1.93 419	9.99 997	20
41	8.07 650	1046	8.07 653	1047	1.92 347	9.99 997	19
42	8.08 696	1022	8.08 700	1022	1.91 300	9.99 997	18
43	8.09 718	999	8.09 722	998	1.90 278	9.99 997	17
44	8.10 717	976	8.10 720	976	1.89 280	9.99 996	16
45	8.11 693	954	8.11 696	955	1.88 304	9.99 996	15
46	8.12 647	934	8.12 651	934	1.87 349	9.99 996	14
47	8.13 581	914	8.13 585	915	1.86 415	9.99 996	13
48	8.14 495	896	8.14 500	895	1.85 500	9.99 996	12
49	8.15 391	877	8.15 395	878	1.84 605	9.99 996	11
50	8.16 268	860	8.16 273	860	1.83 727	9.99 995	10
51	8.17 128	843	8.17 133	843	1.82 867	9.99 995	9
52	8.17 971	827	8.17 976	828	1.82 024	9.99 995	8
53	8.18 798	812	8.18 804	812	1.81 106	9.99 995	7
54	8.19 610	797	8.19 616	797	1.80 384	9.99 995	6
55	8.20 407	782	8.20 413	782	1.79 587	9.99 994	5
56	8.21 189	769	8.21 195	769	1.78 805	9.99 994	4
57	8.21 958	755	8.21 964	756	1.78 036	9.99 994	3
58	8.22 713	743	8.22 720	742	1.77 280	9.99 994	2
59	8.23 456	730	8.23 462	730	1.76 538	9.99 994	1
60	8.24 186		8.24 192		1.75 808	9.99 993	0
	L SIN	D	L TAN	CD	L COT	L COS	359°..179°
	L COS		L COT		L TAN	L SIN	269° ...89°

1°..181°		L SIN	D	L TAN	CD	L COT	L COS		
91°..271°		L COS		L COT		L TAN	L SIN		
	0	8.24 186	717	8.24 192	718	1.75 808	9.99 993	60	
	1	8.24 903	706	8.24 910	706	1.75 090	9.99 993	59	
	2	8.25 609	695	8.25 616	696	1.74 384	9.99 993	58	
	3	8.26 304	684	8.26 312	684	1.73 688	9.99 993	57	
	4	8.26 988	673	8.26 996	673	1.73 004	9.99 992	56	
	5	8.27 661	663	8.27 669	663	1.72 331	9.99 992	55	
	6	8.28 324	653	8.28 332	654	1.71 668	9.99 992	54	
	7	8.28 977	644	8.28 986	643	1.71 014	9.99 992	53	
	8	8.29 621	634	8.29 629	634	1.70 371	9.99 992	52	
	9	8.30 255	624	8.30 263	625	1.69 737	9.99 991	51	
	10	8.30 879	616	8.30 888	617	1.69 112	9.99 991	50	
	11	8.31 495	608	8.31 505	607	1.68 495	9.99 991	49	
	12	8.32 103	599	8.32 112	599	1.67 888	9.99 990	48	
	13	8.32 702	590	8.32 711	591	1.67 289	9.99 990	47	
	14	8.33 292	583	8.33 302	584	1.66 698	9.99 990	46	
	15	8.33 875	575	8.33 886	575	1.66 114	9.99 990	45	
	16	8.34 450	568	8.34 461	568	1.65 539	9.99 989	44	
	17	8.35 018	560	8.35 029	561	1.64 971	9.99 989	43	
	18	8.35 578	553	8.35 590	553	1.64 410	9.99 989	42	
	19	8.36 131	547	8.36 143	546	1.63 857	9.99 989	41	
	20	8.36 678	539	8.36 689	540	1.63 311	9.99 988	40	
	21	8.37 217	533	8.37 229	533	1.62 771	9.99 988	39	
	22	8.37 750	526	8.37 762	527	1.62 238	9.99 988	38	
	23	8.38 276	520	8.38 289	520	1.61 711	9.99 987	37	
	24	8.38 796	514	8.38 809	514	1.61 191	9.99 987	36	
	25	8.39 810	506	8.39 323	509	1.60 677	9.99 987	35	
	26	8.39 818	502	8.39 832	502	1.60 168	9.99 986	34	
	27	8.40 320	496	8.40 334	496	1.59 666	9.99 986	33	
	28	8.40 816	491	8.40 830	491	1.59 170	9.99 986	32	
	29	8.41 307	485	8.41 321	486	1.58 679	9.99 985	31	
	30	8.41 792	480	8.41 807	480	1.58 193	9.99 985	30	
	31	8.42 272	474	8.42 287	475	1.57 713	9.99 985	29	
	32	8.42 746	470	8.42 762	470	1.57 238	9.99 984	28	
	33	8.43 216	464	8.43 232	464	1.56 768	9.99 984	27	
	34	8.43 680	459	8.43 696	460	1.56 304	9.99 984	26	
	35	8.44 139	455	8.44 156	455	1.55 844	9.99 983	25	
	36	8.44 594	450	8.44 611	450	1.55 389	9.99 983	24	
	37	8.45 044	445	8.45 061	446	1.54 939	9.99 983	23	
	38	8.45 489	441	8.45 507	441	1.54 493	9.99 982	22	
	39	8.45 930	436	8.45 948	437	1.54 052	9.99 982	21	
	40	8.46 366	433	8.46 385	432	1.53 615	9.99 982	20	
	41	8.46 799	427	8.46 817	428	1.53 183	9.99 981	19	
	42	8.47 226	424	8.47 245	424	1.52 755	9.99 981	18	
	43	8.47 650	419	8.47 669	420	1.52 331	9.99 981	17	
	44	8.48 069	416	8.48 089	416	1.51 911	9.99 980	16	
	45	8.48 485	411	8.48 505	412	1.51 495	9.99 980	15	
	46	8.48 896	408	8.48 917	408	1.51 083	9.99 979	14	
	47	8.49 304	404	8.49 325	404	1.50 675	9.99 979	13	
	48	8.49 708	400	8.49 729	401	1.50 271	9.99 979	12	
	49	8.50 108	396	8.50 130	397	1.49 870	9.99 978	11	
	50	8.50 504	393	8.50 527	393	1.49 473	9.99 978	10	
	51	8.50 897	390	8.50 920	390	1.49 080	9.99 977	9	
	52	8.51 287	386	8.51 310	386	1.48 690	9.99 977	8	
	53	8.51 673	382	8.51 696	383	1.48 304	9.99 977	7	
	54	8.52 055	379	8.52 079	380	1.47 921	9.99 976	6	
	55	8.52 434	376	8.52 459	376	1.47 541	9.99 976	5	
	56	8.52 810	373	8.52 835	373	1.47 165	9.99 975	4	
	57	8.53 183	369	8.53 208	370	1.46 792	9.99 975	3	
	58	8.53 552	367	8.53 578	367	1.46 422	9.99 974	2	
	59	8.53 919	363	8.53 945	363	1.46 055	9.99 974	1	
	60	8.54 282		8.54 308		1.45 692	9.99 974	0	
		L SIN	D	L TAN	CD	L COT	L COS		358°..178°
		L COS		L COT		L TAN	L SIN		268° ...88°

2°..182°		L SIN	D	L TAN	CD	L COT	L COS		
92°..272°		L COS		L COT		L TAN	L SIN		
	0	8.54 282	360	8.54 308	361	1.45 692	9.99 974	60	
	1	8.54 642	357	8.54 669	358	1.45 331	9.99 973	59	
	2	8.54 999	355	8.55 027	355	1.44 973	9.99 973	58	
	3	8.55 354	351	8.55 382	352	1.44 618	9.99 972	57	
	4	8.55 705	349	8.55 734	349	1.44 266	9.99 972	56	
	5	8.56 054	346	8.56 083	346	1.43 917	9.99 971	55	
	6	8.56 400	343	8.56 429	344	1.43 571	9.99 971	54	
	7	8.56 743	341	8.56 773	341	1.43 227	9.99 970	53	
	8	8.57 084	337	8.57 114	338	1.42 886	9.99 970	52	
	9	8.57 421	336	8.57 452	336	1.43 548	9.99 969	51	
	10	8.57 757	332	8.57 788	333	1.42 212	9.99 969	50	
	11	8.58 089	330	8.58 121	330	1.41 879	9.99 968	49	
	12	8.58 419	328	8.58 451	328	1.41 549	9.99 968	48	
	13	8.58 747	325	8.58 779	326	1.41 221	9.99 967	47	
	14	8.59 072	323	8.59 105	323	1.40 895	9.99 967	46	
	15	8.59 395	320	8.59 428	321	1.40 572	9.99 967	45	
	16	8.59 715	318	8.59 749	319	1.40 251	9.99 966	44	
	17	8.60 033	316	8.60 068	316	1.39 932	9.99 966	43	
	18	8.60 349	313	8.60 384	314	1.39 616	9.99 965	42	
	19	8.60 662	311	8.60 698	311	1.39 302	9.99 964	41	
	20	8.60 973	309	8.61 009	310	1.38 991	9.99 964	40	
	21	8.61 282	307	8.61 319	307	1.38 681	9.99 963	39	
	22	8.61 589	305	8.61 626	305	1.38 374	9.99 963	38	
	23	8.61 894	302	8.61 931	303	1.38 069	9.99 962	37	
	24	8.62 196	301	8.62 234	301	1.37 766	9.99 962	36	
	25	8.62 497	298	8.62 535	299	1.37 465	9.99 961	35	
	26	8.62 795	296	8.62 834	297	1.37 166	9.99 961	34	
	27	8.63 091	294	8.63 131	295	1.36 869	9.99 960	33	
	28	8.63 385	293	8.63 426	292	1.36 574	9.99 960	32	
	29	8.63 678	290	8.63 718	291	1.36 282	9.99 959	31	
	30	8.63 963	288	8.64 009	289	1.35 991	9.99 959	30	
	31	8.64 256	287	8.64 298	287	1.35 702	9.99 958	29	
	32	8.64 543	284	8.64 585	285	1.35 415	9.99 958	28	
	33	8.64 827	283	8.64 870	284	1.35 130	9.99 957	27	
	34	8.65 110	281	8.65 154	281	1.34 846	9.99 956	26	
	35	8.65 391	279	8.65 435	280	1.34 565	9.99 956	25	
	36	8.65 670	277	8.65 715	278	1.34 285	9.99 955	24	
	37	8.65 947	276	8.65 993	276	1.34 007	9.99 955	23	
	38	8.66 223	274	8.66 269	274	1.33 731	9.99 954	22	
	39	8.66 497	272	8.66 543	273	1.33 457	9.99 954	21	
	40	8.66 769	270	8.66 816	271	1.33 184	9.99 953	20	
	41	8.67 039	269	8.67 087	269	1.32 913	9.99 952	19	
	42	8.67 308	267	8.67 356	268	1.32 644	9.99 952	18	
	43	8.67 575	266	8.67 624	266	1.32 376	9.99 951	17	
	44	8.67 841	263	8.67 890	264	1.32 110	9.99 951	16	
	45	8.68 104	263	8.68 154	263	1.31 846	9.99 950	15	
	46	8.68 367	260	8.68 417	261	1.31 583	9.99 949	14	
	47	8.68 627	259	8.68 678	260	1.31 322	9.99 949	13	
	48	8.68 886	258	8.68 938	258	1.31 062	9.99 948	12	
	49	8.69 144	256	8.69 196	257	1.30 804	9.99 948	11	
	50	8.69 400	254	8.69 453	255	1.30 547	9.99 947	10	
	51	8.69 654	253	8.69 708	254	1.30 202	9.99 946	9	
	52	8.69 907	252	8.69 962	252	1.30 038	9.99 946	8	
	53	8.70 159	250	8.70 214	251	1.29 786	9.99 945	7	
	54	8.70 409	249	8.70 465	249	1.29 535	9.99 944	6	
	55	8.70 658	247	8.70 714	248	1.29 286	9.99 944	5	
	56	8.70 905	246	8.70 962	246	1.29 038	9.99 943	4	
	57	8.71 151	244	8.71 208	245	1.28 792	9.99 942	3	
	58	8.71 395	243	8.71 453	244	1.28 547	9.99 942	2	
	59	8.71 638	242	8.71 697	243	1.28 303	9.99 941	1	
	60	8.71 880		8.71 940		1.28 060	9.99 940	0	
		L SIN	D	L TAN	CD	L COT	L COS		357°..177°
		L COS		L COT		L TAN	L SIN		267°...87°

3°..183°		L SIN	D	L TAN	CD	L COT	L COS	
93°..273°		L COS		L COT		L TAN	L SIN	
	0	8.71 880	240	8.71 940	241	1.28 060	9.99 940	60
	1	8.72 120	239	8.72 181	239	1.27 819	9.99 940	59
	2	8.72 359	239	8.72 420	239	1.27 580	9.99 939	58
	3	8.72 597	237	8.72 659	237	1.27 341	9.99 938	57
	4	8.72 834	235	8.72 896	236	1.27 104	9.99 938	56
	5	8.73 069	234	8.73 132	234	1.26 868	9.99 937	55
	6	8.73 303	232	8.73 366	234	1.26 634	9.99 936	54
	7	8.73 535	232	8.73 600	232	1.26 400	9.99 936	53
	8	8.73 767	230	8.73 832	230	1.26 168	9.99 935	52
	9	8.73 997	229	8.74 063	229	1.25 937	9.99 934	51
	10	8.74 226	228	8.74 292	229	1.25 708	9.99 934	50
	11	8.74 454	226	8.74 521	227	1.25 479	9.99 933	49
	12	8.74 680	226	8.74 748	226	1.25 252	9.99 932	48
	13	8.74 906	224	8.74 974	225	1.25 026	9.99 932	47
	14	8.75 130	223	8.75 199	224	1.24 801	9.99 931	46
	15	8.75 353	222	8.75 423	222	1.24 577	9.99 930	45
	16	8.75 575	220	8.75 645	222	1.24 355	9.99 929	44
	17	8.75 795	220	8.75 867	220	1.24 133	9.99 929	43
	18	8.76 015	219	8.76 087	219	1.23 913	9.99 928	42
	19	8.76 234	217	8.76 306	219	1.23 694	9.99 927	41
	20	8.76 451	216	8.76 525	217	1.23 475	9.99 926	40
	21	8.76 667	216	8.76 742	216	1.23 258	9.99 926	39
	22	8.76 883	214	8.76 958	215	1.23 042	9.99 925	38
	23	8.77 097	213	8.77 173	214	1.22 827	9.99 924	37
	24	8.77 610	212	8.77 387	213	1.22 613	9.99 923	36
	25	8.77 522	211	8.77 600	211	1.22 400	9.99 923	35
	26	8.77 733	210	8.77 811	211	1.22 189	9.99 922	34
	27	8.77 943	209	8.78 022	210	1.21 978	9.99 921	33
	28	8.78 152	208	8.78 232	209	1.21 768	9.99 920	32
	29	8.78 360	208	8.78 441	208	1.21 559	9.99 920	31
	30	8.78 568	206	8.78 649	206	1.21 351	9.99 919	30
	31	8.78 774	205	8.78 855	206	1.21 145	9.99 918	29
	32	8.78 979	204	8.79 061	205	1.20 939	9.99 917	28
	33	8.79 138	203	8.79 266	204	1.20 734	9.99 917	27
	34	8.79 386	202	8.79 470	203	1.20 530	9.99 916	26
	35	8.79 588	201	8.79 673	202	1.20 327	9.99 915	25
	36	8.79 789	201	8.79 875	201	1.20 125	9.99 914	24
	37	8.79 990	199	8.80 076	201	1.19 924	9.99 913	23
	38	8.80 189	199	8.80 277	199	1.19 723	9.99 913	22
	39	8.80 388	197	8.80 476	198	1.19 524	9.99 912	21
	40	8.80 585	197	8.80 674	198	1.19 326	9.99 911	20
	41	8.80 782	196	8.80 872	196	1.19 128	9.99 910	19
	42	8.80 978	195	8.81 068	196	1.18 932	9.99 909	18
	43	8.81 173	194	8.81 264	195	1.18 736	9.99 909	17
	44	8.81 367	193	8.81 459	194	1.18 541	9.99 908	16
	45	8.81 560	192	8.81 653	193	1.18 347	9.99 907	15
	46	8.81 752	192	8.81 846	192	1.18 154	9.99 906	14
	47	8.81 944	190	8.82 038	192	1.17 962	9.99 905	13
	48	8.82 134	190	8.82 230	190	1.17 770	9.99 904	12
	49	8.82 324	189	8.82 420	190	1.17 580	9.99 904	11
	50	8.82 513	188	8.82 610	189	1.17 390	9.99 903	10
	51	8.82 701	187	8.82 799	188	1.17 201	9.99 902	9
	52	8.82 888	187	8.82 987	188	1.17 013	9.99 901	8
	53	8.83 075	186	8.83 175	186	1.16 825	9.99 900	7
	54	8.83 261	185	8.83 361	186	1.16 639	9.99 899	6
	55	8.83 446	184	8.83 547	185	1.16 453	9.99 898	5
	56	8.83 630	183	8.83 732	184	1.16 268	9.99 898	4
	57	8.83 813	183	8.83 916	184	1.16 084	9.99 897	3
	58	8.83 996	181	8.84 100	182	1.15 900	9.99 896	2
	59	8.84 177	181	8.84 282	182	1.15 718	9.99 895	1
	60	8.84 358		8.84 464		1.15 536	9.99 894	0
		L SIN	D	L TAN	CD	L COT	L COS	356°..176°
		L COS		L COT		L TAN	L SIN	266°...86°

4°..184°		L SIN	D	L TAN	CD	L COT	L COS		
94°..274°		L COS		L COT		L TAN	L SIN		
	0	8.84 358	181	8.84 464	182	1.15 536	9.99 894	60	
	1	8.84 539	179	8.84 646	180	1.15 354	9.99 893	59	
	2	8.84 718	179	8.84 826	180	1.15 174	9.99 892	58	
	3	8.84 897	178	8.85 006	179	1.14 994	9.99 891	57	
	4	8.85 075	177	8.85 185	178	1.14 815	9.99 891	56	
	5	8.85 252	177	8.85 363	177	1.14 637	9.99 890	55	
	6	8.85 429	176	8.85 540	177	1.14 460	9.99 889	54	
	7	8.85 605	175	8.85 717	176	1.14 283	9.99 888	53	
	8	8.85 780	175	8.85 893	176	1.14 107	9.99 887	52	
	9	8.85 955	173	8.86 069	174	1.13 931	9.99 886	51	
	10	8.86 128	173	8.86 243	174	1.13 757	9.99 885	50	
	11	8.86 301	173	8.86 417	174	1.13 583	9.99 884	49	
	12	8.86 474	171	8.86 591	172	1.13 409	9.99 883	48	
	13	8.86 645	171	8.86 763	172	1.13 237	9.99 882	47	
	14	8.86 816	171	8.86 935	171	1.13 065	9.99 881	46	
	15	8.86 987	169	8.87 106	171	1.12 894	9.99 880	45	
	16	8.87 156	169	8.87 277	170	1.12 723	9.99 879	44	
	17	8.87 325	169	8.87 447	169	1.12 553	9.99 879	43	
	18	8.87 494	167	8.87 616	169	1.12 384	9.99 878	42	
	19	8.87 661	168	8.87 785	168	1.12 215	9.99 877	41	
	20	8.87 829	166	8.87 953	167	1.12 047	9.99 876	40	
	21	8.87 995	166	8.88 120	167	1.11 880	9.99 875	39	
	22	8.88 161	165	8.88 287	166	1.11 713	9.99 874	38	
	23	8.88 326	164	8.88 453	165	1.11 547	9.99 873	37	
	24	8.88 490	164	8.88 618	165	1.11 382	9.99 872	36	
	25	8.88 654	163	8.88 783	165	1.11 217	9.99 871	35	
	26	8.88 817	163	8.88 948	163	1.11 052	9.99 870	34	
	27	8.88 980	162	8.89 111	163	1.10 889	9.99 869	33	
	28	8.89 142	162	8.89 274	163	1.10 726	9.99 868	32	
	29	8.89 304	160	8.89 437	161	1.10 563	9.99 867	31	
	30	8.89 464	161	8.89 598	162	1.10 402	9.99 866	30	
	31	8.89 625	159	8.89 760	160	1.10 240	9.99 865	29	
	32	8.89 784	159	8.89 920	160	1.10 080	9.99 864	28	
	33	8.89 943	159	8.90 080	160	1.09 920	9.99 863	27	
	34	8.90 102	158	8.90 240	159	1.09 760	9.99 862	26	
	35	8.90 260	157	8.90 399	158	1.09 601	9.99 861	25	
	36	8.90 417	157	8.90 557	158	1.09 443	9.99 860	24	
	37	8.90 574	156	8.90 715	157	1.09 285	9.99 859	23	
	38	8.90 730	155	8.90 872	157	1.09 128	9.99 858	22	
	39	8.90 885	155	8.91 029	156	1.08 971	9.99 857	21	
	40	8.91 040	155	8.91 185	155	1.08 815	9.99 856	20	
	41	8.91 195	154	8.91 340	155	1.08 660	9.99 855	19	
	42	8.91 349	153	8.91 495	155	1.08 505	9.99 854	18	
	43	8.91 502	153	8.91 650	153	1.08 350	9.99 853	17	
	44	8.91 655	152	8.91 803	154	1.08 197	9.99 852	16	
	45	8.91 807	152	8.91 957	153	1.08 043	9.99 851	15	
	46	8.91 959	151	8.92 110	152	1.07 890	9.99 850	14	
	47	8.92 110	151	8.92 262	152	1.07 738	9.99 848	13	
	48	8.92 261	150	8.92 414	151	1.07 586	9.99 847	12	
	49	8.92 411	150	8.92 665	151	1.07 435	9.99 846	11	
	50	8.92 561	149	8.92 716	150	1.07 284	9.99 845	10	
	51	8.92 710	149	8.92 866	150	1.07 134	9.99 844	9	
	52	8.92 859	148	8.92 016	149	1.06 984	9.99 843	8	
	53	8.93 077	147	8.93 165	148	1.06 835	9.99 842	7	
	54	8.93 154	147	8.93 313	149	1.06 687	9.99 841	6	
	55	8.93 301	147	8.93 462	147	1.06 538	9.99 840	5	
	56	8.93 448	146	8.93 609	147	1.06 391	9.99 839	4	
	57	8.93 594	146	8.93 756	147	1.06 244	9.99 838	3	
	58	8.93 740	145	8.93 903	146	1.06 097	9.99 837	2	
	59	8.93 885	145	8.94 049	146	1.05 951	9.99 836	1	
	60	8.94 030		8.94 195		1.05 805	9.99 834	0	
		L SIN	D	L TAN	CD	L COT	L COS		355°..175°
		L COS		L COT		L TAN	L SIN		265° ...85°

5°..185°		L SIN	D	L TAN	CD	L COT	L COS	
95°..275°		L COS		L COT		L TAN	L SIN	
	0	8.94 030	144	8.94 195	145	1.05 805	9.99 834	60
	1	8.94 174	143	8.94 340	145	1.05 660	9.99 833	59
	2	8.94 317	144	8.94 458	145	1.05 515	9.99 832	58
	3	8.94 461	142	8.94 630	143	1.05 370	9.99 831	57
	4	8.94 603	143	8.94 773	144	1.05 227	9.99 830	56
	5	8.94 746	141	8.94 917	143	1.05 083	9.99 829	55
	6	8.94 887	142	8.95 060	142	1.04 940	9.99 828	54
	7	8.95 029	141	8.95 202	142	1.04 798	9.99 827	53
	8	8.95 170	140	8.95 344	142	1.04 656	9.99 825	52
	9	8.95 310	140	8.95 486	141	1.04 514	9.99 824	51
	10	8.95 450	139	8.95 627	140	1.04 373	9.99 823	50
	11	8.95 589	139	8.95 767	141	1.04 233	9.99 822	49
	12	8.95 728	139	8.95 908	139	1.04 092	9.99 821	48
	13	8.95 867	138	8.96 047	140	1.03 953	9.99 820	47
	14	8.96 005	138	8.96 187	138	1.03 813	9.99 819	46
	15	8.96 143	137	8.96 325	139	1.03 675	9.99 817	45
	16	8.96 280	137	8.96 464	138	1.03 536	9.99 816	44
	17	8.96 417	136	8.96 602	137	1.03 398	9.99 815	43
	18	8.96 553	136	8.96 739	138	1.03 261	9.99 814	42
	19	8.96 689	136	8.96 877	136	1.03 123	9.99 813	41
	20	8.96 825	135	8.97 013	137	1.02 987	9.99 812	40
	21	8.96 960	135	8.97 150	135	1.02 850	9.99 810	39
	22	8.97 095	134	8.97 285	136	1.02 715	9.99 809	38
	23	8.97 229	134	8.97 421	135	1.02 579	9.99 808	37
	24	8.97 363	133	8.97 556	135	1.02 444	9.99 807	36
	25	8.97 496	133	8.97 691	134	1.02 309	9.99 806	35
	26	8.97 629	133	8.97 825	134	1.02 175	9.99 804	34
	27	8.97 762	132	8.97 959	133	1.02 041	9.99 803	33
	28	8.97 894	132	8.98 002	133	1.01 908	9.99 802	32
	29	8.98 026	131	8.98 225	133	1.01 775	9.99 801	31
	30	8.98 157	131	8.98 358	132	1.01 642	9.99 800	30
	31	8.98 288	131	8.98 490	132	1.01 510	9.99 798	29
	32	8.98 419	130	8.98 622	131	1.01 378	9.99 797	28
	33	8.98 549	130	8.98 753	131	1.01 247	9.99 796	27
	34	8.98 679	129	8.98 884	131	1.01 116	9.99 795	26
	35	8.98 808	129	8.99 015	130	1.00 985	9.99 793	25
	36	8.98 937	129	8.99 145	130	1.00 855	9.99 792	24
	37	8.99 066	128	8.99 275	130	1.00 725	9.99 791	23
	38	8.99 194	128	8.99 405	129	1.00 595	9.99 790	22
	39	8.99 322	128	8.99 534	128	1.00 466	9.99 788	21
	40	8.99 450	127	8.99 662	129	1.00 338	9.99 787	20
	41	8.99 577	127	8.99 791	128	1.00 209	9.99 786	19
	42	8.99 704	126	8.99 919	127	1.00 081	9.99 785	18
	43	8.99 830	126	9.00 046	128	0.99 954	9.99 783	17
	44	8.99 956	126	9.00 174	127	0.99 826	9.99 782	16
	45	9.00 082	125	9.00 301	126	0.99 699	9.99 781	15
	46	9.00 207	125	9.00 427	126	0.99 573	9.99 780	14
	47	9.00 332	124	9.00 553	126	0.99 447	9.99 778	13
	48	9.00 456	125	9.00 679	126	0.99 321	9.99 777	12
	49	9.00 581	123	9.00 805	125	0.99 195	9.99 776	11
	50	9.00 704	124	9.00 930	125	0.99 070	9.99 775	10
	51	9.00 828	123	9.01 055	124	0.98 945	9.99 773	9
	52	9.00 951	123	9.01 179	124	0.98 821	9.99 772	8
	53	9.01 074	122	9.01 303	124	0.98 697	9.99 771	7
	54	9.01 196	122	9.01 427	123	0.98 573	9.99 769	6
	55	9.01 318	122	9.01 550	123	0.98 450	9.99 768	5
	56	9.01 440	121	9.01 673	123	0.98 327	9.99 767	4
	57	9.01 561	121	9.01 796	122	0.98 204	9.99 765	3
	58	9.01 682	121	9.01 918	122	0.98 082	9.99 764	2
	59	9.01 803	120	9.02 040	122	0.97 960	9.99 763	1
	60	9.01 923		9.02 162		0.97 838	9.99 761	0
		L SIN	D	L TAN	CD	L COT	L COS	354°..174°
		L COS		L COT		L TAN	L SIN	264° ...84°

6°..186°		L SIN	D	L TAN	CD	L COT	L COS	
96°..276°		L COS		L COT		L TAN	L SIN	
	0	9.01 923	120	9.02 162	121	0.97 838	9.99 761	60
	1	9.02 043	120	9.02 283	121	0.97 717	9.99 760	59
	2	9.02 163	120	9.02 404	121	0.97 596	9.99 759	58
	3	9.02 283	119	9.02 525	120	0.97 475	9.99 757	57
	4	9.02 402	118	9.02 645	121	0.97 355	9.99 756	56
	5	9.02 520	119	9.02 766	119	0.97 234	9.99 755	55
	6	9.02 639	118	9.02 885	120	0.97 115	9.99 753	54
	7	9.02 757	117	9.03 005	119	0.96 995	9.99 752	53
	8	9.02 874	118	9.03 124	118	0.96 876	9.99 751	52
	9	9.02 992	117	9.03 242	119	0.96 758	9.99 749	51
	10	9.03 109	117	9.03 361	118	0.96 639	9.99 748	50
	11	9.03 226	116	9.03 479	118	0.96 521	9.99 747	49
	12	9.03 423	116	9.03 597	117	0.96 403	9.99 745	48
	13	9.03 458	116	9.03 714	118	0.96 286	9.99 744	47
	14	9.03 574	116	9.03 832	116	0.96 168	9.99 742	46
	15	9.03 690	115	9.03 948	117	0.96 052	9.99 741	45
	16	9.03 805	115	9.04 065	116	0.95 935	9.99 740	44
	17	9.03 920	114	9.04 181	116	0.95 819	9.99 738	43
	18	9.04 034	115	9.04 297	116	0.95 703	9.99 737	42
	19	9.04 149	113	9.04 413	115	0.95 587	9.99 736	41
	20	9.04 262	114	9.04 528	115	0.95 472	9.99 734	40
	21	9.04 376	114	9.04 643	115	0.95 357	9.99 733	39
	22	9.04 490	113	9.04 758	115	0.95 242	9.99 731	38
	23	9.04 603	112	9.04 873	114	0.95 127	9.99 730	37
	24	9.04 715	113	9.04 987	114	0.95 013	9.99 728	36
	25	9.04 828	112	9.05 101	113	0.94 899	9.99 727	35
	26	9.04 940	112	9.05 214	114	0.94 786	9.99 726	34
	27	9.05 052	112	9.05 328	113	0.94 672	9.99 724	33
	28	9.05 164	111	9.05 441	112	0.94 559	9.99 723	32
	29	9.05 275	111	9.05 553	113	0.94 447	9.99 721	31
	30	9.05 386	111	9.05 666	112	0.94 334	9.99 720	30
	31	9.05 497	110	9.05 778	112	0.94 222	9.99 718	29
	32	9.05 607	110	9.05 890	112	0.94 110	9.99 717	28
	33	9.05 717	110	9.06 002	111	0.93 998	9.99 716	27
	34	9.05 827	110	9.06 113	111	0.93 887	9.99 714	26
	35	9.05 937	109	9.06 224	111	0.93 776	9.99 713	25
	36	9.06 046	109	9.06 335	110	0.93 665	9.99 711	24
	37	9.06 155	109	9.06 445	111	0.93 555	9.99 710	23
	38	9.06 264	108	9.06 556	110	0.93 444	9.99 708	22
	39	9.06 372	109	9.06 666	109	0.93 334	9.99 707	21
	40	9.06 481	108	9.06 775	110	0.93 225	9.99 705	20
	41	9.06 589	107	9.06 885	109	0.93 115	9.99 704	19
	42	9.06 696	108	9.06 994	109	0.93 006	9.99 702	18
	43	9.06 804	107	9.07 103	108	0.92 897	9.99 701	17
	44	9.06 911	107	9.07 211	109	0.92 789	9.99 699	16
	45	9.07 018	106	9.07 320	108	0.92 680	9.99 698	15
	46	9.07 124	107	9.07 428	108	0.92 572	9.99 696	14
	47	9.07 231	106	9.07 536	107	0.92 464	9.99 695	13
	48	9.07 337	105	9.07 643	108	0.92 357	9.99 693	12
	49	9.07 442	106	9.07 751	107	0.92 249	9.99 692	11
	50	9.07 548	105	9.07 858	106	0.92 142	9.99 690	10
	51	9.07 653	105	9.07 964	107	0.92 036	9.99 689	9
	52	9.07 758	105	9.08 071	106	0.91 929	9.99 687	8
	53	9.07 863	105	9.08 177	106	0.91 823	9.99 686	7
	54	9.07 968	104	9.08 283	106	0.91 717	9.99 684	6
	55	9.08 072	104	9.08 389	106	0.91 611	9.99 683	5
	56	9.08 176	104	9.08 495	105	0.91 505	9.99 681	4
	57	9.08 280	103	9.08 600	105	0.91 400	9.99 680	3
	58	9.08 383	103	9.08 706	105	0.91 295	9.99 678	2
	59	9.08 486	103	9.08 810	104	0.91 190	9.99 677	1
	60	9.08 589		9.08 914		0.91 086	9.99 675	0
		L SIN	D	L TAN	CD	L COT	L COS	353°..173°
		L COS		L COT		L TAN	L SIN	263° ...83°

7°..187°	L SIN	D	L TAN	CD	L COT	L COS	
97°..277°	L COS		L COT		L TAN	L SIN	
0	9.08 589	103	9.08 914	105	0.91 086	9.99 675	60
1	9.08 692	103	9.09 019	104	0.90 981	9.99 674	59
2	9.08 795	102	9.09 123	104	0.90 877	9.99 672	58
3	9.08 897	102	9.09 227	103	0.90 773	9.99 670	57
4	9.08 999	102	9.09 330	104	0.90 670	9.99 669	56
5	9.09 101	101	9.09 434	103	0.90 566	9.99 667	55
6	9.09 202	102	9.09 537	103	0.90 463	9.99 666	54
7	9.09 304	101	9.09 640	102	0.90 360	9.99 664	53
8	9.09 405	101	9.09 742	103	0.90 258	9.99 663	52
9	9.09 506	100	9.09 845	102	0.90 155	9.99 661	51
10	9.09 606	101	9.09 947	102	0.90 053	9.99 659	50
11	9.09 707	100	9.10 049	101	0.89 951	9.99 658	49
12	9.09 807	100	9.10 150	102	0.89 850	9.99 656	48
13	9.09 907	99	9.10 252	101	0.89 748	9.99 655	47
14	9.10 006	100	9.10 353	101	0.89 647	9.99 653	46
15	9.10 106	99	9.10 454	101	0.89 546	9.99 651	45
16	9.10 205	99	9.10 555	101	0.89 445	9.99 650	44
17	9.10 304	98	9.10 666	100	0.89 344	9.99 648	43
18	9.10 402	99	9.10 756	100	0.89 244	9.99 647	42
19	9.10 501	98	9.10 856	100	0.89 144	9.99 645	41
20	9.10 599	98	9.10 956	100	0.89 044	9.99 643	40
21	9.10 697	98	9.11 056	99	0.88 944	9.99 642	39
22	9.10 795	98	9.11 155	99	0.88 845	9.99 640	38
23	9.10 893	97	9.11 254	99	0.88 746	9.99 638	37
24	9.10 990	97	9.11 353	99	0.88 647	9.99 637	36
25	9.11 087	97	9.11 452	99	0.88 548	9.99 635	35
26	9.11 184	97	9.11 551	98	0.88 449	9.99 633	34
27	9.11 281	96	9.11 649	98	0.88 351	9.99 632	33
28	9.11 377	97	9.11 747	98	0.88 253	9.99 630	32
29	9.11 474	96	9.11 845	98	0.88 155	9.99 629	31
30	9.11 570	96	9.11 943	97	0.88 057	9.99 627	30
31	9.11 666	95	9.12 040	98	0.87 960	9.99 625	29
32	9.11 761	96	9.12 138	97	0.87 862	9.99 624	28
33	9.11 857	95	9.12 235	97	0.87 765	9.99 622	27
34	9.11 952	95	9.12 332	96	0.87 668	9.99 620	26
35	9.12 047	95	9.12 428	97	0.87 572	9.99 618	25
36	9.12 142	94	9.12 525	96	0.87 475	9.99 617	24
37	9.12 236	95	9.12 621	96	0.87 379	9.99 615	23
38	9.12 331	94	9.12 717	96	0.87 283	9.99 613	22
39	9.12 425	94	9.12 813	96	0.87 187	9.99 612	21
40	9.12 519	93	9.12 909	95	0.87 091	9.99 610	20
41	9.12 612	94	9.13 004	95	0.86 996	9.99 608	19
42	9.12 706	93	9.13 099	95	0.86 901	9.99 607	18
43	9.12 799	93	9.13 194	95	0.86 806	9.99 605	17
44	9.12 892	93	9.13 289	95	0.86 711	9.99 603	16
45	9.12 985	93	9.13 384	94	0.86 616	9.99 601	15
46	9.13 078	93	9.13 478	95	0.86 522	9.99 600	14
47	9.13 171	92	9.13 573	94	0.86 427	9.99 598	13
48	9.13 263	92	9.13 667	94	0.86 333	9.99 596	12
49	9.13 355	92	9.13 761	93	0.86 239	9.99 595	11
50	9.13 447	92	9.13 854	94	0.86 146	9.99 593	10
51	9.13 539	91	9.13 948	93	0.86 052	9.99 591	9
52	9.13 630	92	9.14 041	93	0.85 959	9.99 589	8
53	9.13 772	91	9.14 134	93	0.85 866	9.99 588	7
54	9.13 813	91	9.14 227	93	0.85 773	9.99 586	6
55	9.13 904	90	9.14 320	92	0.85 680	9.99 584	5
56	9.13 994	91	9.14 412	92	0.85 588	9.99 582	4
57	9.14 085	90	9.14 504	93	0.85 496	9.99 581	3
58	9.14 175	91	9.14 597	91	0.85 403	9.99 579	2
59	9.14 266	90	9.14 688	92	0.85 312	9.99 577	1
60	9.14 356		9.14 780		0.85 220	9.99 575	0
	L SIN	D	L TAN	CD	L COT	L COS	352°..172°
	L COS		L COT		L TAN	L SIN	262° ...82°

8°..188° / 98°..278°		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN		
	0	9.14 356	89	9.14 780	92	0.85 220	9.99 575	60	
	1	9.14 445	90	9.14 872	91	0.85 128	9.99 574	59	
	2	9.14 535	89	9.14 963	91	0.85 037	9.99 572	58	
	3	9.14 624	90	9.15 054	91	0.84 946	9.99 570	57	
	4	9.14 714	89	9.15 145	91	0.84 855	9.99 568	56	
	5	9.14 803	88	9.15 236	91	0.84 764	9.99 566	55	
	6	9.14 891	89	9.15 327	90	0.84 673	9.99 565	54	
	7	9.14 980	89	9.15 417	91	0.84 583	9.99 563	53	
	8	9.15 069	88	9.15 508	90	0.84 492	9.99 561	52	
	9	9.15 157	88	9.15 598	90	0.84 402	9.99 559	51	
	10	9.15 245	88	9.15 688	89	0.84 312	9.99 557	50	
	11	9.15 333	88	9.15 777	90	0.84 223	9.99 556	49	
	12	9.15 421	87	9.15 867	89	0.84 133	9.99 554	48	
	13	9.15 508	88	9.15 956	90	0.84 044	9.99 552	47	
	14	9.15 596	87	9.16 046	89	0.83 954	9.99 550	46	
	15	9.15 683	87	9.16 135	89	0.83 865	9.99 548	45	
	16	9.15 770	87	9.16 224	88	0.83 776	9.99 546	44	
	17	9.15 857	87	9.16 312	89	0.83 688	9.99 545	43	
	18	9.15 944	86	9.16 401	88	0.83 599	9.99 543	42	
	19	9.16 030	86	9.16 489	88	0.83 511	9.99 541	41	
	20	9.16 116	87	9.16 577	88	0.83 423	9.99 539	40	
	21	9.16 203	86	9.16 665	88	0.83 335	9.99 537	39	
	22	9.16 289	85	9.16 753	88	0.83 247	9.99 535	38	
	23	9.16 374	86	9.16 841	87	0.83 159	9.99 533	37	
	24	9.16 460	85	9.16 928	88	0.83 072	9.99 532	36	
	25	9.16 545	86	9.17 016	87	0.82 984	9.99 530	35	
	26	9.16 631	85	9.17 103	87	0.82 897	9.99 528	34	
	27	9.16 716	85	9.17 190	87	0.82 810	9.99 526	33	
	28	9.16 801	85	9.17 277	86	0.82 723	9.99 524	32	
	29	9.16 886	84	9.17 363	87	0.82 637	9.99 522	31	
	30	9.16 970	85	9.17 450	86	0.82 550	9.99 520	30	
	31	9.17 055	84	9.17 536	86	0.82 464	9.99 518	29	
	32	9.17 139	84	9.17 622	86	0.82 378	9.99 517	28	
	33	9.17 223	84	9.17 708	86	0.82 292	9.99 515	27	
	34	9.17 307	84	9.17 794	86	0.82 206	9.99 513	26	
	35	9.17 391	83	9.17 880	85	0.82 120	9.99 511	25	
	36	9.17 474	84	9.17 965	86	0.82 035	9.99 509	24	
	37	9.17 558	83	9.18 051	85	0.81 949	9.99 507	23	
	38	9.17 641	83	9.18 136	85	0.81 864	9.99 505	22	
	39	9.17 724	83	9.18 221	85	0.81 779	9.99 503	21	
	40	9.17 807	83	9.18 306	85	0.81 694	9.99 501	20	
	41	9.17 890	83	9.18 391	84	0.81 609	9.99 499	19	
	42	9.17 973	82	9.18 475	85	0.81 525	9.99 497	18	
	43	9.18 055	82	9.18 560	84	0.81 440	9.99 495	17	
	44	9.18 137	83	9.18 644	84	0.81 356	9.99 494	16	
	45	9.18 220	82	9.18 728	84	0.81 272	9.99 492	15	
	46	9.18 302	81	9.18 812	84	0.81 188	9.99 490	14	
	47	9.18 383	82	9.18 896	83	0.81 104	9.99 488	13	
	48	9.18 465	82	9.18 979	84	0.81 021	9.99 486	12	
	49	9.18 547	81	9.19 063	83	0.80 937	9.99 484	11	
	50	9.18 628	81	9.19 146	83	0.80 854	9.99 482	10	
	51	9.18 709	81	9.19 229	83	0.80 771	9.99 480	9	
	52	9.18 790	81	9.19 342	83	0.80 688	9.99 478	8	
	53	9.18 871	81	9.19 395	83	0.80 605	9.99 476	7	
	54	9.18 952	81	9.19 478	83	0.80 522	9.99 474	6	
	55	9.19 033	80	9.19 561	82	0.80 439	9.99 472	5	
	56	9.19 113	80	9.19 643	82	0.80 357	9.99 470	4	
	57	9.19 193	80	9.19 725	82	0.80 275	9.99 468	3	
	58	9.19 273	80	9.19 807	82	0.80 193	9.99 466	2	
	59	9.19 353	80	9.19 889	82	0.80 111	9.99 464	1	
	60	9.19 433		9.19 971		0.80 029	9.99 462	0	
		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN		351°..171° / 261°...81°

9°..189°		L SIN	D	L TAN	CD	L COT	L COS	
99°..279°		L COS		L COT		L TAN	L SIN	
	0	9.19 433	80	9.19 971	82	0.80 029	9.99 462	60
	1	9.19 513	79	9.20 053	81	0.79 947	9.99 460	59
	2	9.19 592	80	9.20 134	82	0.79 866	9.99 458	58
	3	9.19 672	79	9.20 216	81	0.79 784	9.99 456	57
	4	9.19 751	79	9.20 297	81	0.79 703	9.99 454	56
	5	9.19 830	79	9.20 378	81	0.79 622	9.99 452	55
	6	9.19 909	79	9.20 459	81	0.79 541	9.99 450	54
	7	9.19 988	79	9.20 540	81	0.79 460	9.99 448	53
	8	9.20 067	78	9.20 621	80	0.79 379	9.99 446	52
	9	9.20 145	78	9.20 701	81	0.79 299	9.99 444	51
	10	9.20 223	79	9.20 782	80	0.79 218	9.99 442	50
	11	9.20 302	78	9.20 862	80	0.79 138	9.99 440	49
	12	9.20 380	78	9.20 942	80	0.79 058	9.99 438	48
	13	9.20 458	77	9.21 022	80	0.78 978	9.99 436	47
	14	9.20 535	78	9.21 102	80	0.78 898	9.99 434	46
	15	9.20 613	78	9.21 182	79	0.78 818	9.99 432	45
	16	9.20 691	77	9.21 261	80	0.78 739	9.99 429	44
	17	9.20 768	77	9.21 341	79	0.78 659	9.99 427	43
	18	9.20 845	77	9.21 420	79	0.78 580	9.99 425	42
	19	9.20 922	77	9.21 499	79	0.78 501	9.99 423	41
	20	9.20 999	77	9.21 578	79	0.78 422	9.99 421	40
	21	9.21 076	77	9.21 657	79	0.78 343	9.99 419	39
	22	9.21 153	76	9.21 736	78	0.78 264	9.99 417	38
	23	9.21 229	77	9.21 814	79	0.78 186	9.99 415	37
	24	9.21 306	76	9.21 893	78	0.78 107	9.99 413	36
	25	9.21 382	76	9.21 971	78	0.78 029	9.99 411	35
	26	9.21 458	76	9.22 049	78	0.77 951	9.99 409	34
	27	9.21 534	76	9.22 127	78	0.77 873	9.99 407	33
	28	9.21 610	75	9.22 205	78	0.77 795	9.99 404	32
	29	9.21 685	76	9.22 283	78	0.77 717	9.99 402	31
	30	9.21 761	75	9.22 361	77	0.77 639	9.99 400	30
	31	9.21 836	76	9.22 438	78	0.77 562	9.99 398	29
	32	9.21 912	75	9.22 516	77	0.77 484	9.99 396	28
	33	9.21 987	75	9.22 593	77	0.77 407	9.99 394	27
	34	9.22 062	75	9.22 670	77	0.77 330	9.99 392	26
	35	9.22 137	74	9.22 747	77	0.77 253	9.99 390	25
	36	9.22 211	75	9.22 824	77	0.77 176	9.99 388	24
	37	9.22 286	75	9.22 901	76	0.77 099	9.99 385	23
	38	9.22 361	74	9.22 977	77	0.77 023	9.99 383	22
	39	9.22 435	74	9.23 054	76	0.76 945	9.99 381	21
	40	9.22 509	74	9.23 130	76	0.76 870	9.99 379	20
	41	9.22 583	74	9.23 206	77	0.76 794	9.99 377	19
	42	9.22 657	74	9.23 283	76	0.76 717	9.99 375	18
	43	9.22 731	74	9.23 359	76	0.76 641	9.99 372	17
	44	9.22 805	73	9.23 435	75	0.76 565	9.99 370	16
	45	9.22 878	74	9.23 510	76	0.76 490	9.99 368	15
	46	9.22 952	73	9.23 586	75	0.76 414	9.99 366	14
	47	9.23 025	73	9.23 661	76	0.76 339	9.99 364	13
	48	9.23 098	73	9.23 737	75	0.76 263	9.99 362	12
	49	9.23 171	73	9.23 812	75	0.76 188	9.99 359	11
	50	9.23 244	73	9.23 887	75	0.76 113	9.99 357	10
	51	9.23 317	73	9.23 962	75	0.76 038	9.99 355	9
	52	9.23 390	72	9.24 037	75	0.75 963	9.99 353	8
	53	9.23 462	73	9.24 112	74	0.75 888	9.99 351	7
	54	9.23 535	72	9.24 186	75	0.75 814	9.99 348	6
	55	9.23 607	72	9.24 261	74	0.75 739	9.99 346	5
	56	9.23 679	73	9.24 335	75	0.75 665	9.99 344	4
	57	9.23 752	71	9.24 410	74	0.75 590	9.99 342	3
	58	9.23 823	72	9.24 484	74	0.75 516	9.99 340	2
	59	9.23 895	72	9.24 558	74	0.75 442	9.99 337	1
	60	9.23 967		9.24 632		0.75 368	9.99 335	0
		L SIN	D	L TAN	CD	L COT	L COS	350°..170°
		L COS		L COT		L TAN	L SIN	260° ...80°

10°..190°		L SIN	D	L TAN	CD	L COT	L COS	
100°.280°		L COS		L COT		L TAN	L SIN	
	0	9.23 967	72	9.24 632	74	0.75 368	9.99 335	60
	1	9.24 039	71	9.24 706	73	0.75 294	9.99 333	59
	2	9.24 110	71	9.24 779	74	0.75 221	9.99 331	58
	3	9.24 181	72	9.24 853	73	0.75 147	9.99 328	57
	4	9.24 253	71	9.24 926	74	0.75 074	9.99 326	56
	5	9.24 324	71	9.25 000	73	0.75 000	9.99 324	55
	6	9.24 395	71	9.25 073	73	0.74 927	9.99 322	54
	7	9.24 466	70	9.25 146	73	0.74 854	9.99 319	53
	8	9.24 536	71	9.25 219	73	0.74 781	9.99 317	52
	9	9.24 607	70	9.25 292	73	0.74 708	9.99 315	51
	10	9.24 677	71	9.25 365	72	0.74 635	9.99 313	50
	11	9.24 748	70	9.25 437	73	0.74 563	9.99 310	49
	12	9.24 818	70	9.25 510	72	0.74 490	9.99 308	48
	13	9.24 888	70	9.25 582	73	0.74 418	9.99 306	47
	14	9.24 958	70	9.25 655	72	0.74 345	9.99 304	46
	15	9.25 028	70	9.25 727	72	0.74 273	9.99 301	45
	16	9.25 098	70	9.25 799	72	0.74 201	9.99 299	44
	17	9.25 168	69	9.25 871	72	0.74 129	9.99 297	43
	18	9.25 237	70	9.25 943	72	0.74 057	9.99 294	42
	19	9.25 307	69	9.26 015	71	0.73 985	9.99 292	41
	20	9.25 376	69	9.26 086	72	0.73 914	9.99 290	40
	21	9.25 445	69	9.26 158	71	0.73 842	9.99 288	39
	22	9.25 514	69	9.26 229	72	0.73 771	9.99 285	38
	23	9.25 583	69	9.26 301	71	0.73 699	9.99 283	37
	24	9.25 652	69	9.26 372	71	0.73 628	9.99 281	36
	25	9.25 721	69	9.26 443	71	0.73 557	9.99 278	35
	26	9.25 790	68	9.26 514	71	0.73 486	9.99 276	34
	27	9.25 858	69	9.26 585	70	0.73 415	9.99 274	33
	28	9.25 927	68	9.26 665	71	0.73 345	9.99 271	32
	29	9.25 995	68	9.26 726	71	0.73 274	9.99 269	31
	30	9.26 063	68	9.26 797	70	0.73 203	9.99 267	30
	31	9.26 131	68	9.26 867	70	0.73 133	9.99 264	29
	32	9.26 199	68	9.26 937	71	0.73 063	9.99 262	28
	33	9.26 267	68	9.27 008	70	0.72 992	9.99 260	27
	34	9.26 335	68	9.27 078	70	0.72 922	9.99 257	26
	35	9.26 403	67	9.27 148	70	0.72 852	9.99 255	25
	36	9.26 470	68	9.27 218	70	0.72 782	9.99 252	24
	37	9.26 538	67	9.27 288	69	0.72 712	9.99 250	23
	38	9.26 605	67	9.27 357	70	0.72 643	9.99 248	22
	39	9.26 672	67	9.27 427	69	0.72 573	9.99 245	21
	40	9.26 739	67	9.27 496	70	0.72 504	9.99 243	20
	41	9.26 806	67	9.27 566	69	0.72 434	9.99 241	19
	42	9.26 873	67	9.27 635	69	0.72 365	9.99 238	18
	43	9.26 940	67	9.27 704	69	0.72 296	9.99 236	17
	44	9.27 007	66	9.27 773	69	0.72 227	9.99 233	16
	45	9.27 073	67	9.27 842	69	0.72 158	9.99 231	15
	46	9.27 140	66	9.27 911	69	0.72 089	9.99 229	14
	47	9.27 206	67	9.27 980	69	0.72 020	9.99 226	13
	48	9.27 273	66	9.28 049	68	0.71 951	9.99 224	12
	49	9.27 339	66	9.28 117	69	0.71 883	9.99 221	11
	50	9.27 405	66	9.28 186	68	0.71 814	9.99 219	10
	51	9.27 471	66	9.28 254	69	0.71 746	9.99 217	9
	52	9.27 537	65	9.28 323	68	0.71 677	9.99 214	8
	53	9.27 602	66	9.28 391	68	0.71 609	9.99 212	7
	54	9.27 668	66	9.28 459	68	0.71 541	9.99 209	6
	55	9.27 734	65	9.28 527	68	0.71 473	9.99 207	5
	56	9.27 799	65	9.28 595	67	0.71 405	9.99 204	4
	57	9.27 864	66	9.28 662	68	0.71 338	9.99 202	3
	58	9.27 930	65	9.28 730	68	0.71 270	9.99 200	2
	59	9.27 995	65	9.28 798	67	0.71 202	9.99 197	1
	60	9.28 060		9.28 865		0.71 135	9.99 195	0
		L SIN	D	L TAN	CD	L COT	L COS	349°..169°
		L COS		L COT		L TAN	L SIN	259° ...79°

11°..191°	L SIN	D	L TAN	CD	L COT	L COS	
101°..281°	L COS		L COT		L TAN	L SIN	
0	9.28 060	65	9.28 865	68	0.71 135	9.99 195	60
1	9.28 125	65	9.28 933	67	0.71 067	9.99 192	59
2	9.28 190	64	9.29 000	67	0.71 000	9.99 190	58
3	9.28 254	65	9.29 067	67	0.70 933	9.99 187	57
4	9.28 319	65	9.29 134	67	0.70 866	9.99 185	56
5	9.28 384	64	9.29 201	67	0.70 799	9.99 182	55
6	9.28 448	6	9.29 268	67	0.70 732	9.99 180	54
7	9.28 512	65	9.29 335	67	0.70 665	9.99 177	53
8	9.28 577	64	9.29 402	66	0.70 598	9.99 175	52
9	9.28 641	64	9.29 468	67	0.70 532	9.99 172	51
10	9.28 705	64	9.29 535	66	0.70 465	9.99 170	50
11	9.28 769	64	9.29 601	67	0.70 399	9.99 167	49
12	9.28 833	63	9.29 668	66	0.70 332	9.99 165	48
13	9.28 896	64	9.29 734	66	0.70 266	9.99 162	47
14	9.28 960	64	9.29 800	66	0.70 200	9.99 160	46
15	9.29 02	63	9.29 866	66	0.70 134	9.99 157	45
16	9.29 087	63	9.29 932	66	0.70 068	9.99 155	44
17	9.29 150	64	9.29 998	66	0.70 002	9.99 152	43
18	9.29 214	63	9.30 064	66	0.69 936	9.99 150	42
19	9.29 277	63	9.30 130	65	0.69 870	9.99 147	41
20	9.29 340	63	9.30 195	66	0.69 805	9.99 145	40
21	9.29 403	63	9.30 261	65	0.69 739	9.99 142	39
22	9.29 466	63	9.30 326	65	0.69 674	9.99 140	38
23	9.29 529	62	9.30 391	66	0.69 609	9.99 137	37
24	9.29 591	63	9.30 457	65	0.69 543	9.99 135	36
25	9.29 654	62	9.30 522	65	0.69 478	9.99 132	35
26	9.29 716	63	9.30 587	65	0.69 413	9.99 130	34
27	9.29 779	62	9.30 652	65	0.69 348	9.99 127	33
28	9.29 841	62	9.30 717	65	0.69 283	9.99 124	32
29	9.29 903	63	9.30 782	64	0.69 218	9.99 122	31
30	9.29 966	62	9.30 846	65	0.69 154	9.99 119	30
31	9.30 028	62	9.30 911	64	0.69 089	9.99 117	29
32	9.30 090	61	9.30 975	65	0.69 025	9.99 114	28
33	9.30 151	62	9.31 040	64	0.68 960	9.99 112	27
34	9.30 213	62	9.31 104	64	0.68 896	9.99 109	26
35	9.30 275	61	9.31 168	65	0.68 832	9.99 106	25
36	9.30 336	62	9.31 233	64	0.68 767	9.99 104	24
37	9.30 398	61	9.31 297	64	0.68 703	9.99 101	23
38	9.30 459	62	9.31 361	64	0.68 639	9.99 099	22
39	9.30 521	61	9.31 425	64	0.68 575	9.99 096	21
40	9.30 582	61	9.31 489	63	0.68 511	9.99 093	20
41	9.30 643	61	9.31 552	64	0.68 448	9.99 091	19
42	9.30 704	61	9.31 616	63	0.68 384	9.99 088	18
43	9.30 765	61	9.31 679	64	0.68 321	9.99 086	17
44	9.30 826	61	9.31 743	63	0.68 257	9.99 083	16
45	9.30 887	60	9.31 806	64	0.68 194	9.99 080	15
46	9.30 947	61	9.31 870	63	0.68 130	9.99 078	14
47	9.31 008	60	9.31 933	63	0.68 067	9.99 075	13
48	9.31 068	61	9.31 996	63	0.68 004	9.99 072	12
49	9.31 129	60	9.32 059	63	0.67 941	9.99 070	11
50	9.31 189	61	9.32 122	63	0.67 878	9.99 067	10
51	9.31 250	60	9.32 185	63	0.67 815	9.99 064	9
52	9.31 310	60	9.32 248	63	0.67 752	9.99 062	8
53	9.31 370	60	9.32 311	62	0.67 689	9.99 059	7
54	9.31 430	60	9.32 373	63	0.67 627	9.99 056	6
55	9.31 490	59	9.32 436	62	0.67 564	9.99 054	5
56	9.31 549	60	9.32 498	63	0.67 502	9.99 051	4
57	9.31 609	60	9.32 561	62	0.67 439	9.99 048	3
58	9.31 669	59	9.32 623	62	0.67 377	9.99 046	2
59	9.31 728	60	9.32 685	62	0.67 315	9.99 043	1
60	9.31 788		9.32 747		0.67 253	9.99 040	0
	L SIN	D	L TAN	CD	L COT	L COS	348°..168°
	L COS		L COT		L TAN	L SIN	258° ...78°

12°...192°		L SIN	D	L TAN	CD	L COT	L COS		
102°..282°		L COS		L COT		L TAN	L SIN		
	0	9.31 788	59	9.32 747	63	0.67 253	9.99 040	60	
	1	9.31 847	60	9.32 810	62	0.67 190	9.99 038	59	
	2	9.31 907	59	9.32 872	61	0.67 128	9.99 035	58	
	3	9.31 966	59	9.32 933	62	0.67 067	9.99 032	57	
	4	9.32 025	59	9.32 995	62	0.67 005	9.99 030	56	
	5	9.32 084	59	9.33 057	62	0.66 943	9.99 027	55	
	6	9.32 143	59	9.33 119	61	0.66 881	9.99 024	54	
	7	9.32 202	59	9.33 180	62	0.66 820	9.99 022	53	
	8	9.32 261	58	9.33 242	61	0.66 758	9.99 019	52	
	9	9.32 319	59	9.33 303	62	0.66 697	9.99 016	51	
	10	9.32 378	59	9.33 365	61	0.66 635	9.99 013	50	
	11	9.32 437	58	9.33 426	61	0.66 574	9.99 011	49	
	12	9.32 495	58	9.33 487	61	0.66 513	9.99 008	48	
	13	9.32 553	59	9.33 548	61	0.66 452	9.99 005	47	
	14	9.32 612	58	9.33 609	61	0.66 391	9.99 002	46	
	15	9.32 670	58	9.33 670	61	0.66 330	9.99 000	45	
	16	9.32 728	58	9.33 731	61	0.66 269	9.98 997	44	
	17	9.32 786	58	9.33 792	61	0.66 208	9.98 994	43	
	18	9.32 844	58	9.33 853	60	0.66 147	9.98 991	42	
	19	9.32 902	5	9.33 913	61	0.66 087	9.98 989	41	
	20	9.32 960	58	9.33 974	60	0.66 026	9.98 986	40	
	21	9.33 018	57	9.34 034	61	0.65 966	9.98 983	39	
	22	9.33 075	58	9.34 095	60	0.65 905	9.98 980	38	
	23	9.33 133	57	9.34 155	60	0.65 845	9.98 978	37	
	24	9.33 190	58	9.34 215	61	0.65 785	9.98 975	36	
	25	9.33 248	57	9.34 276	60	0.65 724	9.98 972	35	
	26	9.33 305	57	9.34 336	60	0.65 664	9.98 969	34	
	27	9.33 362	58	9.34 396	60	0.65 604	9.98 967	33	
	28	9.33 420	57	9.34 456	60	0.65 544	9.98 964	32	
	29	9.33 477	57	9.34 516	60	0.65 484	9.98 961	31	
	30	9.33 534	57	9.34 576	59	0.65 424	9.98 958	30	
	31	9.33 591	56	9.34 635	60	0.65 365	9.98 955	29	
	32	9.33 647	57	9.34 695	60	0.65 305	9.98 953	28	
	33	9.33 704	57	9.34 755	59	0.65 245	9.98 950	27	
	34	9.33 761	57	9.34 814	60	0.65 186	9.98 947	26	
	35	9.33 818	56	9.34 874	59	0.65 126	9.98 944	25	
	36	9.33 874	57	9.34 933	59	0.65 067	9.98 941	24	
	37	9.33 931	56	9.34 992	59	0.65 008	9.98 938	23	
	38	9.33 987	56	9.35 051	60	0.64 949	9.98 936	22	
	39	9.34 043	57	9.35 111	59	0.64 889	9.98 933	21	
	40	9.34 100	56	9.35 170	59	0.64 830	9.98 930	20	
	41	9.34 156	56	9.35 229	59	0.64 771	9.98 927	19	
	42	9.34 212	56	9.35 288	59	0.64 712	9.98 924	18	
	43	9.34 268	56	9.35 347	58	0.64 653	9.98 921	17	
	44	9.34 324	56	9.35 405	59	0.64 595	9.98 919	16	
	45	9.34 380	56	9.35 464	59	0.64 536	9.98 916	15	
	46	9.34 436	55	9.35 523	58	0.64 477	9.98 913	14	
	47	9.34 491	56	9.35 581	59	0.64 419	9.98 910	13	
	48	9.34 547	55	9.35 640	58	0.64 360	9.98 907	12	
	49	9.34 602	56	9.35 698	59	0.64 302	9.98 904	11	
	50	9.34 658	55	9.35 757	58	0.64 243	9.98 901	10	
	51	9.34 713	56	9.35 815	58	0.64 185	9.98 898	9	
	52	9.34 769	55	9.35 873	58	0.64 127	9.98 896	8	
	53	9.34 824	55	9.35 931	58	0.64 069	9.98 893	7	
	54	9.34 879	55	9.35 989	58	0.64 011	9.98 890	6	
	55	9.34 934	55	9.36 047	58	0.63 953	9.98 887	5	
	56	9.34 989	55	9.36 105	58	0.63 895	9.98 884	4	
	57	9.35 044	55	9.36 163	58	0.63 837	9.98 881	3	
	58	9.35 099	55	9.36 221	58	0.63 779	9.98 878	2	
	59	9.35 154	55	9.36 279	57	0.63 721	9.98 875	1	
	60	9.35 209		9.36 336		0.63 664	9.98 872	0	
		L SIN	D	L TAN	CD	L COT	L COS		347°...167°
		L COS		L COT		L TAN	L SIN		257° ... 77°

13°...193°		L SIN	D	L TAN	CD	L COT	L COS	
103°...283°		L COS		L COT		L TAN	L SIN	
	0	9.35 209	54	9.36 336	58	0.63 664	9.98 872	60
	1	9.35 263	55	9.36 394	58	0.63 606	9.98 869	59
	2	9.35 318	55	9.36 452	57	0.63 548	9.98 867	58
	3	9.35 373	54	9.36 509	57	0.63 491	9.98 864	57
	4	9.35 427	54	9.36 566	58	0.63 434	9.98 861	56
	5	9.35 481	55	9.36 624	57	0.63 376	9.98 858	55
	6	9.35 536	54	9.36 681	57	0.63 319	9.98 855	54
	7	9.35 590	54	9.36 738	57	0.63 262	9.98 852	53
	8	9.35 644	54	9.36 795	57	0.63 205	9.98 849	52
	9	9.35 698	54	9.36 852	57	0.63 148	9.98 846	51
	10	9.35 752	54	9.36 909	57	0.63 091	9.98 843	50
	11	9.35 806	54	9.36 966	57	0.63 034	9.98 840	49
	12	9.35 860	54	9.37 023	57	0.62 977	9.98 837	48
	13	9.35 914	54	9.37 080	57	0.62 920	9.98 834	47
	14	9.35 968	54	9.37 137	56	0.62 863	9.98 831	46
	15	9.36 022	53	9.37 193	57	0.62 807	9.98 828	45
	16	9.36 075	54	9.37 250	56	0.62 750	9.98 825	44
	17	9.36 129	53	9.37 306	57	0.62 694	9.98 822	43
	18	9.36 182	54	9.37 363	56	0.62 637	9.98 819	42
	19	9.36 236	53	9.37 419	57	0.62 581	9.98 816	41
	20	9.36 289	53	9.37 476	56	0.62 524	9.98 813	40
	21	9.36 342	53	9.37 532	56	0.62 468	9.98 810	39
	22	9.36 395	54	9.37 588	56	0.62 412	9.98 807	38
	23	9.36 449	53	9.37 644	56	0.62 356	9.98 804	37
	24	9.36 502	53	9.37 700	56	0.62 300	9.98 801	36
	25	9.36 555	53	9.37 756	56	0.62 244	9.98 798	35
	26	9.36 608	52	9.37 812	56	0.62 188	9.98 795	34
	27	9.36 660	53	9.37 868	56	0.62 132	9.98 792	33
	28	9.36 713	53	9.37 924	56	0.62 076	9.98 789	32
	29	9.36 766	53	9.37 980	55	0.62 020	9.98 786	31
	30	9.36 819	52	9.38 035	56	0.61 965	9.98 783	30
	31	9.36 871	53	9.38 091	56	0.61 909	9.98 780	29
	32	9.36 924	52	9.38 147	55	0.61 853	9.98 777	28
	33	9.36 976	52	9.38 202	55	0.61 798	9.98 774	27
	34	9.37 028	53	9.38 257	56	0.61 743	9.98 771	26
	35	9.37 081	52	9.38 313	55	0.61 687	9.98 768	25
	36	9.37 133	52	9.38 368	55	0.61 632	9.98 765	24
	37	9.37 185	52	9.38 423	56	0.61 577	9.98 762	23
	38	9.37 237	52	9.38 479	55	0.61 521	9.98 759	22
	39	9.37 289	52	9.38 534	55	0.61 466	9.98 756	21
	40	9.37 341	52	9.38 589	55	0.61 411	9.98 753	20
	41	9.37 393	52	9.38 644	55	0.61 356	9.98 750	19
	42	9.37 445	52	9.38 699	55	0.61 301	9.98 746	18
	43	9.37 497	52	9.38 754	54	0.61 246	9.98 743	17
	44	9.37 549	51	9.38 808	55	0.61 192	9.98 740	16
	45	9.37 600	52	9.38 863	55	0.61 137	9.98 737	15
	46	9.37 652	51	9.38 918	54	0.61 082	9.98 734	14
	47	9.37 703	52	9.38 972	55	0.61 028	9.98 731	13
	48	9.37 755	51	9.39 027	55	0.60 973	9.98 728	12
	49	9.37 806	52	9.39 082	54	0.60 918	9.98 725	11
	50	9.37 858	51	9.39 136	54	0.60 864	9.98 722	10
	51	9.37 909	51	9.39 190	55	0.60 810	9.98 719	9
	52	9.37 960	51	9.39 245	54	0.60 755	9.98 715	8
	53	9.38 011	51	9.39 299	54	0.60 701	9.98 712	7
	54	9.38 062	51	9.39 353	54	0.60 647	9.98 709	6
	55	9.38 113	51	9.39 407	54	0.60 593	9.98 706	5
	56	9.38 164	51	9.39 461	54	0.60 539	9.98 703	4
	57	9.38 215	51	9.39 515	54	0.60 485	9.98 700	3
	58	9.38 266	51	9.39 569	54	0.60 431	9.98 697	2
	59	9.38 317	51	9.39 623	54	0.60 377	9.98 694	1
	60	9.38 368		9.39 677		0.60 323	9.98 690	0
		L SIN	D	L TAN	CD	L COT	L COS	346°...166°
		L COS		L COT		L TAN	L SIN	256°....76°

14°..194°		L SIN	D	L TAN	CD	L COT	L COS	D	
104°..284°		L COS		L COT		L TAN	L SIN		
	0	9.38 368	50	9.39 677	54	0.60 323	9.98 690	3	60
	1	9.38 418	51	9.39 731	54	0.60 269	9.98 687	3	59
	2	9.38 469	50	9.39 785	53	0.60 215	9.98 684	3	58
	3	9.38 519	51	9.39 838	54	0.60 162	9.98 681	3	57
	4	9.38 570	50	9.39 892	53	0.60 108	9.98 678	3	56
	5	9.38 620	50	9.39 945	54	0.60 055	9.98 675	4	55
	6	9.38 670	51	9.39 999	53	0.60 001	9.98 671	3	54
	7	9.38 721	50	9.40 052	54	0.59 948	9.98 668	3	53
	8	9.38 771	50	9.40 106	53	0.59 894	9.98 665	3	52
	9	9.38 821	50	9.40 159	53	0.59 841	9.98 662	3	51
	10	9.38 871	50	9.40 212	54	0.59 788	9.98 659	3	50
	11	9.38 921	50	9.40 206	53	0.59 734	9.98 656	4	49
	12	9.38 971	50	9.40 319	53	0.59 681	9.98 652	3	48
	13	9.39 021	50	9.40 372	53	0.59 628	9.98 649	3	47
	14	9.39 071	50	9.40 425	53	0.59 575	9.98 646	3	46
	15	9.39 121	49	9.40 478	53	0.59 522	9.98 643	3	45
	16	9.39 170	50	9.40 531	53	0.59 469	9.98 640	4	44
	17	9.39 220	50	9.40 584	52	0.59 416	9.98 636	3	43
	18	9.39 270	49	9.40 636	53	0.59 364	9.98 633	3	42
	19	9.39 319	50	9.40 689	53	0.59 311	9.98 630	3	41
	20	9.39 369	49	9.40 742	53	0.59 258	9.98 627	4	40
	21	9.39 418	49	9.40 795	52	0.59 205	9.98 623	3	39
	22	9.39 467	50	9.40 847	53	0.59 153	9.98 620	3	38
	23	9.39 517	49	9.40 900	52	0.59 100	9.98 617	3	37
	24	9.39 566	49	9.40 952	53	0.59 048	9.98 614	4	36
	25	9.39 615	49	9.41 005	52	0.58 995	9.98 610	3	35
	26	9.39 664	49	9.41 057	52	0.58 943	9.98 607	3	34
	27	9.39 713	49	9.41 109	52	0.58 891	9.98 604	3	33
	28	9.39 762	49	9.41 161	53	0.58 839	9.98 601	4	32
	29	9.39 811	49	9.41 214	52	0.58 876	9.98 597	3	31
	30	9.39 860	49	9.41 266	52	0.58 734	9.98 594	3	30
	31	9.39 909	49	9.41 318	52	0.58 682	9.98 591	3	29
	32	9.39 958	48	9.41 370	52	0.58 630	9.98 588	4	28
	33	9.40 006	49	9.41 422	52	0.58 578	9.98 584	3	27
	34	9.40 055	48	9.41 474	52	0.58 526	9.98 581	3	26
	35	9.40 103	49	9.41 526	52	0.58 474	9.98 578	4	25
	36	9.40 152	48	9.41 578	51	0.58 422	9.98 574	3	24
	37	9.40 200	49	9.41 629	52	0.58 371	9.98 571	3	23
	38	9.40 249	48	9.41 681	52	0.58 319	9.98 568	3	22
	39	9.40 297	49	9.41 733	51	0.58 267	9.98 565	4	21
	40	9.40 346	48	9.41 784	52	0.58 216	9.98 561	3	20
	41	9.40 394	48	9.41 836	51	0.58 164	9.98 558	3	19
	42	9.40 442	48	9.41 887	52	0.58 113	9.98 555	4	18
	43	9.40 490	48	9.41 939	51	0.58 061	9.98 551	3	17
	44	9.40 538	48	9.41 990	51	0.58 010	9.98 548	3	16
	45	9.40 586	48	9.42 041	52	0.57 959	9.98 545	4	15
	46	9.40 634	48	9.42 093	51	0.57 907	9.98 541	3	14
	47	9.40 682	48	9.42 144	51	0.57 856	9.98 538	3	13
	48	9.40 730	48	9.42 195	51	0.57 805	9.98 535	4	12
	49	9.40 778	47	9.42 246	51	0.57 754	9.98 531	3	11
	50	9.40 825	48	9.42 297	51	0.57 703	9.98 528	3	10
	51	9.40 873	48	9.42 348	51	0.57 652	9.98 525	4	9
	52	9.40 921	47	9.42 399	51	0.57 601	9.98 521	3	8
	53	9.40 968	48	9.42 450	51	0.57 550	9.98 518	3	7
	54	9.41 016	47	9.42 501	51	0.57 499	9.98 515	4	6
	55	9.41 063	48	9.42 552	51	0.57 448	9.98 511	3	5
	56	9.41 111	47	9.42 603	50	0.57 397	9.98 508	3	4
	57	9.41 158	47	9.42 653	51	0.57 347	9.98 505	4	3
	58	9.41 205	47	9.42 704	51	0.57 296	9.98 501	3	2
	59	9.41 252	48	9.42 755	50	0.57 245	9.98 498	4	1
	60	9.41 300		9.42 805		0.57 195	9.98 494		0
		L SIN	D	L TAN	CD	L COT	L COS	D	345°...165°
		L COS		L COT		L TAN	L SIN		255°.... 75°

15°...195°		L SIN	D	L TAN	CD	L COT	L COS	D	
105°...285°		L COS		L COT		L TAN	L SIN		
	0	9.41 300	47	9.42 805	51	0.57 195	9.98 494	3	60
	1	9.41 347	47	9.42 856	50	0.57 144	9.98 491	3	59
	2	9.41 394	47	9.42 906	51	0.57 094	9.98 488	4	58
	3	9.41 441	47	9.42 957	50	0.57 043	9.98 484	3	57
	4	9.41 488	47	9.43 007	50	0.56 993	9.98 481	4	56
	5	9.41 535	47	9.43 057	51	0.56 943	9.98 477	3	55
	6	9.41 582	46	9.43 108	50	0.56 892	9.98 474	3	54
	7	9.41 628	47	9.43 158	50	0.56 842	9.98 471	4	53
	8	9.41 675	47	9.43 208	50	0.56 792	9.98 467	3	52
	9	9.41 722	46	9.43 258	50	0.56 742	9.98 464	4	51
	10	9.41 768	47	9.43 308	50	0.56 692	9.98 460	3	50
	11	9.41 815	46	9.43 358	50	0.56 642	9.98 457	4	49
	12	9.41 861	47	9.43 408	50	0.56 592	9.98 453	3	48
	13	9.41 908	46	9.43 458	50	0.56 542	9.98 450	3	47
	14	9.41 954	47	9.43 508	50	0.56 492	9.98 447	4	46
	15	9.42 001	46	9.43 558	49	0.56 442	9.98 443	3	45
	16	9.42 047	46	9.43 607	50	0.56 393	9.98 440	4	44
	17	9.42 093	47	9.43 657	50	0.56 343	9.98 436	3	43
	18	9.42 140	46	9.43 707	49	0.56 293	9.98 433	4	42
	19	9.42 186	46	9.43 756	50	0.56 244	9.98 429	3	41
	20	9.42 232	46	9.43 806	49	0.56 194	9.98 426	4	40
	21	9.42 278	46	9.43 855	50	0.56 145	9.98 422	3	39
	22	9.42 324	46	9.43 905	49	0.56 095	9.98 419	4	38
	23	9.42 370	46	9.43 954	50	0.56 046	9.98 415	3	37
	24	9.42 416	45	9.44 004	49	0.55 996	9.98 412	3	36
	25	9.42 461	46	9.44 053	49	0.55 947	9.98 409	4	35
	26	9.42 507	46	9.44 102	49	0.55 898	9.98 405	3	34
	27	9.42 553	46	9.44 151	50	0.55 849	9.98 402	4	33
	28	9.42 599	45	9.44 201	49	0.55 799	9.98 398	3	32
	29	9.42 644	46	9.44 250	49	0.55 750	9.98 395	4	31
	30	9.42 690	45	9.44 299	49	0.55 701	9.98 391	3	30
	31	9.42 735	46	9.44 348	49	0.55 652	9.98 388	4	29
	32	9.42 781	45	9.44 397	49	0.55 603	9.98 384	3	28
	33	9.42 826	46	9.44 446	49	0.55 554	9.98 381	4	27
	34	9.42 872	45	9.44 495	49	0.55 505	9.98 377	4	26
	35	9.42 917	45	9.44 544	48	0.55 456	9.98 373	3	25
	36	9.42 962	46	9.44 592	49	0.55 408	9.98 370	4	24
	37	9.43 008	45	9.44 641	49	0.55 359	9.98 366	3	23
	38	9.43 053	45	9.44 690	48	0.55 310	9.98 363	4	22
	39	9.43 098	45	9.44 738	49	0.55 262	9.98 359	3	21
	40	9.43 143	45	9.44 787	49	0.55 213	9.98 356	4	20
	41	9.43 188	45	9.44 836	48	0.55 164	9.98 352	3	19
	42	9.43 233	45	9.44 884	49	0.55 116	9.98 349	4	18
	43	9.43 278	45	9.44 933	48	0.55 067	9.98 345	3	17
	44	9.43 323	44	9.44 981	48	0.55 019	9.98 342	4	16
	45	9.43 367	45	9.45 029	49	0.54 971	9.98 338	4	15
	46	9.43 412	45	9.45 078	48	0.54 922	9.98 334	3	14
	47	9.43 457	45	9.45 126	48	0.54 874	9.98 331	4	13
	48	9.43 502	44	9.45 174	48	0.54 826	9.98 327	3	12
	49	9.43 546	45	9.45 222	49	0.54 778	9.98 324	4	11
	50	9.43 591	44	9.45 271	48	0.54 729	9.98 320	3	10
	51	9.43 635	45	9.45 319	48	0.54 681	9.98 317	4	9
	52	9.43 680	44	9.45 367	48	0.54 633	9.98 313	4	8
	53	9.43 724	45	9.45 415	48	0.54 585	9.98 309	3	7
	54	9.43 769	44	9.45 463	48	0.54 537	9.98 306	4	6
	55	9.43 813	44	9.45 511	48	0.54 489	9.98 302	3	5
	56	9.43 857	44	9.45 559	47	0.54 441	9.98 299	4	4
	57	9.43 901	45	9.45 606	48	0.54 394	9.98 295	4	3
	58	9.43 946	44	9.45 654	48	0.54 346	9.98 291	3	2
	59	9.43 990	44	9.45 702	48	0.54 298	9.98 288	4	1
	60	9.44 034		9.45 750		0.54 250	9.98 284		0
		L SIN	D	L TAN	CD	L COT	L COS	D	344°...164°
		L COS		L COT		L TAN	L SIN		254°... 74°

16°...196°		L SIN	D	L TAN	CD	L COT	L COS	D	
106°...286°		L COS		L COT		L TAN	L SIN		
	0	9.44 034	44	9.45 750	47	0.54 250	9.98 284	3	60
	1	9.44 078	44	9.45 797	48	0.54 203	9.98 281	4	59
	2	9.44 122	44	9.45 845	47	0.54 155	9.98 277	4	58
	3	9.44 166	44	9.45 892	48	0.54 108	9.98 273	3	57
	4	9.44 210	43	9.45 940	47	0.54 060	9.98 270	4	56
	5	9.44 253	44	9.45 987	48	0.54 013	9.98 266	4	55
	6	9.44 297	44	9.46 035	47	0.53 965	9.98 262	3	54
	7	9.44 341	44	9.46 082	48	0.53 918	9.98 259	4	53
	8	9.44 385	43	9.46 130	47	0.53 870	9.98 255	4	52
	9	9.44 428	44	9.46 177	47	0.53 823	9.98 251	3	51
	10	9.44 472	44	9.46 224	47	0.53 776	9.98 248	4	50
	11	9.44 516	43	9.46 271	48	0.53 729	9.98 244	4	49
	12	9.44 559	43	9.46 319	47	0.53 681	9.98 240	3	48
	13	9.44 602	44	9.46 366	47	0.53 634	9.98 237	4	47
	14	9.44 646	43	9.46 413	47	0.53 587	9.98 233	4	46
	15	9.44 689	44	9.46 460	47	0.53 540	9.98 229	3	45
	16	9.44 733	43	9.46 507	47	0.53 493	9.98 226	4	44
	17	9.44 776	43	9.46 554	47	0.53 446	9.98 222	4	43
	18	9.44 819	43	9.46 601	47	0.53 399	9.98 218	3	42
	19	9.44 862	43	9.46 648	46	0.53 352	9.98 215	4	41
	20	9.44 905	43	9.46 694	47	0.53 306	9.98 211	4	40
	21	9.44 948	44	9.46 711	47	0.53 259	9.98 207	3	39
	22	9.44 992	43	9.46 788	47	0.53 212	9.98 204	4	38
	23	9.45 035	42	9.46 835	46	0.53 165	9.98 200	4	37
	24	9.45 077	43	9.46 861	47	0.53 119	9.98 196	4	36
	25	9.45 120	43	9.46 928	47	0.53 072	9.98 192	3	35
	26	9.45 163	43	9.46 975	46	0.53 025	9.98 189	4	34
	27	9.45 206	43	9.47 021	47	0.52 979	9.98 185	4	33
	28	9.45 249	43	9.47 068	46	0.52 932	9.98 181	4	32
	29	9.45 292	42	9.47 114	46	0.52 886	9.98 177	3	31
	30	9.45 334	43	9.47 160	47	0.52 840	9.98 174	4	30
	31	9.45 377	42	9.47 207	46	0.52 793	9.98 170	4	29
	32	9.45 419	43	9.47 253	46	0.52 747	9.98 166	4	28
	33	9.45 462	42	9.47 299	47	0.52 701	9.98 162	3	27
	34	9.45 504	43	9.47 346	46	0.52 654	9.98 159	4	26
	35	9.45 547	42	9.47 392	46	0.52 608	9.98 155	4	25
	36	9.45 589	43	9.47 438	46	0.52 562	9.98 151	4	24
	37	9.45 632	42	9.47 484	46	0.52 516	9.98 147	3	23
	38	9.45 674	42	9.47 530	46	0.52 470	9.98 144	4	22
	39	9.45 716	42	9.47 576	46	0.52 424	9.98 140	4	21
	40	9.45 758	43	9.47 622	46	0.52 378	9.98 136	4	20
	41	9.45 801	42	9.47 668	46	0.52 332	9.98 132	3	19
	42	9.45 843	42	9.47 714	46	0.52 286	9.98 129	4	18
	43	9.45 885	42	9.47 760	46	0.52 240	9.98 125	4	17
	44	9.45 927	42	9.47 806	46	0.52 194	9.98 121	4	16
	45	9.45 969	42	9.47 852	45	0.52 148	9.98 117	4	15
	46	9.46 011	42	9.47 897	46	0.52 103	9.98 113	3	14
	47	9.46 053	42	9.47 943	46	0.52 057	9.98 110	4	13
	48	9.46 095	41	9.47 989	46	0.52 011	9.98 106	4	12
	49	9.46 136	42	9.48 035	45	0.51 965	9.98 102	4	11
	50	9.46 178	42	9.48 080	46	0.51 920	9.98 098	4	10
	51	9.46 220	42	9.48 126	45	0.51 874	9.98 094	4	9
	52	9.46 262	41	9.48 171	46	0.51 829	9.98 090	3	8
	53	9.46 303	42	9.48 217	45	0.51 783	9.98 087	4	7
	54	9.46 345	41	9.48 262	45	0.51 738	9.98 083	4	6
	55	9.46 386	42	9.48 307	46	0.51 693	9.98 079	4	5
	56	9.46 428	41	9.48 353	45	0.51 647	9.98 075	4	4
	57	9.46 469	42	9.98 398	45	0.51 602	9.98 071	4	3
	58	9.46 511	41	9.48 443	46	0.51 557	9.98 067	4	2
	59	9.46 552	42	9.48 489	45	0.51 511	9.98 063	3	1
	60	9.46 594		9.48 534		0.51 466	9.98 060		0
		L SIN	D	L TAN	CD	L COT	L COS	D	343°...163°
		L COS		L COT		L TAN	L SIN		253°... 73°

17°...197°		L SIN	D	L TAN	CD	L COT	L COS	D	
107°...287°		L COS		L COT		L TAN	L SIN		
	0	9.46 594	41	9.48 534	45	0.51 466	9.98 060	4	60
	1	9.46 635	41	9.48 579	45	0.51 421	9.98 056	4	59
	2	9.46 676	41	9.48 624	45	0.51 376	9.98 052	4	58
	3	9.46 717	41	9.48 669	45	0.51 331	9.98 048	4	57
	4	9.46 758	42	9.48 714	45	0.51 286	9.98 044	4	56
	5	9.46 800	41	9.48 759	45	0.51 241	9.98 040	4	55
	6	9.46 841	41	9.48 804	45	0.51 196	9.98 036	4	54
	7	9.46 882	41	9.48 849	45	0.51 151	9.98 032	3	53
	8	9.46 923	41	9.48 894	45	0.51 106	9.98 029	4	52
	9	9.46 964	41	9.48 939	45	0.51 061	9.98 025	4	51
	10	9.47 005	40	9.48 984	45	0.51 016	9.98 021	4	50
	11	9.47 045	41	9.49 029	44	0.50 971	9.98 017	4	49
	12	9.47 086	41	9.49 073	45	0.50 927	9.98 013	4	48
	13	9.47 127	41	9.49 118	45	0.50 882	9.98 009	4	47
	14	9.47 168	41	9.49 163	44	0.50 837	9.98 005	4	46
	15	9.47 209	40	9.49 207	45	0.50 793	9.98 001	4	45
	16	9.47 249	41	9.49 252	44	0.50 748	9.97 997	4	44
	17	9.47 290	40	9.49 296	45	0.50 704	9.97 993	4	43
	18	9.47 330	41	9.49 341	44	0.50 659	9.97 989	3	42
	19	9.47 371	40	9.49 385	45	0.50 615	9.97 986	4	41
	20	9.47 411	41	9.49 430	44	0.50 570	9.97 982	4	40
	21	9.47 452	40	9.49 474	45	0.50 526	9.97 978	4	39
	22	9.47 492	41	9.49 519	44	0.50 481	9.97 974	4	38
	23	9.47 533	40	9.49 563	44	0.50 437	9.97 970	4	37
	24	9.47 573	40	9.49 607	45	0.50 393	9.97 966	4	36
	25	9.47 613	41	9.49 652	44	0.50 348	9.97 962	4	35
	26	9.47 654	40	9.49 696	44	0.50 304	9.97 958	4	34
	27	9.47 694	40	9.49 740	44	0.50 260	9.97 954	4	33
	28	9.47 734	40	9.49 784	44	0.50 216	9.97 950	4	32
	29	9.47 774	40	9.49 828	44	0.50 172	9.97 946	4	31
	30	9.47 814	40	9.49 872	44	0.50 128	9.97 942	4	30
	31	9.47 854	40	9.49 916	44	0.50 084	9.97 938	4	29
	32	9.47 894	40	9.49 960	44	0.50 040	9.97 934	4	28
	33	9.47 934	40	9.50 004	44	0.49 996	9.97 930	4	27
	34	9.47 974	40	9.50 048	44	0.49 952	9.97 926	4	26
	35	9.48 014	40	9.50 092	44	0.49 908	9.97 922	4	25
	36	9.48 054	40	9.50 136	44	0.49 864	9.97 918	4	24
	37	9.48 094	39	9.50 180	43	0.49 820	9.97 914	4	23
	38	9.48 133	40	9.50 223	44	0.49 777	9.97 910	4	22
	39	9.48 173	40	9.50 267	44	0.49 733	9.97 906	4	21
	40	9.48 213	39	9.50 311	44	0.49 689	9.97 902	4	20
	41	9.48 252	40	9.50 355	43	0.49 645	9.97 898	4	19
	42	9.48 292	40	9.50 398	44	0.49 602	9.97 894	4	18
	43	9.48 332	39	9.50 442	43	0.49 558	9.97 890	4	17
	44	9.48 371	40	9.50 485	44	0.49 515	9.97 886	4	16
	45	9.48 411	39	9.50 529	43	0.49 471	9.97 882	4	15
	46	9.48 450	40	9.50 572	44	0.49 428	9.97 878	4	14
	47	9.48 490	39	9.50 616	43	0.49 384	9.97 874	4	13
	48	9.48 529	39	9.50 659	44	0.49 341	9.97 870	4	12
	49	9.48 568	39	9.50 703	43	0.49 297	9.97 866	5	11
	50	9.48 607	40	9.50 746	43	0.49 254	9.97 861	4	10
	51	9.48 647	39	9.50 789	44	0.49 211	9.97 857	4	9
	52	9.48 686	39	9.50 833	43	0.49 167	9.97 853	4	8
	53	9.48 725	39	9.50 876	43	0.49 124	9.97 849	4	7
	54	9.48 764	39	9.50 919	43	0.49 081	9.97 845	4	6
	55	9.48 803	39	9.50 962	43	0.49 038	9.97 841	4	5
	56	9.48 842	39	9.51 005	43	0.48 995	9.97 837	4	4
	57	9.48 881	39	9.51 048	44	0.48 952	9.97 833	4	3
	58	9.48 920	39	9.51 092	43	0.48 908	9.97 829	4	2
	59	9.48 959	39	9.51 135	43	0.48 865	9.97 825	4	1
	60	9.48 998		9.51 178		0.48 822	9.97 821		0
		L SIN	D	L TAN	CD	L COT	L COS	D	342°...162°
		L COS		L COT		L TAN	L SIN		252°... 72°

18°...198°		L SIN	D	L TAN	CD	L COT	L COS	D		
108°...288°		L COS		L COT		L TAN	L SIN			
	0	9.48 098	39	9.51 178	43	0.48 822	9.97 821	4	60	
	1	9.49 037	39	9.51 221	43	0.48 779	9.97 817	5	59	
	2	9.49 076	39	9.51 264	42	0.48 736	9.97 812	4	58	
	3	9.49 115	38	9.51 306	43	0.48 694	9.97 808	4	57	
	4	9.49 153	39	9.51 349	43	0.48 651	9.97 804	4	56	
	5	9.49 192	39	9.51 392	43	0.48 608	9.97 800	4	55	
	6	9.49 231	38	9.51 435	43	0.48 565	9.97 796	4	54	
	7	9.49 269	39	9.51 478	42	0.48 522	9.97 792	4	53	
	8	9.49 308	39	9.51 520	43	0.48 480	9.97 788	4	52	
	9	9.49 347	38	9.51 563	43	0.48 437	9.97 784	5	51	
	10	9.49 385	39	9.51 606	42	0.48 394	9.97 779	4	50	
	11	9.49 424	38	9.51 648	43	0.48 352	9.97 775	4	49	
	12	9.49 462	38	9.51 691	43	0.48 309	9.97 771	4	48	
	13	9.49 500	39	9.51 734	42	0.48 266	9.97 767	4	47	
	14	9.49 539	38	9.51 776	43	0.48 224	9.97 763	4	46	
	15	9.49 577	38	9.51 819	42	0.48 181	9.97 759	5	45	
	16	9.49 615	39	9.51 861	42	0.48 139	9.97 754	4	44	
	17	9.49 654	38	9.51 903	43	0.48 097	9.97 750	4	43	
	18	9.49 692	38	9.51 946	42	0.48 054	9.97 746	4	42	
	19	9.49 730	38	9.51 988	43	0.48 012	9.97 742	4	41	
	20	9.49 768	38	9.52 031	42	0.47 969	9.97 738	4	40	
	21	9.49 806	38	9.52 073	42	0.47 927	9.97 734	5	39	
	22	9.49 844	38	9.52 115	42	0.47 885	9.97 729	4	38	
	23	9.49 822	38	9.52 157	43	0.47 843	9.97 725	4	37	
	24	9.49 920	38	9.52 200	42	0.47 800	9.97 721	4	36	
	25	9.49 958	38	9.52 242	42	0.47 758	9.97 717	4	35	
	26	9.49 996	38	9.52 284	42	0.47 716	9.97 713	5	34	
	27	9.50 034	38	9.52 326	42	0.47 674	9.97 708	4	33	
	28	9.50 072	38	9.52 368	42	0.47 632	9.97 704	4	32	
	29	9.50 110	38	9.52 410	42	0.47 590	9.97 700	4	31	
	30	9.50 148	37	9.52 452	42	0.47 548	9.97 699	5	30	
	31	9.50 185	38	9.52 494	42	0.47 506	9.97 691	4	29	
	32	9.50 223	38	9.52 536	42	0.47 464	9.97 687	4	28	
	33	9.50 281	37	9.52 578	42	0.47 422	9.97 683	4	27	
	34	9.50 298	38	9.52 620	41	0.47 380	9.97 679	5	26	
	35	9.50 336	38	9.52 661	42	0.47 339	9.97 674	4	25	
	36	9.50 374	37	9.52 703	42	0.47 297	9.97 670	4	24	
	37	9.50 411	38	9.52 745	42	0.47 255	9.97 666	4	23	
	38	9.50 449	37	9.52 787	42	0.47 213	9.97 662	5	22	
	39	9.50 486	37	9.52 829	41	0.47 171	9.97 657	4	21	
	40	9.50 523	38	9.52 870	42	0.47 130	9.97 653	4	20	
	41	9.50 561	37	9.52 912	41	0.47 088	9.97 649	4	19	
	42	9.50 598	37	9.52 953	42	0.47 047	9.97 645	5	18	
	43	9.50 635	38	9.52 995	42	0.47 005	9.97 640	4	17	
	44	9.50 673	37	9.53 037	41	0.46 963	9.97 636	4	16	
	45	9.50 710	37	9.53 078	42	0.46 922	9.97 632	4	15	
	46	9.50 747	37	9.53 120	41	0.46 880	9.97 628	5	14	
	47	9.50 784	37	9.53 161	41	0.46 839	9.97 623	4	13	
	48	9.50 821	37	9.53 202	42	0.46 798	9.97 619	4	12	
	49	9.50 858	38	9.53 244	41	0.46 756	9.97 615	5	11	
	50	9.50 896	37	9.53 285	42	0.46 715	9.97 610	4	10	
	51	9.50 933	37	9.53 327	41	0.46 673	9.97 606	4	9	
	52	9.50 970	37	9.53 368	41	0.46 632	9.97 602	5	8	
	53	9.51 007	36	9.53 409	41	0.46 591	9.97 597	4	7	
	54	9.51 043	37	9.53 450	42	0.46 550	9.97 593	4	6	
	55	9.51 080	37	9.53 492	41	0.46 508	9.97 589	5	5	
	56	9.51 117	37	9.53 533	41	0.46 467	9.97 584	4	4	
	57	9.51 154	37	9.53 574	41	0.46 426	9.97 580	4	3	
	58	9.51 191	36	9.53 615	41	0.46 385	9.97 576	5	2	
	59	9.51 227	37	9.53 656	41	0.46 344	9.97 571	4	1	
	60	9.51 264		9.53 697		0.46 303	9.97 567		0	
		L SIN	D	L TAN	CD	L COT	L COS	D		341°...161°
		L COS		L COT		L TAN	L SIN			251°... 71°

19°...199° / 109°...289°	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	
0	9.51 264	37	9.53 697	41	0.46 303	9.97 567	4	60
1	9.51 301	37	9.53 738	41	0.46 262	9.97 563	5	59
2	9.51 338	36	9.53 779	41	0.46 221	9.97 558	4	58
3	9.51 374	37	9.53 820	41	0.46 180	9.97 554	4	57
4	9.51 411	36	9.53 861	41	0.46 139	9.97 550	5	56
5	9.51 447	37	9.53 902	41	0.46 098	9.97 545	4	55
6	9.51 484	36	9.53 943	41	0.46 057	9.97 541	5	54
7	9.51 520	37	9.53 984	41	0.46 016	9.97 536	4	53
8	9.51 557	36	9.54 025	40	0.45 975	9.97 532	4	52
9	9.51 593	36	9.54 065	41	0.45 935	9.97 528	5	51
10	9.51 629	37	9.54 106	41	0.45 894	9.97 523	4	50
11	9.51 666	36	9.54 147	40	0.45 853	9.97 519	4	49
12	9.51 702	36	9.54 187	41	0.45 813	9.97 515	5	48
13	9.51 738	36	9.54 228	41	0.45 772	9.97 510	4	47
14	9.51 774	37	9.54 269	40	0.45 731	9.97 506	5	46
15	9.51 811	36	9.54 309	41	0.45 691	9.97 501	4	45
16	9.51 847	36	9.54 350	40	0.45 650	9.97 497	5	44
17	9.51 883	36	9.54 390	41	0.45 610	9.97 492	4	43
18	9.51 919	36	9.54 431	40	0.45 569	9.97 488	4	42
19	9.51 955	36	9.54 471	41	0.45 529	9.97 484	5	41
20	9.51 991	36	9.54 512	40	0.45 488	9.97 479	4	40
21	9.52 027	36	9.54 552	41	0.45 448	9.97 475	5	39
22	9.52 063	36	9.54 593	40	0.45 407	9.97 470	4	38
23	9.52 099	36	9.54 633	40	0.45 367	9.97 466	5	37
24	9.52 135	36	9.54 673	41	0.45 327	9.97 461	4	36
25	9.52 171	36	9.54 714	40	0.45 286	9.97 457	4	35
26	9.52 207	35	9.54 754	40	0.45 246	9.97 453	5	34
27	9.52 242	36	9.54 794	41	0.45 206	9.97 448	4	33
28	9.52 278	36	9.54 835	40	0.45 165	9.97 444	5	32
29	9.52 314	36	9.54 875	40	0.45 125	9.97 439	4	31
30	9.52 350	35	9.54 915	40	0.45 085	9.97 435	5	30
31	9.52 385	36	9.54 955	40	0.45 045	9.97 430	4	29
32	9.52 421	35	9.54 995	40	0.45 005	9.97 426	5	28
33	9.52 456	36	9.55 035	40	0.44 965	9.97 421	4	27
34	9.52 492	35	9.55 075	40	0.44 925	9.97 417	5	26
35	9.52 527	36	9.55 115	40	0.44 885	9.97 412	4	25
36	9.52 563	35	9.55 155	40	0.44 845	9.97 408	5	24
37	9.52 598	36	9.55 195	40	0.44 805	9.97 403	4	23
38	9.52 634	35	9.55 235	40	0.44 765	9.97 399	5	22
39	9.52 669	36	9.55 275	40	0.44 725	9.97 394	4	21
40	9.52 705	35	9.55 315	40	0.44 685	9.97 390	5	20
41	9.52 740	35	9.55 355	40	0.44 645	9.97 385	4	19
42	9.52 775	36	9.55 395	39	0.44 605	9.97 381	5	18
43	9.52 811	35	9.55 434	40	0.44 566	9.97 376	4	17
44	9.52 846	35	9.55 474	40	0.44 526	9.97 372	5	16
45	9.52 881	35	9.55 514	40	0.44 486	9.97 367	4	15
46	9.52 916	35	9.55 554	39	0.44 446	9.97 363	5	14
47	9.52 951	35	9.55 593	40	0.44 407	9.97 358	5	13
48	9.52 986	35	9.55 633	40	0.44 367	9.97 353	4	12
49	9.53 021	35	9.55 673	39	0.44 327	9.97 349	5	11
50	9.53 056	36	9.55 712	40	0.44 288	9.97 344	4	10
51	9.53 092	34	9.55 752	39	0.44 248	9.97 340	5	9
52	9.53 126	35	9.55 791	40	0.44 209	9.97 335	4	8
53	9.53 161	35	9.55 831	39	0.44 169	9.97 331	5	7
54	9.53 196	35	9.55 870	40	0.44 130	9.97 326	4	6
55	9.53 231	35	9.55 910	39	0.44 090	9.97 322	5	5
56	9.53 266	35	9.55 949	40	0.44 051	9.97 317	5	4
57	9.53 301	35	9.55 989	39	0.44 011	9.97 312	4	3
58	9.53 336	34	9.56 028	39	0.43 972	9.97 308	5	2
59	9.53 370	35	9.56 067	40	0.43 933	9.97 303	4	1
60	9.53 405		9.56 107		0.43 893	9.97 299		0
	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	340°...160° / 250°... 70°

20°...200°		L SIN	D	L TAN	CD	L COT	L COS	D		
110°...290°		L COS		L COT		L TAN	L SIN			
	0	9.53 405		9.56 107		0.43 893	9.97 299		60	
	1	9.53 440	35	9.56 146	39	0.43 854	9.97 294	5	59	
	2	9.53 475	35	9.56 185	39	0.43 815	9.97 289	5	58	
	3	9.53 509	34	9.56 224	39	0.43 776	9.97 285	4	57	
	4	9.53 544	35	9.56 264	40	0.43 736	9.97 280	5	56	
	5	9.53 578	34	9.56 303	39	0.43 697	9.97 276	4	55	
	6	9.53 613	35	9.56 342	39	0.43 658	9.97 271	5	54	
	7	9.53 647	34	9.56 381	39	0.43 619	9.97 266	5	53	
	8	9.53 682	35	9.56 420	39	0.43 580	9.97 262	4	52	
	9	9.53 716	34	9.56 459	39	0.43 541	9.97 257	5	51	
	10	9.53 751	35	9.56 498	39	0.43 502	9.97 252	5	50	
	11	9.53 785	34	9.56 537	39	0.43 463	9.97 248	4	49	
	12	9.53 819	34	9.56 576	39	0.43 424	9.97 243	5	48	
	13	9.53 854	35	9.56 615	39	0.43 385	9.97 238	5	47	
	14	9.53 888	34	9.56 654	39	0.43 346	9.97 234	4	46	
	15	9.53 922	34	9.56 693	39	0.43 307	9.97 229	5	45	
	16	9.53 957	35	9.56 732	39	0.43 268	9.97 224	5	44	
	17	9.53 991	34	9.56 771	39	0.43 229	9.97 220	4	43	
	18	9.54 025	34	9.56 810	39	0.43 190	9.97 215	5	42	
	19	9.54 059	34	9.56 849	39	0.43 151	9.97 210	5	41	
	20	9.54 093	34	9.56 887	38	0.43 113	9.97 206	4	40	
	21	9.54 127	34	9.56 926	39	0.43 074	9.97 201	5	39	
	22	9.54 161	34	9.56 965	39	0.43 035	9.97 196	5	38	
	23	9.54 195	34	9.57 004	39	0.42 996	9.97 192	4	37	
	24	9.54 229	34	9.57 042	38	0.42 958	9.97 187	5	36	
	25	9.54 263	34	9.57 081	39	0.42 919	9.97 182	5	35	
	26	9.54 297	34	9.57 120	39	0.42 880	9.97 178	4	34	
	27	9.54 331	34	9.57 158	38	0.42 842	9.97 173	5	33	
	28	9.54 365	34	9.57 197	39	0.42 803	9.97 168	5	32	
	29	9.54 399	34	9.57 235	38	0.42 765	9.97 163	5	31	
	30	9.54 433	34	9.57 274	39	0.42 726	9.97 159	4	30	
	31	9.54 466	33	9.57 312	38	0.42 688	9.97 154	5	29	
	32	9.54 500	34	9.57 351	39	0.42 649	9.97 149	5	28	
	33	9.54 534	34	9.57 389	38	0.42 611	9.97 145	4	27	
	34	9.54 567	33	9.57 428	39	0.42 572	9.97 140	5	26	
	35	9.54 601	34	9.57 466	38	0.42 534	9.97 135	5	25	
	36	9.54 635	34	9.57 504	38	0.42 496	9.97 130	5	24	
	37	9.54 668	33	9.57 543	39	0.42 457	9.97 126	4	23	
	38	9.54 702	34	9.57 581	38	0.42 419	9.57 121	5	22	
	39	9.54 735	33	9.57 619	38	0.42 381	9.57 116	5	21	
	40	9.54 769	34	9.57 658	39	0.42 342	9.97 111	5	20	
	41	9.54 802	33	9.57 696	38	0.42 304	9.97 107	4	19	
	42	9.54 836	34	9.57 734	38	0.42 266	9.97 102	5	18	
	43	9.54 869	33	9.57 772	38	0.42 228	9.97 097	5	17	
	44	9.54 903	34	9.57 810	38	0.42 190	9.97 092	5	16	
	45	9.54 936	33	9.57 849	39	0.42 151	9.97 087	5	15	
	46	9.54 969	33	9.57 887	38	0.42 113	9.97 083	4	14	
	47	9.55 003	34	9.57 925	38	0.42 075	9.97 078	5	13	
	48	9.55 036	33	9.57 963	38	0.42 037	9.97 073	5	12	
	49	9.55 069	33	9.58 001	38	0.41 999	9.97 068	5	11	
	50	9.55 102	33	9.58 039	38	0.41 961	9.97 063	5	10	
	51	9.55 136	34	9.58 077	38	0.41 923	9.97 059	4	9	
	52	9.55 169	33	9.58 115	38	0.41 885	9.97 054	5	8	
	53	9.55 202	33	9.58 153	38	0.41 847	9.97 049	5	7	
	54	9.55 235	33	9.58 191	38	0.41 809	9.97 044	5	6	
	55	9.55 268	33	9.58 229	38	0.41 771	9.97 039	5	5	
	56	9.55 301	33	9.58 267	38	0.41 733	9.97 035	4	4	
	57	9.55 334	33	9.58 304	37	0.41 696	9.97 030	5	3	
	58	9.55 367	33	9.58 342	38	0.41 658	9.97 025	5	2	
	59	9.55 400	33	9.58 380	38	0.41 620	9.97 020	5	1	
	60	9.55 433	33	9.58 418	38	0.41 582	9.97 015	5	0	
		L SIN	D	L TAN	CD	L COT	L COS	D		339°...159°
		L COS		L COT		L TAN	L SIN			249°... 69°

21°...201°		L SIN	D	L TAN	CD	L COT	L COS	D		
111°...291°		L COS		L COT		L TAN	L SIN			
	0	9.55 433	33	9.58 418	37	0.41 582	9.97 015	5	60	
	1	9.55 466	33	9.58 455	38	0.41 545	9.97 010	5	59	
	2	9.55 499	33	9.58 493	38	0.41 507	9.97 005	4	58	
	3	9.55 532	32	9.58 531	38	0.41 469	9.97 001	5	57	
	4	9.55 564	33	9.58 569	37	0.41 431	9.96 996	5	56	
	5	9.55 597	33	9.58 606	38	0.41 394	9.96 991	5	55	
	6	9.55 630	33	9.58 644	37	0.41 356	9.96 986	5	54	
	7	9.55 663	32	9.58 681	38	0.41 319	9.96 981	5	53	
	8	9.55 695	33	9.58 719	38	0.41 281	9.96 976	5	52	
	9	9.55 728	33	9.58 757	37	0.41 243	9.96 971	5	51	
	10	9.55 761	32	9.58 794	38	0.41 206	9.96 966	4	50	
	11	9.55 793	33	9.58 832	37	0.41 168	9.96 962	5	49	
	12	9.55 826	32	9.58 869	38	0.41 131	9.96 957	5	48	
	13	9.55 858	33	9.58 907	37	0.41 093	9.96 952	5	47	
	14	9.55 891	32	9.58 944	37	0.41 056	9.96 947	5	46	
	15	9.55 923	33	9.58 981	38	0.41 019	9.96 942	5	45	
	16	9.55 956	32	9.59 019	37	0.40 981	9.96 937	5	44	
	17	9.55 988	33	9.59 056	38	0.40 944	9.96 932	5	43	
	18	9.56 021	32	9.59 094	37	0.40 906	9.96 927	5	42	
	19	9.56 053	32	9.59 131	37	0.40 869	9.96 922	5	41	
	20	9.56 085	33	9.59 168	37	0.40 832	9.96 917	5	40	
	21	9.56 118	32	9.59 205	38	0.40 795	9.96 912	5	39	
	22	9.56 150	32	9.59 243	37	0.40 757	9.96 907	4	38	
	23	9.56 182	33	9.59 280	37	0.40 720	9.96 903	5	37	
	24	9.56 215	32	9.59 317	37	0.40 683	9.96 898	5	36	
	25	9.56 247	32	9.59 354	37	0.40 646	9.96 893	5	35	
	26	9.56 279	32	9.59 391	38	0.40 609	9.96 888	5	34	
	27	9.56 311	32	9.59 429	37	0.40 571	9.96 883	5	33	
	28	9.56 343	32	9.59 466	37	0.40 534	9.96 878	5	32	
	29	9.56 375	33	9.59 503	37	0.40 497	9.96 873	5	31	
	30	9.56 408	32	9.59 540	37	0.40 460	9.96 868	5	30	
	31	9.56 440	32	9.59 577	37	0.40 423	9.96 863	5	29	
	32	9.56 472	32	9.59 614	37	0.40 386	9.96 858	5	28	
	33	9.56 504	32	9.59 651	37	0.40 349	9.96 853	5	27	
	34	9.56 536	32	9.59 688	37	0.40 312	9.96 848	5	26	
	35	9.56 568	31	9.59 725	37	0.40 275	9.96 843	5	25	
	36	9.56 599	32	9.59 762	37	0.40 238	9.96 838	5	24	
	37	9.96 631	32	9.59 799	36	0.40 201	9.96 833	5	23	
	38	9.56 663	32	9.59 835	37	0.40 165	9.96 828	5	22	
	39	9.56 695	32	9.59 872	37	0.40 128	9.96 823	5	21	
	40	9.56 727	32	9.59 909	37	0.40 091	9.96 818	5	20	
	41	9.56 759	31	9.59 946	37	0.40 054	9.96 813	5	19	
	42	9.56 790	32	9.59 983	36	0.40 017	9.96 808	5	18	
	43	9.56 822	32	9.60 019	37	0.39 981	9.96 803	5	17	
	44	9.56 854	32	9.60 056	37	0.39 944	9.96 798	5	16	
	45	9.56 886	31	9.60 093	37	0.39 907	9.96 793	5	15	
	46	9.56 917	32	9.60 130	36	0.39 870	9.96 788	5	14	
	47	9.56 949	31	9.60 166	37	0.39 834	9.96 783	5	13	
	48	9.56 980	32	9.60 203	37	0.39 797	9.96 778	5	12	
	49	9.57 012	32	9.60 240	36	0.39 760	9.96 772	5	11	
	50	9.57 044	31	9.60 276	37	0.39 724	9.96 767	5	10	
	51	9.57 075	32	9.60 313	36	0.39 687	9.96 762	5	9	
	52	9.57 107	31	9.60 349	37	0.39 651	9.96 757	5	8	
	53	9.57 133	31	9.60 386	36	0.39 614	9.96 752	5	7	
	54	9.57 169	32	9.60 422	37	0.39 578	9.96 747	5	6	
	55	9.57 201	31	9.60 459	36	0.39 541	9.96 742	5	5	
	56	9.57 232	32	9.60 495	37	0.39 505	9.96 737	5	4	
	57	9.57 264	31	9.60 532	36	0.39 468	9.96 732	5	3	
	58	9.57 295	31	9.60 568	37	0.39 432	9.96 727	5	2	
	59	9.57 326	32	9.60 605	36	0.39 395	9.96 722	5	1	
	60	9.57 358		9.60 641		0.39 359	9.96 717		0	
		L SIN	D	L TAN	CD	L COT	L COS	D		338°...158°
		L COS		L COT		L TAN	L SIN			248°... 68°

22°...202°	L SIN	D	L TAN	CD	L COT	L COS	D	
112°...292°	L COS		L COT		L TAN	L SIN		
0	9.57 358	31	9.60 641	36	0.39 359	9.96 717	6	60
1	9.57 389	31	9.60 677	37	0.39 323	9.96 711	5	59
2	9.57 420	31	9.60 714	36	0.39 286	9.96 706	5	58
3	9.57 451	31	9.60 750	36	0.39 250	9.96 701	5	57
4	9.57 482	32	9.60 786	37	0.39 214	9.96 696	5	56
5	9.57 514	31	9.60 823	36	0.39 177	9.96 691	5	55
6	9.57 545	31	9.60 859	36	0.39 141	9.96 686	5	54
7	9.57 576	31	9.60 895	36	0.39 105	9.96 681	5	53
8	9.57 607	31	9.60 931	36	0.39 069	9.96 676	6	52
9	9.57 638	31	9.60 967	37	0.39 033	9.96 670	5	51
10	9.57 669	31	9.61 004	36	0.38 996	9.96 665	5	50
11	9.57 700	31	9.61 040	36	0.38 960	9.96 660	5	49
12	9.57 731	31	9.61 076	36	0.38 924	9.96 655	5	48
13	9.57 762	31	9.61 112	36	0.38 888	9.96 650	5	47
14	9.57 793	31	9.61 148	36	0.38 852	9.96 645	5	46
15	9.57 824	31	9.61 184	36	0.38 816	9.96 640	6	45
16	9.57 855	30	9.61 220	36	0.38 780	9.96 634	5	44
17	9.57 885	31	9.61 256	36	0.38 744	9.96 629	5	43
18	9.57 916	31	9.61 292	36	0.38 708	9.96 624	5	42
19	9.57 947	31	9.61 328	36	0.38 672	9.96 619	5	41
20	9.57 978	30	9.61 364	36	0.38 636	9.96 614	6	40
21	9.58 008	31	9.61 400	36	0.38 600	9.96 608	5	39
22	9.58 039	31	9.61 436	36	0.38 564	9.96 603	5	38
23	9.58 070	31	9.61 472	36	0.38 528	9.96 598	5	37
24	9.58 101	30	9.61 508	36	0.38 492	9.96 593	5	36
25	9.58 131	31	9.61 544	35	0.38 456	9.96 588	6	35
26	9.58 162	30	9.61 579	36	0.38 421	9.96 582	5	34
27	9.58 192	31	9.61 615	36	0.38 385	9.96 577	5	33
28	9.58 223	30	9.61 651	36	0.38 349	9.96 572	5	32
29	9.58 253	31	9.61 687	35	0.38 313	9.96 567	5	31
30	9.58 284	30	9.61 722	36	0.38 278	9.96 562	6	30
31	9.58 314	31	9.61 758	36	0.38 242	9.96 556	5	29
32	9.58 345	30	9.61 794	36	0.38 206	9.96 551	5	28
33	9.58 375	31	9.61 830	35	0.38 170	9.96 546	5	27
34	9.58 406	30	9.61 865	36	0.38 135	9.96 541	6	26
35	9.58 436	31	9.61 901	35	0.38 099	9.96 535	5	25
36	9.58 467	30	9.61 936	36	0.38 064	9.96 530	5	24
37	9.58 497	30	9.61 972	36	0.38 028	9.96 525	5	23
38	9.58 527	30	9.62 008	35	0.37 992	9.96 520	6	22
39	9.58 557	31	9.62 043	36	0.37 957	9.96 514	5	21
40	9.58 588	30	9.62 079	35	0.37 921	9.96 509	5	20
41	9.58 618	30	9.62 114	36	0.37 886	9.96 504	6	19
42	9.58 648	30	9.62 150	35	0.37 850	9.96 498	5	18
43	9.58 678	31	9.62 185	36	0.37 815	9.96 493	5	17
44	9.58 709	30	9.62 221	35	0.37 779	9.96 488	5	16
45	9.58 739	30	9.62 256	36	0.37 744	9.96 483	6	15
46	9.58 769	30	9.62 292	35	0.37 708	9.96 477	5	14
47	9.58 799	30	9.62 327	35	0.37 673	9.96 472	5	13
48	9.58 829	30	9.62 362	36	0.37 638	9.96 467	6	12
49	9.58 859	30	9.62 398	35	0.37 602	9.96 461	5	11
50	9.58 889	30	9.62 433	35	0.37 567	9.96 456	5	10
51	9.58 919	30	9.62 468	36	0.37 532	9.96 451	6	9
52	9.58 949	30	9.62 504	35	0.37 496	9.96 445	5	8
53	9.58 979	30	9.62 539	35	0.37 461	9.96 440	5	7
54	9.59 009	30	9.62 574	35	0.37 426	9.96 435	6	6
55	9.59 039	30	9.62 609	36	0.37 391	9.96 429	5	5
56	9.59 069	29	9.62 645	35	0.37 355	9.96 424	5	4
57	9.59 098	30	9.62 680	35	0.37 320	9.96 419	6	3
58	9.59 128	30	9.62 715	35	0.37 285	9.96 413	5	2
59	9.59 158	30	9.62 750	35	0.37 250	9.96 408	5	1
60	9.59 188		9.62 785		0.37 215	9.96 403		0
	L SIN	D	L TAN	CD	L COT	L COS	D	337°...157°
	L COS		L COT		L TAN	L SIN		247°... 67°

23°...203°		L SIN	D	L TAN	CD	L COT	L COS	D	
113°...293°		L COS		L COT		L TAN	L SIN		
	0	9.59 188	30	9.62 785	35	0.37 215	9.96 403	6	60
	1	9.59 218	29	9.62 820	35	0.37 180	9.96 397	5	59
	2	9.59 247	30	9.62 855	35	0.37 145	9.96 392	5	58
	3	9.59 277	30	9.62 890	36	0.37 110	9.96 387	6	57
	4	9.59 307	29	9.62 926	35	0.37 074	9.96 381	5	56
	5	9.59 336	30	9.62 961	35	0.37 039	9.96 376	6	55
	6	9.59 366	30	9.62 996	35	0.37 004	9.96 370	5	54
	7	9.59 396	29	9.63 031	35	0.36 969	9.96 365	5	53
	8	9.59 425	30	9.63 066	35	0.36 934	9.96 360	6	52
	9	9.59 455	29	9.63 101	34	0.36 899	9.96 354	5	51
	10	9.59 484	30	9.63 135	35	0.36 865	9.96 349	6	50
	11	9.59 514	29	9.63 170	35	0.36 830	9.96 343	5	49
	12	9.59 543	30	9.63 205	35	0.36 795	9.96 338	5	48
	13	9.59 573	29	9.63 240	35	0.36 760	9.96 333	6	47
	14	9.59 602	30	9.63 275	35	0.36 725	9.96 327	5	46
	15	9.59 632	29	9.63 310	35	0.36 690	9.96 322	6	45
	16	9.59 661	29	9.63 345	34	0.36 655	9.96 316	5	44
	17	9.59 690	30	9.63 379	35	0.36 621	9.96 311	6	43
	18	9.59 720	29	9.63 414	35	0.36 586	9.96 305	5	42
	19	9.59 749	29	9.63 449	35	0.36 551	9.96 300	6	41
	20	9.59 778	30	9.63 484	35	0.36 516	9.96 294	5	40
	21	9.59 808	29	9.63 519	34	0.36 481	9.96 289	5	39
	22	9.59 837	29	9.63 553	35	0.36 447	9.96 284	6	38
	23	9.59 866	29	9.63 588	35	0.36 412	9.96 278	5	37
	24	9.59 895	29	9.63 623	34	0.36 377	9.96 273	6	36
	25	9.59 924	30	9.63 657	35	0.36 343	9.96 267	5	35
	26	9.59 954	29	9.63 692	34	0.36 308	9.96 262	6	34
	27	9.59 983	29	9.63 726	35	0.36 274	9.96 256	5	33
	28	9.60 012	29	9.63 761	35	0.36 239	9.96 251	6	32
	29	9.60 041	29	9.63 796	34	0.36 204	9.96 245	5	31
	30	9.60 070	29	9.63 830	35	0.36 170	9.96 240	6	30
	31	9.60 099	29	9.63 865	34	0.36 135	9.96 234	5	29
	32	9.60 128	29	9.63 899	35	0.36 101	9.96 229	6	28
	33	9.60 157	29	9.63 934	34	0.36 066	9.96 223	5	27
	34	9.60 186	29	9.63 968	35	0.36 032	9.96 218	6	26
	35	9.60 215	29	9.64 003	34	0.35 997	9.96 212	5	25
	36	9.60 244	29	9.64 037	35	0.35 963	9.96 207	6	24
	37	9.60 273	29	9.64 072	34	0.35 928	9.96 201	5	23
	38	9.60 302	29	9.64 106	34	0.35 894	9.96 196	6	22
	39	9.60 331	28	9.64 140	35	0.35 860	9.96 190	5	21
	40	9.60 359	29	9.64 175	34	0.35 825	9.96 185	6	20
	41	9.60 388	29	9.64 209	34	0.35 791	9.96 179	5	19
	42	9.60 417	29	9.64 243	35	0.35 757	9.96 174	6	18
	43	9.60 446	28	9.64 278	34	0.35 722	9.96 168	6	17
	44	9.60 474	29	9.64 312	34	0.35 688	9.96 162	5	16
	45	9.60 503	29	9.64 346	35	0.35 654	9.96 157	6	15
	46	9.60 532	29	9.64 381	34	0.35 619	9.96 151	5	14
	47	9.60 561	28	9.64 415	34	0.35 585	9.96 146	6	13
	48	9.60 589	29	9.64 449	34	0.35 551	9.96 140	5	12
	49	9.60 618	28	9.64 483	34	0.35 517	9.96 135	6	11
	50	9.60 646	29	9.64 517	35	0.35 483	9.96 129	6	10
	51	9.60 675	29	9.64 552	34	0.35 448	9.96 123	5	9
	52	9.60 704	28	9.64 586	34	0.35 414	9.96 118	6	8
	53	9.60 732	29	9.64 620	34	0.35 380	9.96 112	5	7
	54	9.60 761	28	9.64 654	34	0.35 346	9.96 107	6	6
	55	9.60 789	29	9.64 688	34	0.35 312	9.96 101	6	5
	56	9.60 818	28	9.64 722	34	0.35 278	9.96 095	5	4
	57	9.60 846	29	9.64 756	34	0.35 244	9.96 090	6	3
	58	9.60 875	28	9.64 790	34	0.35 210	9.96 084	5	2
	59	9.60 903	28	9.64 824	34	0.35 176	9.96 079	6	1
	60	9.60 931		9.64 858		0.35 142	9.96 073		0
		L SIN	D	L TAN	CD	L COT	L COS	D	336°...156°
		L COS		L COT		L TAN	L SIN		246°... 66°

24°...204° / 114°...294°	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	
0	9.60 931	29	9.64 858	34	0.35 142	9.96 073	6	60
1	9.60 960	28	9.64 892	34	0.35 108	9.96 067	5	59
2	9.60 988	28	9.64 926	34	0.35 074	9.96 062	6	58
3	9.61 016	29	9.64 960	34	0.35 040	9.96 056	6	57
4	9.61 045	28	9.64 994	34	0.35 006	9.95 050	5	56
5	9.61 073	28	9.65 028	34	0.34 972	9.96 045	6	55
6	9.61 101	28	9.65 062	34	0.34 938	9.96 039	5	54
7	9.61 129	29	9.65 096	34	0.34 904	9.96 034	6	53
8	9.61 158	28	9.65 130	34	0.34 870	9.96 028	6	52
9	9.61 186	28	9.65 164	33	0.34 836	9.96 022	5	51
10	9.61 214	28	9.65 197	34	0.34 803	9.96 017	6	50
11	9.61 242	28	9.65 231	34	0.34 769	9.96 011	6	49
12	9.61 270	28	9.65 265	34	0.34 735	9.96 005	5	48
13	9.61 298	28	9.65 299	34	0.34 701	9.96 000	6	47
14	9.61 326	28	9.65 333	33	0.34 667	9.95 994	6	46
15	9.61 354	28	9.65 366	34	0.34 634	9.95 988	6	45
16	9.61 382	29	9.65 400	34	0.34 600	9.95 982	5	44
17	9.61 411	27	9.65 434	33	0.34 566	9.95 977	6	43
18	9.61 438	28	9.65 467	34	0.34 533	9.95 971	6	42
19	9.61 466	28	9.65 501	34	0.34 499	9.95 965	5	41
20	9.61 494	28	9.65 535	33	0.34 465	9.95 960	6	40
21	9.61 522	28	9.65 568	34	0.34 432	9.95 954	6	39
22	9.61 550	28	9.65 602	34	0.34 398	9.95 948	6	38
23	9.61 578	28	9.65 636	33	0.34 364	9.95 942	5	37
24	9.61 606	28	9.65 669	34	0.34 331	9.95 937	6	36
25	9.61 634	28	9.65 703	33	0.34 297	9.95 931	6	35
26	9.61 662	27	9.65 736	34	0.34 264	9.95 925	5	34
27	9.61 689	28	9.65 770	33	0.34 230	9.95 920	6	33
28	9.61 717	28	9.65 803	34	0.34 197	9.95 914	6	32
29	9.61 745	28	9.65 837	33	0.34 163	9.95 908	6	31
30	9.61 773	27	9.65 870	34	0.34 130	9.95 902	5	30
31	9.61 800	28	9.65 904	33	0.34 096	9.95 897	6	29
32	9.61 828	28	9.65 937	34	0.34 063	9.95 891	6	28
33	9.61 856	27	9.65 971	33	0.34 029	9.95 885	6	27
34	9.61 883	28	9.66 004	34	0.33 996	9.95 879	6	26
35	9.61 911	28	9.66 038	33	0.33 962	9.95 873	5	25
36	9.61 939	27	9.66 071	33	0.33 929	9.95 868	6	24
37	9.61 966	28	9.66 104	34	0.33 896	9.95 862	6	23
38	9.61 994	27	9.66 138	33	0.33 862	9.95 856	6	22
39	9.62 021	28	9.66 171	33	0.33 829	9.95 850	6	21
40	9.62 049	27	9.66 204	34	0.33 796	9.95 844	5	20
41	9.62 076	28	9.66 238	33	0.33 762	9.95 839	6	19
42	9.62 104	27	9.66 271	33	0.33 729	9.95 833	6	18
43	9.62 131	28	9.66 304	33	0.33 696	9.95 827	6	17
44	9.62 159	27	9.66 337	34	0.33 663	9.95 821	6	16
45	9.62 186	28	9.66 371	33	0.33 629	9.95 815	5	15
46	9.62 214	27	9.66 404	33	0.33 596	9.95 810	6	14
47	9.62 241	27	9.66 437	33	0.33 563	9.95 804	6	13
48	9.62 268	28	9.66 470	33	0.33 530	9.95 798	6	12
49	9.62 296	27	9.66 503	34	0.33 497	9.95 792	6	11
50	9.62 323	27	9.66 527	33	0.33 463	9.95 786	6	10
51	9.62 350	27	9.66 570	33	0.33 430	9.95 780	5	9
52	9.62 377	28	9.66 603	33	0.33 397	9.95 775	6	8
53	9.62 405	27	9.66 636	33	0.33 364	9.95 769	6	7
54	9.62 432	27	9.66 669	33	0.33 331	9.95 763	6	6
55	9.62 459	27	9.66 702	33	0.33 298	9.95 757	6	5
56	9.62 486	27	9.66 735	33	0.33 265	9.95 751	6	4
57	9.62 513	28	9.66 768	33	0.33 232	9.95 745	6	3
58	9.62 541	27	9.66 801	33	0.33 199	9.95 739	6	2
59	9.62 568	27	9.66 834	33	0.33 166	9.95 733	5	1
60	9.62 595		9.66 867		0.33 133	9.95 728		0
335°...155° / 245°... 65°	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	

25°...205°		L SIN	D	L TAN	CD	L COT	L COS	D		
115°...295°		L COS		L COT		L TAN	L SIN			
	0	9.62 595	27	9.66 867	33	0.33 133	9.95 728	6	60	
	1	9.62 622	27	9.66 900	33	0.33 100	9.95 722	6	59	
	2	9.62 649	27	9.66 933	33	0.33 067	9.95 716	6	58	
	3	9.62 676	27	9.66 966	33	0.33 034	9.95 710	6	57	
	4	9.62 703	27	9.66 999	33	0.33 001	9.95 704	6	56	
	5	9.62 730	27	9.67 032	33	0.32 968	9.95 698	6	55	
	6	9.62 757	27	9.67 065	33	0.32 935	9.95 692	6	54	
	7	9.62 784	27	9.67 098	33	0.32 902	9.95 686	6	53	
	8	9.62 811	27	9.67 131	32	0.32 869	9.95 680	6	52	
	9	9.62 838	27	9.67 163	33	0.32 837	9.95 674	6	51	
	10	9.62 865	27	9.67 196	33	0.32 804	9.95 668	5	50	
	11	9.62 892	26	9.67 229	33	0.32 771	9.95 663	6	49	
	12	9.62 918	27	9.67 262	33	0.32 738	9.95 657	6	48	
	13	9.62 945	27	9.67 295	32	0.32 705	9.95 651	6	47	
	14	9.62 972	27	9.67 327	33	0.32 673	9.95 645	6	46	
	15	9.62 999	27	9.67 360	33	0.32 640	9.95 639	6	45	
	16	9.63 026	26	9.67 393	33	0.32 607	9.95 633	6	44	
	17	9.63 052	27	9.67 426	32	0.32 574	9.95 627	6	43	
	18	9.63 079	27	9.67 458	33	0.32 542	9.95 621	6	42	
	19	9.63 106	27	9.67 491	33	0.32 509	9.95 615	6	41	
	20	9.63 133	26	9.67 524	32	0.32 476	9.95 609	6	40	
	21	9.63 159	27	9.67 556	33	0.32 444	9.95 603	6	39	
	22	9.63 186	27	9.67 589	33	0.32 411	9.95 597	6	38	
	23	9.63 213	26	9.67 622	32	0.32 378	9.95 591	6	37	
	24	9.63 239	27	9.67 654	33	0.32 346	9.95 585	6	36	
	25	9.63 266	26	9.67 687	32	0.32 313	9.95 579	6	35	
	26	9.63 292	27	9.67 719	33	0.32 281	9.95 573	6	34	
	27	9.63 319	26	9.67 752	33	0.32 248	9.95 567	6	33	
	28	9.63 345	27	9.67 785	32	0.32 215	9.95 561	6	32	
	29	9.63 372	26	9.67 817	33	0.32 183	9.95 555	6	31	
	30	9.63 398	27	9.67 850	32	0.32 150	9.95 549	6	30	
	31	9.63 425	26	9.67 882	33	0.32 118	9.95 543	6	29	
	32	9.63 451	27	9.67 915	32	0.32 085	9.95 537	6	28	
	33	9.63 478	26	9.67 947	33	0.32 053	9.95 531	6	27	
	34	9.63 504	27	9.67 980	32	0.32 020	9.95 525	6	26	
	35	9.63 531	26	9.68 012	32	0.31 988	9.95 519	6	25	
	36	9.63 557	26	9.68 044	33	0.31 956	9.95 513	6	24	
	37	9.63 583	27	9.68 077	32	0.31 923	9.95 507	7	23	
	38	9.63 610	26	9.68 109	33	0.31 891	9.95 500	6	22	
	39	9.63 636	26	9.68 142	32	0.31 858	9.95 494	6	21	
	40	9.63 662	27	9.68 174	32	0.31 826	9.95 488	6	20	
	41	9.63 689	26	9.68 206	33	0.31 794	9.95 482	6	19	
	42	9.63 715	26	9.68 239	32	0.31 761	9.95 476	6	18	
	43	9.63 741	26	9.68 271	32	0.31 729	9.95 470	6	17	
	44	9.63 767	27	9.68 303	33	0.31 697	9.95 464	6	16	
	45	9.63 794	26	9.68 336	32	0.31 664	9.95 458	6	15	
	46	9.63 820	26	9.68 368	32	0.31 632	9.95 452	6	14	
	47	9.63 846	26	9.68 400	32	0.31 600	9.95 446	6	13	
	48	9.63 872	26	9.68 432	33	0.31 568	9.95 440	6	12	
	49	9.63 898	26	9.68 465	32	0.31 535	9.95 434	7	11	
	50	9.63 924	26	9.68 497	32	0.31 503	9.95 427	6	10	
	51	9.63 950	26	9.68 529	32	0.31 471	9.95 421	6	9	
	52	9.63 976	26	9.68 561	32	0.31 439	9.95 415	6	8	
	53	9.64 002	26	9.68 593	33	0.31 407	9.95 409	6	7	
	54	9.64 028	26	9.68 626	32	0.31 374	9.95 403	6	6	
	55	9.64 054	26	9.68 658	32	0.31 342	9.95 397	6	5	
	56	9.64 080	26	9.68 690	32	0.31 310	9.95 391	7	4	
	57	9.64 106	26	9.68 722	32	0.31 278	9.95 384	6	3	
	58	9.64 132	26	9.68 754	32	0.31 246	9.95 378	6	2	
	59	9.64 158	26	9.68 786	32	0.31 214	9.95 372	6	1	
	60	9.64 184		9.68 818		0.31 182	9.95 366		0	
		L SIN	D	L TAN	CD	L COT	L COS	D		334°...154°
		L COS		L COT		L TAN	L SIN			244°... 64°

26°...206° / 116°...296°		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D		
	0	9.64 184	26	9.68 818	32	0.31 182	9.95 366	6	60	
	1	9.64 210	26	9.68 850	32	0.31 150	9.95 360	6	59	
	2	9.64 236	26	9.68 882	32	0.31 118	9.95 354	6	58	
	3	9.64 262	26	9.68 914	32	0.31 086	9.95 348	7	57	
	4	9.64 288	25	9.68 946	32	0.31 054	9.95 341	6	56	
	5	9.64 313	26	9.68 978	32	0.31 022	9.95 335	6	55	
	6	9.64 339	26	9.69 010	32	0.30 990	9.95 329	6	54	
	7	9.64 365	26	9.69 042	32	0.30 958	9.95 323	6	53	
	8	9.64 391	26	9.69 074	32	0.30 926	9.95 317	7	52	
	9	9.64 417	25	9.69 106	32	0.30 894	9.95 310	6	51	
	10	9.64 442	26	9.69 138	32	0.30 862	9.95 304	6	50	
	11	9.64 468	26	9.69 170	32	0.30 830	9.95 298	6	49	
	12	9.64 494	25	9.69 202	32	0.30 798	9.95 292	6	48	
	13	9.64 519	26	9.69 234	32	0.30 766	9.95 286	7	47	
	14	9.64 545	26	9.69 266	32	0.30 734	9.95 279	6	46	
	15	9.64 571	25	9.69 298	31	0.30 702	9.95 273	6	45	
	16	9.64 596	26	9.69 329	32	0.30 671	9.95 267	6	45	
	17	9.64 622	25	9.69 361	32	0.30 639	9.95 261	7	43	
	18	9.64 647	26	9.69 393	32	0.30 607	9.95 254	6	42	
	19	9.64 673	25	9.69 425	32	0.30 575	9.95 248	6	41	
	20	9.64 698	26	9.69 457	31	0.30 543	9.95 242	6	40	
	21	9.64 724	25	9.69 488	32	0.30 512	9.95 236	7	39	
	22	9.64 749	26	9.69 520	32	0.30 480	9.95 229	6	38	
	23	9.64 775	25	9.69 552	32	0.30 448	9.95 223	6	37	
	24	9.64 800	26	9.69 584	31	0.30 416	9.95 217	6	36	
	25	9.64 826	25	9.69 615	32	0.30 385	9.95 211	7	35	
	26	9.64 851	26	9.69 647	32	0.30 353	9.95 204	6	34	
	27	9.64 877	25	9.69 679	31	0.30 321	9.95 198	6	33	
	28	9.64 902	25	9.69 710	32	0.30 290	9.95 192	7	32	
	29	9.64 927	26	9.69 742	32	0.30 258	9.95 185	6	31	
	30	9.64 953	25	9.69 774	31	0.30 226	9.95 179	6	30	
	31	9.64 978	25	9.69 805	32	0.30 195	9.95 173	6	29	
	32	9.65 003	26	9.69 837	31	0.30 163	9.95 167	7	28	
	33	9.65 029	25	9.69 868	32	0.30 132	9.95 160	6	27	
	34	9.65 054	25	9.69 900	32	0.30 100	9.95 154	6	26	
	35	9.65 079	25	9.69 932	31	0.30 068	9.95 148	7	25	
	36	9.65 104	26	9.69 963	32	0.30 037	9.95 141	6	24	
	37	9.65 130	25	9.69 995	31	0.30 005	9.95 135	6	23	
	38	9.65 155	25	9.70 026	32	0.29 974	9.95 129	7	22	
	39	9.65 180	25	9.70 058	31	0.29 942	9.95 122	6	21	
	40	9.65 205	25	9.70 089	32	0.29 911	9.95 116	6	20	
	41	9.65 230	25	9.70 121	31	0.29 879	9.95 110	7	19	
	42	9.65 255	26	9.70 152	32	0.29 848	9.95 103	6	18	
	43	9.65 281	25	9.70 184	31	0.29 816	9.95 097	7	17	
	44	9.65 306	25	9.70 215	32	0.29 785	9.95 090	6	16	
	45	9.65 331	25	9.70 247	31	0.29 753	9.95 084	6	15	
	46	9.65 356	25	9.70 278	31	0.29 722	9.95 078	7	14	
	47	9.65 381	25	9.70 309	32	0.29 691	9.95 071	6	13	
	48	9.65 406	25	9.70 341	31	0.29 659	9.95 065	6	12	
	49	9.65 431	25	9.70 372	32	0.29 628	9.95 059	7	11	
	50	9.65 456	25	9.70 404	31	0.29 596	9.95 052	6	10	
	51	9.65 481	25	9.70 435	31	0.29 565	9.95 046	7	9	
	52	9.65 506	25	9.70 466	32	0.29 534	9.95 039	6	8	
	53	9.65 531	25	9.70 498	31	0.29 502	9.95 033	6	7	
	54	9.65 556	24	9.70 529	31	0.29 471	9.95 027	7	6	
	55	9.65 580	25	9.70 560	32	0.29 440	9.95 020	6	5	
	56	9.65 605	25	9.70 592	31	0.29 408	9.95 014	7	4	
	57	9.65 630	25	9.70 623	31	0.29 377	9.95 007	6	3	
	58	9,65 655	25	9.70 654	31	0.29 346	9.95 001	6	2	
	59	9.65 680	25	9.70 685	32	0.29 315	9.94 995	7	1	
	60	9.65 705		9.70 717		0.29 283	9.94 988		0	
		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D		333°...153° / 243° ... 63°

27°...207°	L SIN	D	L TAN	CD	L COT	L COS	D	
117°...297°	L COS		L COT		L TAN	L SIN		
0	9.65 705	24	9.70 717	31	0.29 283	9.94 988	6	60
1	9.65 729	25	9.70 748	31	0.29 252	9.94 982	7	59
2	9.65 754	25	9.70 779	31	0.29 221	9.94 975	6	58
3	9.65 779	25	9.70 810	31	0.29 190	9.94 969	7	57
4	9.65 804	24	9.70 841	32	0.29 159	9.94 962	6	56
5	9.65 828	25	9.70 873	31	0.29 127	9.94 956	7	55
6	9.65 853	25	9.70 904	31	0.29 096	9.94 949	6	54
7	9.65 878	24	9.70 935	31	0.29 065	9.94 943	7	53
8	9.65 902	25	9.70 966	31	0.29 034	9.94 936	6	52
9	9.65 927	25	9.70 997	31	0.29 003	9.94 930	7	51
10	9.65 962	24	9.71 028	31	0.28 972	9.94 923	6	50
11	9.65 976	25	9.71 059	31	0.28 941	9.94 917	6	49
12	9.66 001	24	9.71 090	31	0.28 910	9.94 911	7	48
13	9.66 025	25	9.71 121	32	0.28 879	9.94 904	6	47
14	9.66 050	25	9.71 153	31	0.28 847	9.94 898	7	46
15	9.66 075	24	9.71 184	31	0.28 816	9.94 891	6	45
16	9.66 099	25	9.71 215	31	0.28 785	9.94 885	7	44
17	9.66 124	24	9.71 246	31	0.28 754	9.94 878	7	43
18	9.66 148	25	9.71 277	31	0.28 723	9.94 871	6	42
19	9.66 173	24	9.71 308	31	0.28 692	9.94 865	7	41
20	9.66 197	24	9.71 339	31	0.28 661	9.94 858	6	40
21	9.66 221	25	9.71 370	31	0.28 630	9.94 852	7	39
22	9.66 246	24	9.71 401	30	0.28 599	9.94 845	6	38
23	9.66 270	25	9.71 431	31	0.28 569	9.94 839	7	37
24	9.66 295	24	9.71 462	31	0.28 538	9.94 832	6	36
25	9.66 319	24	9.71 493	31	0.28 507	9.94 826	7	35
26	9.66 343	25	9.71 524	31	0.28 476	9.94 819	6	34
27	9.66 368	24	9.71 555	31	0.28 445	9.94 813	7	33
28	9.66 392	24	9.71 586	31	0.28 414	9.94 806	7	32
29	9.66 416	25	9.71 617	31	0.28 383	9.94 799	6	31
30	9.66 441	24	9.71 648	31	0.28 352	9.94 793	7	30
31	9.66 465	24	9.71 679	30	0.28 321	9.94 786	6	29
32	9.66 489	24	9.71 709	31	0.28 291	9.94 780	7	28
33	9.66 513	24	9.71 740	31	0.28 260	9.94 773	6	27
34	9.66 537	25	9.71 771	31	0.28 229	9.94 767	7	26
35	9.66 562	24	9.71 802	31	0.28 198	9.94 760	7	25
36	9.66 586	24	9.71 833	30	0.28 167	9.94 753	6	24
37	9.66 610	24	9.71 863	31	0.28 137	9.94 747	7	23
38	9.66 634	24	9.71 894	31	0.28 106	9.94 740	6	22
39	9.66 658	24	9.71 925	30	0.28 075	9.94 734	7	21
40	9.66 682	24	9.71 955	31	0.28 045	9.94 727	7	20
41	9.66 706	25	9.71 986	31	0.28 014	9.94 720	6	19
42	9.66 731	24	9.72 017	31	0.27 983	9.94 714	7	18
43	9.66 755	24	9.72 048	30	0.27 952	9.94 707	7	17
44	9.66 779	24	9.72 078	31	0.27 922	9.94 700	6	16
45	9.66 803	24	9.72 109	31	0.27 891	9.94 694	7	15
46	9.66 827	24	9.72 140	30	0.27 860	9.94 687	7	14
47	9.66 851	24	9.72 170	31	0.27 830	9.94 680	6	13
48	9.66 875	24	9.72 201	30	0.27 799	9.94 674	7	12
49	9.66 899	23	9.72 231	31	0.27 769	9.94 667	7	11
50	9.66 922	24	9.72 262	31	0.27 738	9.94 660	6	10
51	9.66 946	24	9.72 293	30	0.27 707	9.94 654	7	9
52	9.66 970	24	9.72 323	31	0.27 677	9.94 647	7	8
53	9.66 994	24	9.72 354	30	0.27 646	9.94 640	6	7
54	9.67 018	24	9.72 384	31	0.27 616	9.94 634	7	6
55	9.67 042	24	9.72 415	30	0.27 585	9.94 627	7	5
56	9.67 066	24	9.72 445	31	0.27 555	9.94 620	6	4
57	9.67 090	23	9.72 476	30	0.27 524	9.94 614	7	3
58	9.67 113	24	9.72 506	31	0.27 494	9.94 607	7	2
59	9.67 137	24	9.72 537	30	0.27 463	9.94 600	7	1
60	9.67 161		9.72 567		0.27 433	9.94 593		0
	L SIN	D	L TAN	CD	L COT	L COS	D	332°...152°
	L COS		L COT		L TAN	L SIN		242°... 62°

28°...208° / 118°...298°	′	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	′
	0	9.67 161	24	9.72 567	31	0.27 433	9.94 593	6	60
	1	9.67 185	23	9.72 598	30	0.27 402	9.94 587	7	59
	2	9.67 208	24	9.72 628	31	0.27 372	9.94 580	7	58
	3	9.67 232	24	9.72 659	30	0.27 341	9.94 573	6	57
	4	9.67 256	24	9.72 689	31	0.27 311	9.94 567	7	56
	5	9.67 280	23	9.72 720	30	0.27 280	9.94 560	7	55
	6	9.67 303	24	9.72 750	30	0.27 250	9.94 553	7	54
	7	9.67 327	23	9.72 780	31	0.27 220	9.94 546	6	53
	8	9.67 350	24	9.72 811	30	0.27 189	9.94 540	7	52
	9	9.67 374	24	9.72 841	31	0.27 159	9.94 533	7	51
	10	9.67 398	23	9.72 872	30	0.27 128	9.94 526	7	50
	11	9.67 421	24	9.72 902	30	0.27 098	9.94 519	6	49
	12	9.67 445	23	9.72 932	31	0.27 068	9.94 513	7	48
	13	9.67 468	24	9.72 963	30	0.27 037	9.94 506	7	47
	14	9.67 492	23	9.72 993	30	0.27 007	9.94 499	7	46
	15	9.67 515	24	9.73 023	31	0.26 977	9.94 492	7	45
	16	9.67 539	23	9.73 054	30	0.26 946	9.94 485	6	44
	17	9.67 562	24	9.73 084	30	0.26 916	9.94 479	7	43
	18	9.67 586	23	9.73 114	30	0.26 886	9.94 472	7	42
	19	9.67 609	24	9.73 144	31	0.26 856	9.94 465	7	41
	20	9.67 633	23	9.73 175	30	0.26 825	9.94 458	7	40
	21	9.67 656	24	9.73 205	30	0.26 795	9.94 451	6	39
	22	9.67 680	23	9.73 235	30	0.26 765	9.94 445	7	38
	23	9.67 703	23	9.73 265	30	0.26 735	9.94 438	7	37
	24	9.67 726	24	9.73 295	31	0.26 705	9.94 431	7	36
	25	9.67 750	23	9.73 326	30	0.26 674	9.94 424	7	35
	26	9.67 773	23	9.73 356	30	0.26 644	9.94 417	7	34
	27	9.67 796	24	9.73 386	30	0.26 614	9.94 410	6	33
	28	9.67 820	23	9.73 416	30	0.26 584	9.94 404	7	32
	29	9.67 843	23	9.73 446	30	0.26 554	9.94 397	7	31
	30	9.67 866	24	9.73 476	31	0.26 524	9.94 390	7	30
	31	9.67 890	23	9.73 507	30	0.26 493	9.94 383	7	29
	32	9.76 913	23	9.73 537	30	0.26 463	9.94 376	7	28
	33	9.67 936	23	9.73 567	30	0.26 433	9.94 369	7	27
	34	9.67 959	23	9.73 597	30	0.26 403	9.94 362	7	26
	35	9.67 982	24	9.73 627	30	0.26 373	9.94 355	6	25
	36	9.68 006	23	9.73 657	30	0.26 343	9.94 349	7	24
	37	9.68 029	23	9.73 687	30	0.26 313	9.94 342	7	23
	38	9.68 052	23	9.73 717	30	0.26 283	9.94 335	7	22
	39	9.68 075	23	9.73 747	30	0.26 253	9.94 328	7	21
	40	9.68 098	23	9.73 777	30	0.26 223	9.94 321	7	20
	41	9.68 121	23	9.73 807	30	0.26 193	9.94 314	7	19
	42	9.68 144	23	9.73 837	30	0.26 163	9.94 307	7	18
	43	9.68 167	23	9.73 867	30	0.26 133	9.94 300	7	17
	44	9.68 190	23	9.73 897	30	0.26 103	9.94 293	7	16
	45	9.68 213	24	9.73 927	30	0.26 073	9.94 286	7	15
	46	9.68 237	23	9.73 957	30	0.26 043	9.94 279	6	14
	47	9.68 260	23	9.73 987	30	0.26 013	9.94 273	7	13
	48	9.68 283	22	9.74 017	30	0.25 983	9.94 266	7	12
	49	9.68 305	23	9.74 047	30	0.25 953	9.94 259	7	11
	50	9.68 328	23	9.74 077	30	0.25 923	9.94 252	7	10
	51	9.68 351	23	9.74 107	30	0.25 893	9.94 245	7	9
	52	9.68 374	23	9.74 137	29	0.25 863	9.94 238	7	8
	53	9.68 397	23	9.74 166	30	0.25 834	9.94 231	7	7
	54	9.68 420	23	9.74 196	30	0.25 804	9.94 224	7	6
	55	9.68 443	23	9.74 226	30	0.25 774	9.94 217	7	5
	56	9.68 466	23	9.74 256	30	0.25 744	9.94 210	7	4
	57	9.68 489	23	9.74 286	30	0.25 714	9.94 203	7	3
	58	9.68 512	22	9.74 316	29	0.25 684	9.94 196	7	2
	59	9.68 534	23	9.74 345	30	0.25 655	9.94 189	7	1
	60	9.68 557		9.74 375		0.25 625	9.94 182		0
		L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	331°...151° / 241°... 61°

29°...209°	L SIN	D	L TAN	CD	L COT	L COS	D	
119°...299°	L COS		L COT		L TAN	L SIN		
0	9.68 557	23	9.74 375	30	0.25 625	9.94 182	7	60
1	9.68 580	23	9.74 405	30	0.25 595	9.94 175	7	59
2	9.68 603	22	9.74 435	30	0.25 565	9.94 168	7	58
3	9.68 625	23	9.74 465	29	0.25 535	9.94 161	7	57
4	9.68 648	23	9.74 494	30	0.25 506	9.94 154	7	56
5	9.68 671	23	9.74 524	30	0.25 476	9.94 147	7	55
6	9.68 694	22	9.74 554	29	0.25 446	9.94 140	7	54
7	9.68 716	23	9.74 583	30	0.25 417	9.94 133	7	53
8	9.68 739	23	9.74 613	30	0.25 387	9.94 126	7	52
9	9.68 762	22	9.74 643	30	0.25 357	9.94 119	7	51
10	9.68 784	23	9.74 673	29	0.25 327	9.94 112	7	50
11	9.68 807	22	9.74 702	30	0.25 298	9.94 105	7	49
12	9.68 829	23	9.74 732	30	0.25 268	9.94 098	8	48
13	9.68 852	23	9.74 762	29	0.25 238	9.94 090	7	47
14	9.68 875	22	9.74 791	30	0.25 209	9.94 083	7	46
15	9.68 897	23	9.74 821	30	0.25 179	9.94 076	7	45
16	9.68 920	22	9.74 851	29	0.25 149	9.94 069	7	44
17	9.68 942	23	9.74 880	30	0.25 120	9.94 062	7	43
18	9.68 965	22	9.74 910	29	0.25 090	9.94 055	7	42
19	9.68 987	23	9.74 939	30	0.25 061	9.94 048	7	41
20	9.69 010	22	9.74 969	29	0.25 031	9.94 041	7	40
21	9.69 032	23	9.74 998	30	0.25 002	9.94 034	7	39
22	9.69 055	22	9.75 028	30	0.24 972	9.94 027	7	38
23	9.69 077	23	9.75 058	29	0.24 942	9.94 020	8	37
24	9.69 100	22	9.75 087	30	0.24 913	9.94 012	7	36
25	9.69 122	22	9.75 117	29	0.24 883	9.94 005	7	35
26	9.69 144	23	9.75 146	30	0.24 854	9.93 998	7	34
27	9.69 167	22	9.75 176	29	0.24 824	9.93 991	7	33
28	9.69 189	23	9.75 205	30	0.24 795	9.93 984	7	32
29	9.69 212	22	9.75 235	29	0.24 765	9.93 977	7	31
30	9.69 234	22	9.75 264	30	0.24 736	9.93 970	7	30
31	9.69 256	23	9.75 294	29	0.24 706	9.93 963	8	29
32	9.69 279	22	9.75 323	30	0.24 677	9.93 955	7	28
33	9.69 301	22	9.75 353	29	0.24 647	9.93 948	7	27
34	9.69 323	22	9.75 382	29	0.24 618	9.93 941	7	26
35	9.69 345	23	9.75 411	30	0.24 589	9.93 934	7	25
36	9.69 368	22	9.75 441	29	0.24 559	9.93 927	7	24
37	9.69 390	22	9.75 470	30	0.24 530	9.93 920	8	23
38	9.69 412	22	9.75 500	29	0.24 500	9.93 912	7	22
39	9.69 434	22	9.75 529	29	0.24 471	9.93 905	7	21
40	9.69 456	23	9.75 558	30	0.24 442	9.93 898	7	20
41	9.69 479	22	9.75 588	29	0.24 412	9.93 891	7	19
42	9.69 501	22	9.75 617	30	0.24 383	9.93 884	8	18
43	9.69 523	22	9.75 647	29	0.24 353	9.93 876	7	17
44	9.69 545	22	9.75 676	29	0.24 324	9.93 869	7	16
45	9.69 567	22	9.75 705	30	0.24 295	9.93 862	7	15
46	9.69 589	22	9.75 735	29	0.24 265	9.93 855	8	14
47	9.69 611	22	9.75 764	29	0.24 236	9.93 847	7	13
48	9.69 633	22	9.75 793	29	0.24 207	9.93 840	7	12
49	9.69 655	22	9.75 822	30	0.24 178	9.93 833	7	11
50	9.69 677	22	9.75 852	29	0.24 148	9.93 826	7	10
51	9.69 699	22	9.75 881	29	0.24 119	9.93 819	8	9
52	9.69 721	22	9.75 910	29	0.24 090	9.93 811	7	8
53	9.69 743	22	9.75 939	30	0.24 061	9.93 804	7	7
54	9.69 765	22	9.75 969	29	0.24 031	9.93 797	8	6
55	9.69 787	22	9.75 998	29	0.24 002	9.93 789	7	5
56	9.69 809	22	9.76 027	29	0.23 973	9.93 782	7	4
57	9.69 831	22	9.76 056	30	0.23 944	9.93 775	7	3
58	9.69 853	22	9.76 086	29	0.23 914	9.93 768	8	2
59	9.69 875	22	9.76 115	29	0.23 885	9.93 760	7	1
60	9.69 897		9.76 144		0.23 856	9.93 753		0
	L SIN	D	L TAN	CD	L COT	L COS	D	330°...150°
	L COS		L COT		L TAN	L SIN		240°... 60°

30°...210°		L SIN	D	L TAN	CD	L COT	L COS	D	
120°...300°		L COS		L COT		L TAN	L SIN		
	0	9.69 897	22	9.76 144	29	0.23 856	9.93 753	7	60
	1	9.69 919	22	9.76 173	29	0.23 827	9.93 746	8	59
	2	9.69 941	22	9.76 202	29	0.23 798	9.93 738	7	58
	3	9.69 963	21	9.76 231	30	0.23 769	9.93 731	7	57
	4	9.69 984	22	9.76 261	29	0.23 739	9.93 724	7	56
	5	9.70 006	22	9.76 290	29	0.23 710	9.93 717	8	55
	6	9.70 028	22	9.76 319	29	0.23 681	9.93 709	7	54
	7	9.70 050	22	9.76 348	29	0.23 652	9.93 702	7	53
	8	9.70 072	21	9.76 377	29	0.23 623	9.93 695	8	52
	9	9.70 093	22	9.76 406	29	0.23 594	9.93 687	7	51
	10	9.70 115	22	9.76 435	29	0.23 565	9.93 680	7	50
	11	9.70 137	22	9.76 464	29	0.23 536	9.93 673	8	49
	12	9.70 159	21	9.76 493	29	0.23 507	9.93 665	7	48
	13	9.70 180	22	9.76 522	29	0.23 478	9.93 658	8	47
	14	9.70 202	22	9.76 551	29	0.23 449	9.93 650	7	46
	15	9.70 224	21	9.76 580	29	0.23 420	9.93 643	7	45
	16	9.70 245	22	9.76 609	30	0.23 391	9.93 636	8	44
	17	9.70 267	21	9.76 639	29	0.23 361	9.93 628	7	43
	18	9.70 288	22	9.76 668	29	0.23 332	9.93 621	7	42
	19	9.70 310	22	9.76 697	28	0.23 303	9.93 614	8	41
	20	9.70 332	21	9.76 725	29	0.23 275	9.93 606	7	40
	21	9.70 353	22	9.76 754	29	0.23 246	9.93 599	8	39
	22	9.70 375	21	9.76 783	29	0.23 217	9.93 591	7	38
	23	9.70 396	22	9.76 812	29	0.23 188	9.93 584	7	37
	24	9.70 418	21	9.76 841	29	0.23 159	9.93 577	8	36
	25	9.70 439	22	9.76 870	29	0.23 130	9.93 569	7	35
	26	9.70 461	21	9.76 899	29	0.23 101	9.93 562	8	34
	27	9.70 482	22	9.76 928	29	0.23 072	9.93 554	7	33
	28	9.70 504	21	9.76 957	29	0.23 043	9.93 547	8	32
	29	9.70 525	22	9.76 986	29	0.23 014	9.93 539	7	31
	30	9.70 547	21	9.77 015	29	0.22 985	9.93 532	7	30
	31	9.70 568	22	9.77 044	29	0.22 956	9.93 525	8	29
	32	9.70 590	21	9.77 073	28	0.22 927	9.93 517	7	28
	33	9.70 611	22	9.77 101	29	0.22 899	9.93 510	8	27
	34	9.70 633	21	9.77 130	29	0.22 870	9.93 502	7	26
	35	9.70 654	21	9.77 159	29	0.22 841	9.93 495	8	25
	36	9.70 675	22	9.77 188	29	0.22 812	9.93 487	7	24
	37	9.70 697	21	9.77 217	29	0.22 783	9.93 480	8	23
	38	9.70 718	21	9.77 246	28	0.22 754	9.93 472	7	22
	39	9.70 739	22	9.77 274	29	0.22 726	9.93 465	8	21
	40	9.70 761	21	9.77 303	29	0.22 697	9.93 457	7	20
	41	9.70 782	21	9.77 332	29	0.22 668	9.93 450	8	19
	42	9.70 803	21	9.77 361	29	0.22 639	9.93 442	7	18
	43	9.70 824	22	9.77 390	28	0.22 610	9.93 435	8	17
	44	9.70 846	21	9.77 418	29	0.22 582	9.93 427	7	16
	45	9.70 867	21	9.77 447	29	0.22 553	9.93 420	8	15
	46	9.70 888	21	9.77 476	29	0.22 524	9.93 412	7	14
	47	9.70 909	22	9.77 505	28	0.22 495	9.93 405	8	13
	48	9.70 931	21	9.77 533	29	0.22 467	9.93 397	7	12
	49	9.70 952	21	9.77 562	29	0.22 438	9.93 390	8	11
	50	9.70 973	21	9.77 591	28	0.22 409	9.93 382	7	10
	51	9.70 994	21	9.77 619	29	0.22 381	9.93 375	8	9
	52	9.71 015	21	9.77 648	29	0.22 352	9.93 367	7	8
	53	9.71 036	22	9.77 677	29	0.22 323	9.93 360	8	7
	54	9.71 058	21	9.77 706	28	0.22 294	9.93 352	8	6
	55	9.71 079	21	9.77 734	29	0.22 266	9.93 344	7	5
	56	9.71 100	21	9.77 763	28	0.22 237	9.93 337	8	4
	57	9.71 121	21	9.77 791	29	0.22 209	9.93 329	7	3
	58	9.71 142	21	9.77 820	29	0.22 180	9.93 322	8	2
	59	9.71 163	21	9.77 849	28	0.22 151	9.93 314	7	1
	60	9.71 184		9.77 877		0.22 123	9.93 307		0
		L SIN	D	L TAN	CD	L COT	L COS	D	329°...149°
		L COS		L COT		L TAN	L SIN		239° ... 59°

31°...211°	L SIN	D	L TAN	CD	L COT	L COS	D	
121°...301°	L COS		L COT		L TAN	L SIN		
0	9.71 184	21	9.77 877	29	0.22 123	9.93 307	8	60
1	9.71 205	21	9.77 906	29	0.22 094	9.93 299	8	59
2	9.71 226	21	9.77 935	28	0.22 085	9.93 291	7	58
3	9.71 247	21	9.77 963	29	0.22 037	9.93 284	8	57
4	9.71 268	21	9.77 992	28	0.22 008	9.93 276	7	56
5	9.71 289	21	9.78 020	29	0.21 980	9.93 269	8	55
6	9.71 310	21	9.78 049	28	0.21 951	9.93 261	8	54
7	9.71 331	21	9.78 077	29	0.21 923	9.93 253	7	53
8	9.71 352	21	9.78 106	29	0.21 894	9.93 246	8	52
9	9.71 373	20	9.78 135	28	0.21 865	9.93 238	8	51
10	9.71 393	21	9.78 163	29	0.21 837	9.93 230	7	50
11	9.71 414	21	9.78 192	28	0.21 808	9.93 223	8	49
12	9.71 435	21	9.78 220	29	0.21 780	9.93 215	8	48
13	9.71 456	21	9.78 249	28	0.21 751	9.93 207	7	47
14	9.71 477	21	9.78 277	29	0.21 723	9.93 200	8	46
15	9.71 498	21	9.78 306	28	0.21 694	9.93 192	8	45
16	9.71 519	20	9.78 334	29	0.21 666	9.93 184	7	44
17	9.71 539	21	9.78 363	28	0.21 637	9.93 177	8	43
18	9.71 560	21	9.78 391	28	0.21 609	9.93 169	8	42
19	9.71 581	21	9.78 419	29	0.21 581	9.93 161	7	41
20	9.71 602	20	9.78 448	28	0.21 552	9.93 154	8	40
21	9.71 622	21	9.78 476	29	0.21 524	9.93 146	8	39
22	9.71 643	21	9.78 505	28	0.21 495	9.93 138	7	38
23	9.71 664	21	9.78 533	29	0.21 467	9.93 131	8	37
24	9.71 685	20	9.78 562	28	0.21 438	9.93 123	8	36
25	9.71 705	21	9.78 590	28	0.21 410	9.93 115	7	35
26	9.71 726	21	9.78 618	29	0.21 382	9.93 108	8	34
27	9.71 747	20	9.78 647	28	0.21 353	9.93 100	8	33
28	9.71 767	21	9.78 675	29	0.21 325	9.93 092	8	32
29	9.71 788	21	9.78 704	28	0.21 296	9.93 084	7	31
30	9.71 809	20	9.78 732	28	0.21 268	9.93 077	8	30
31	9.71 829	21	9.78 760	29	0.21 240	9.93 069	8	29
32	9.71 850	20	9.78 789	28	0.21 211	9.93 061	8	28
33	9.71 870	21	9.78 817	28	0.21 183	9.93 053	7	27
34	9.71 891	20	9.78 845	29	0.21 155	9.93 046	8	26
35	9.71 911	21	9.78 874	28	0.21 126	9.93 038	8	25
36	9.71 932	20	9.78 902	28	0.21 098	9.93 030	8	24
37	9.71 952	21	9.78 930	29	0.21 070	9.93 022	8	23
38	9.71 973	21	9.78 959	28	0.21 041	9.93 014	7	22
39	9.71 994	20	9.78 987	28	0.21 013	9.93 007	8	21
40	9.72 014	20	9.79 015	28	0.20 985	9.92 999	8	20
41	9.72 034	21	9.79 043	29	0.20 957	9.92 991	8	19
42	9.72 055	20	9.79 072	28	0.20 928	9.92 983	7	18
43	9.72 075	21	9.79 100	28	0.20 900	9.92 976	8	17
44	9.72 096	20	9.79 128	28	0.20 872	9.92 968	8	16
45	9.72 116	21	9.79 156	29	0.20 844	9.92 960	8	15
46	9.72 137	20	9.79 185	28	0.20 815	9.92 952	8	14
47	9.72 157	20	9.79 213	28	0.20 787	9.92 944	8	13
48	9.72 177	21	9.79 241	28	0.20 759	9.92 936	7	12
49	9.72 198	20	9.79 269	28	0.20 731	9.92 929	8	11
50	9.72 218	20	9.79 297	29	0.20 703	9.92 921	8	10
51	9.72 238	21	9.79 326	28	0.20 674	9.92 913	8	9
52	9.72 259	20	9.79 354	28	0.20 646	9.92 905	8	8
53	9.72 279	20	9.79 382	28	0.20 618	9.92 897	8	7
54	9.72 299	21	9.79 410	28	0.20 590	9.92 889	8	6
55	9.72 320	20	9.79 438	28	0.20 562	9.92 881	7	5
56	9.72 340	20	9.79 466	29	0.20 534	9.92 874	8	4
57	9.72 360	21	9.79 495	28	0.20 505	9.92 866	8	3
58	9.72 381	20	9.79 523	28	0.20 477	9.92 858	8	2
59	9.72 401	20	9.79 551	28	0.20 449	9.92 850	8	1
60	9.72 421		9.79 579		0.20 421	9.92 842		0
	L SIN	D	L TAN	CD	L COT	L COS	D	328°...148°
	L COS		L COT		L TAN	L SIN		238°... 58°

32°...212°	L SIN	D	L TAN	CD	L COT	L COS	D	
122°...302°	L COS		L COT		L TAN	L SIN		
0	9.72 421	20	9.79 579	28	0.20 421	9.92 842	8	60
1	9.72 441	20	9.79 607	28	0.20 393	9.92 834	8	59
2	9.72 461	21	9.79 635	28	0.20 365	9.92 826	8	58
3	9.72 482	20	9.79 663	28	0.20 337	9.92 818	8	57
4	9.72 502	20	9.79 691	28	0.20 309	9.92 810	7	56
5	9.72 522	20	9.79 719	28	0.20 281	9.92 803	8	55
6	9.72 542	20	9.79 747	29	0.20 253	9.92 795	8	54
7	9.72 562	20	9.79 776	28	0.20 224	9.92 787	8	53
8	9.72 582	20	9.79 804	28	0.20 196	9.92 779	8	52
9	9.72 602	20	9.79 832	28	0.20 168	9.92 771	8	51
10	9.72 622	21	9.79 860	28	0.20 140	9.92 763	8	50
11	9.72 643	20	9.79 888	28	0.20 112	9.92 755	8	49
12	9.72 663	20	9.79 916	28	0.20 084	9.92 747	8	48
13	9.72 683	20	9.79 944	28	0.20 056	9.92 739	8	47
14	9.72 703	20	9.79 972	28	0.20 028	9.92 731	8	46
15	9.72 723	20	9.80 000	28	0.20 000	9.92 723	8	45
16	9.72 743	20	9.80 028	28	0.19 972	9.92 715	8	44
17	9.72 763	20	9.80 056	28	0.19 944	9.92 707	8	43
18	9.72 783	20	9.80 084	28	0.19 916	9.92 699	8	42
19	9.72 803	20	9.80 112	28	0.19 888	9.92 691	8	41
20	9.72 823	20	9.80 140	28	0.19 860	9.92 683	8	40
21	9.72 843	20	9.80 168	27	0.19 832	9.92 675	8	39
22	9.72 863	20	9.80 195	28	0.19 805	9.92 667	8	38
23	9.72 883	19	9.80 223	28	0.19 777	9.92 659	8	37
24	9.72 902	20	9.80 251	28	0.19 749	9.92 651	8	36
25	9.72 922	20	9.80 279	28	0.19 721	9.92 643	8	35
26	9.72 942	20	9.80 307	28	0.19 693	9.92 635	8	34
27	9.72 962	20	9.80 335	28	0.19 665	9.92 627	8	33
28	9.72 982	20	9.80 363	28	0.19 637	9.92 619	8	32
29	9.73 002	20	9.80 391	28	0.19 609	9.92 611	8	31
30	9.73 022	19	9.80 419	28	0.19 581	9.92 603	8	30
31	9.73 041	20	9.80 447	27	0.19 553	9.92 595	8	29
32	9.73 061	20	9.80 474	28	0.19 526	9.92 587	8	28
33	9.73 081	20	9.80 502	28	0.19 498	9.92 579	8	27
34	9.73 101	20	9.80 530	28	0.19 470	9.92 571	8	26
35	9.73 121	19	9.80 558	28	0.19 442	9.92 563	8	25
36	9.73 140	20	9.80 586	28	0.19 414	9.92 555	9	24
37	9.73 160	20	9.80 614	28	0.19 386	9.92 546	8	23
38	9.73 180	20	9.80 642	27	0.19 358	9.92 538	8	22
39	9.73 200	19	9.80 669	28	0.19 331	9.92 530	8	21
40	9.73 219	20	9.80 697	28	0.19 303	9.92 522	8	20
41	9.73 239	20	9.80 725	28	0.19 275	9.92 514	8	19
42	9.73 259	19	9.80 753	28	0.19 247	9.92 506	8	18
43	9.73 278	20	9.80 781	27	0.19 219	9.92 498	8	17
44	9.73 298	20	9.80 808	28	0.19 192	9.92 490	8	16
45	9.73 318	19	9.80 836	28	0.19 164	9.92 482	9	15
46	9.73 337	20	9.80 864	28	0.19 136	9.92 473	8	14
47	9.73 357	20	9.80 892	27	0.19 108	9.92 465	8	13
48	9.73 377	19	9.80 919	28	0.19 081	9.92 457	8	12
49	9.73 396	20	9.80 947	28	0.19 053	9.92 449	8	11
50	9.73 416	19	9.80 975	28	0.19 025	9.92 441	8	10
51	9.73 435	20	9.81 003	27	0.18 997	9.92 433	8	9
52	9.73 455	19	9.81 030	28	0.18 970	9.92 425	9	8
53	9.73 474	20	9.81 058	28	0.18 942	9.92 416	8	7
54	9.73 494	19	9.81 086	27	0.18 914	9.92 408	8	6
55	9.73 513	20	9.81 113	28	0.18 887	9.92 400	8	5
56	9.73 533	19	9.81 141	28	0.18 859	9.92 392	8	4
57	9.73 552	20	9.81 169	27	0.18 831	9.92 384	8	3
58	9.73 572	19	9.81 196	28	0.18 804	9.92 376	9	2
59	9.73 591	20	9.81 224	28	0.18 776	9.92 367	8	1
60	9.73 611		9.81 252		0.18 748	9.92 359		0
	L SIN	D	L TAN	CD	L COT	L COS	D	227°...147°
	L COS		L COT		L TAN	L SIN		237°... 57°

33°...213°		L SIN	D	L TAN	CD	L COT	L COS	D		
123°...303°		L COS		L COT		L TAN	L SIN			
	0	9.73 611	19	9.81 252	27	0.18 748	9.92 359	8	60	
	1	9.73 630	20	9.81 279	28	0.18 721	9.92 351	8	59	
	2	9.73 650	19	9.81 307	28	0.18 693	9.92 343	8	58	
	3	9.73 669	20	9.81 335	27	0.18 665	9.92 335	9	57	
	4	9.73 689	19	9.81 362	28	0.18 638	9.92 326	8	56	
	5	9.73 708	19	9.81 390	28	0.18 610	9.92 318	8	55	
	6	9.73 727	20	9.81 418	27	0.18 582	9.92 310	8	54	
	7	9.73 747	19	9.81 445	28	0.18 555	9.92 302	9	53	
	8	9.73 766	19	9.81 473	27	0.18 527	9.92 293	8	52	
	9	9.73 785	20	9.81 500	28	0.18 500	9.92 285	8	51	
	10	9.73 805	19	9.81 528	28	0.18 472	9.92 277	8	50	
	11	9.73 824	19	9.81 556	27	0.18 444	9.92 269	9	49	
	12	9.73 843	20	9.81 583	28	0.18 417	9.92 260	8	48	
	13	9.73 863	19	9.81 611	27	0.18 389	9.92 252	8	47	
	14	9.73 882	19	9.81 638	28	0.18 362	9.92 244	9	46	
	15	9.73 901	20	9.81 666	27	0.18 334	9.92 235	8	45	
	16	9.73 921	19	9.81 693	28	0.18 307	9.92 227	8	44	
	17	9.73 940	19	9.81 721	27	0.18 279	9.92 219	8	43	
	18	9.73 959	19	9.81 748	28	0.18 252	9.92 211	9	42	
	19	9.73 978	19	9.81 776	27	0.18 224	9.92 202	8	41	
	20	9.73 997	20	9.81 803	28	0.18 197	9.92 194	8	40	
	21	9.74 017	19	9.81 831	27	0.18 169	9.92 186	9	39	
	22	9.74 036	19	9.81 858	28	0.18 142	9.92 177	8	38	
	23	9.74 055	19	9.81 886	27	0.18 114	9.92 169	8	37	
	24	9.74 074	19	9.81 913	28	0.18 087	9.92 161	9	36	
	25	9.74 093	20	9.81 941	27	0.18 059	9.92 152	8	35	
	26	9.74 113	19	9.81 968	28	0.18 032	9.92 144	8	34	
	27	9.74 132	19	9.81 996	27	0.18 004	9.92 136	9	33	
	28	9.74 151	19	9.82 023	28	0.17 977	9.92 127	8	32	
	29	9.74 170	19	9.82 051	27	0.17 949	9.92 119	8	31	
	30	9.74 189	19	9.82 078	28	0.17 922	9.92 111	9	30	
	31	9.74 208	19	9.82 106	27	0.17 894	9.92 102	8	29	
	32	9.74 227	19	9.82 133	28	0.17 867	9.92 094	8	28	
	33	9.74 246	19	9.82 161	27	0.17 839	9.92 086	9	27	
	34	9.74 265	19	9.82 188	27	0.17 812	9.92 077	8	26	
	35	9.74 284	19	9.82 215	28	0.17 785	9.92 069	9	25	
	36	9.74 303	19	9.82 243	27	0.17 757	9.92 060	8	24	
	37	9.74 322	19	9.82 270	28	0.17 730	9.92 052	8	23	
	38	9.74 341	19	9.82 298	27	0.17 702	9.92 044	9	22	
	39	9.74 360	19	9.82 325	27	0.17 675	9.92 035	8	21	
	40	9.74 379	19	9.82 352	28	0.17 648	9.92 027	9	20	
	41	9.74 398	19	9.82 380	27	0.17 620	9.92 018	8	19	
	42	9.74 417	19	9.82 407	28	0.17 593	9.92 010	8	18	
	43	9.74 436	19	9.82 435	27	0.17 565	9.92 002	9	17	
	44	9.74 455	19	9.82 462	27	0.17 538	9.91 993	8	16	
	45	9.74 474	19	9.82 489	28	0.17 511	9.91 985	9	15	
	46	9.74 493	19	9.82 517	27	0.17 483	9.91 976	8	14	
	47	9.74 512	19	9.82 544	27	0.17 456	9.91 968	9	13	
	48	9.74 531	18	9.82 571	28	0.17 429	9.91 959	8	12	
	49	9.74 549	19	9.82 599	27	0.17 401	9.91 951	9	11	
	50	9.74 568	19	9.82 626	27	0.17 374	9.91 942	8	10	
	51	9.74 587	19	9.82 653	28	0.17 347	9.91 934	9	9	
	52	9.74 606	19	9.82 681	27	0.17 319	9.91 925	8	8	
	53	9.74 625	19	9.82 708	27	0.17 292	9.91 917	9	7	
	54	9.74 644	18	9.82 735	27	0.17 265	9.91 908	8	6	
	55	9.74 662	19	9.82 762	28	0.17 238	9.91 900	9	5	
	56	9.74 681	19	9.82 790	27	0.17 210	9.91 891	8	4	
	57	9.74 700	19	9.82 817	27	0.17 183	9.91 883	9	3	
	58	9.74 719	18	9.82 844	27	0.17 156	9.91 874	8	2	
	59	9.74 737	19	9.82 871	28	0.17 129	9.91 866	9	1	
	60	9.74 756		9.82 899		0.17 101	9.91 857		0	
		L SIN	D	L TAN	CD	L COT	L COS	D		326°..146°
		L COS		L COT		L TAN	L SIN			236°... 56°

34°...214°		L SIN	D	L TAN	CD	L COT	L COS	D		
124°...304°		L COS		L COT		L TAN	L SIN			
	0	9.74 756	19	9.82 899	27	0.17 101	9.91 857	8	60	
	1	9.74 775	19	9.82 926	27	0.17 074	9.91 849	9	59	
	2	9.74 794	18	9.82 953	27	0.17 047	9.91 840	8	58	
	3	9.74 812	19	9.82 980	28	0.17 020	9.91 832	9	57	
	4	9.74 831	19	9.83 008	27	0.16 992	9.91 823	8	56	
	5	9.74 850	18	9.83 035	27	0.16 956	9.91 815	9	55	
	6	9.74 868	19	9.83 062	27	0.16 938	9.91 806	8	54	
	7	9.74 887	19	9.83 089	28	0.16 911	9.91 798	9	53	
	8	9.74 906	18	9.83 117	27	0.16 883	9.91 789	8	52	
	9	9.74 924	19	9.83 144	27	0.16 856	9.91 781	9	51	
	10	9.74 943	18	9.83 171	27	0.16 829	9.91 772	9	50	
	11	9.74 961	19	9.83 198	27	0.16 802	9.91 763	8	49	
	12	9.74 980	19	9.83 225	27	0.16 775	9.91 755	9	48	
	13	9.74 999	18	9.83 252	28	0.16 748	9.91 746	8	47	
	14	9.75 017	19	9.83 280	27	0.16 720	9.91 738	9	46	
	15	9.75 036	18	9.83 307	27	0.16 693	9.91 729	9	45	
	16	9.75 054	19	9.83 334	27	0.16 666	9.91 720	8	44	
	17	9.75 073	18	9.83 361	27	0.16 639	9.91 712	9	43	
	18	9.75 091	19	9.83 388	27	0.16 612	9.91 703	8	42	
	19	9.75 110	18	9.83 415	27	0.16 585	9.91 695	9	41	
	20	9.75 128	19	9.83 442	28	0.16 558	9.91 686	9	40	
	21	9.75 147	18	9.83 470	27	0.16 530	9.91 677	8	39	
	22	9.75 165	19	9.83 497	27	0.16 503	9.91 669	9	38	
	23	9.75 184	18	9.83 524	27	0.16 476	9.91 660	9	37	
	24	9.75 202	19	9.83 551	27	0.16 449	9.91 651	8	36	
	25	9.75 221	18	9.83 578	27	0.16 422	9.91 643	9	35	
	26	9.75 239	19	9.83 605	27	0.16 395	9.91 634	9	34	
	27	9.75 258	18	9.83 632	27	0.16 368	9.91 625	8	33	
	28	9.75 276	18	9.83 659	27	0.16 341	9.91 617	9	32	
	29	9.75 294	19	9.83 686	27	0.16 314	9.91 608	9	31	
	30	9.75 313	18	9.83 713	27	0.16 287	9.91 599	8	30	
	31	9.75 331	19	9.83 740	28	0.16 260	9.91 591	9	29	
	32	9.75 350	18	9.83 768	27	0.16 232	9.91 582	9	28	
	33	9.75 368	18	9.83 795	27	0.16 205	9.91 573	8	27	
	34	9.75 386	19	9.83 822	27	0.16 178	9.91 565	9	26	
	35	9.75 405	18	9.83 849	27	0.16 151	9.91 556	9	25	
	36	9.75 423	18	9.83 876	27	0.16 124	9.91 547	9	24	
	37	9.75 441	18	9.83 903	27	0.16 097	9.91 538	8	23	
	38	9.75 459	19	9.83 930	27	0.16 070	9.91 530	9	22	
	39	9.75 478	18	9.83 957	27	0.16 043	9.91 521	9	21	
	40	9.75 496	18	9.83 984	27	0.16 016	9.91 512	8	20	
	41	9.75 514	19	9.84 011	27	0.15 989	9.91 504	9	19	
	42	9.75 533	18	9.84 038	27	0.15 962	9.91 495	9	18	
	43	9.75 551	18	9.84 065	27	0.15 935	9.91 486	9	17	
	44	9.75 569	18	9.84 092	27	0.15 908	9.91 477	8	16	
	45	9.75 587	18	9.84 119	27	0.15 881	9.91 469	9	15	
	46	9.75 605	19	9.84 146	27	0.15 854	9.91 460	9	14	
	47	9.75 624	18	9.84 173	27	0.15 827	9.91 451	9	13	
	48	9.75 642	18	9.84 200	27	0.15 800	9.91 442	9	12	
	49	9.75 660	18	9.84 227	27	0.15 773	9.91 433	8	11	
	50	9.75 678	18	9.84 254	26	0.15 746	9.91 425	9	10	
	51	9.75 696	18	9.84 280	27	0.15 720	9.91 416	9	9	
	52	9.75 714	19	9.84 307	27	0.15 693	9.91 407	9	8	
	53	9.75 733	18	9.84 334	27	0.15 666	9.91 398	9	7	
	54	9.75 751	18	9.84 361	27	0.15 639	9.91 389	8	6	
	55	9.75 769	18	9.84 388	27	0.15 612	9.91 381	9	5	
	56	9.75 787	18	9.84 415	27	0.15 585	9.91 372	9	4	
	57	9.75 805	18	9.84 442	27	0.15 558	9.91 363	9	3	
	58	9.75 823	18	9.84 469	27	0.15 531	9.91 354	9	2	
	59	9.75 841	18	9.84 496	27	0.15 504	9.91 345	9	1	
	60	9.75 859		9.84 523		0.15 477	9.91 336		0	
		L SIN	D	L TAN	CD	L COT	L COS	D		325°...145°
		L COS		L COT		L TAN	L SIN			235°... 55°

35°...215°	L SIN	D	L TAN	CD	L COT	L COS	D	
125°...305°	L COS		L COT		L TAN	L SIN		
0	9.75 859	18	9.84 523	27	0.15 477	9.91 336	8	60
1	9.75 877	18	9.84 550	26	0.15 450	9.91 328	9	59
2	9.75 895	18	9.84 576	27	0.15 424	9.91 319	9	58
3	9.75 913	18	9.84 603	27	0.15 397	9.91 310	9	57
4	9.75 931	18	9.84 630	27	0.15 370	9.91 301	9	56
5	9.75 949	18	9.84 657	27	0.15 343	9.91 292	9	55
6	9.75 967	18	9.84 684	27	0.15 316	9.91 283	9	54
7	9.75 985	18	9.84 711	27	0.15 289	9.91 274	8	53
8	9.76 003	18	9.84 738	26	0.15 262	9.91 266	9	52
9	9.76 021	18	9.84 764	27	0.15 236	9.91 257	9	51
10	9.76 039	18	9.84 791	27	0.15 209	9.91 248	9	50
11	9.76 057	18	9.84 818	27	0.15 182	9.91 239	9	49
12	9.76 075	18	9.84 845	27	0.15 155	9.91 230	9	48
13	9.76 093	18	9.84 872	27	0.15 128	9.91 221	9	47
14	9.76 111	18	9.84 899	26	0.15 101	9.91 212	9	46
15	9.76 129	17	9.84 925	27	0.15 075	9.91 203	9	45
16	9.76 146	18	9.84 952	27	0.15 048	9.91 194	9	44
17	9.76 164	18	9.84 979	27	0.15 021	9.91 185	9	43
18	9.76 182	18	9.85 006	27	0.14 994	9.91 176	9	42
19	9.76 200	18	9.85 033	26	0.14 967	9.91 167	9	41
20	9.76 218	18	9.85 059	27	0.14 941	9.91 158	9	40
21	9.76 236	17	9.85 086	27	0.14 914	9.91 149	8	39
22	9.76 253	18	9.85 113	27	0.14 887	9.91 141	9	38
23	9.76 271	18	9.85 140	26	0.14 860	9.91 132	9	37
24	9.76 289	18	9.85 166	27	0.14 834	9.91 123	9	36
25	9.76 307	17	9.85 193	27	0.14 807	9.91 114	9	35
26	9.76 324	18	9.85 220	27	0.14 780	9.91 105	9	34
27	9.76 342	18	9.85 247	26	0.14 753	9.91 096	9	33
28	9.76 360	18	9.85 273	27	0.14 727	9.91 087	9	32
29	9.76 378	17	9.85 300	27	0.14 700	9.91 078	9	31
30	9.76 395	18	9.85 327	27	0.14 673	9.91 069	9	30
31	9.76 413	18	9.85 354	26	0.14 646	9.91 060	9	29
32	9.76 431	17	9.85 380	27	0.14 620	9.91 051	9	28
33	9.76 448	18	9.85 407	27	0.14 593	9.91 042	9	27
34	9.76 466	18	9.85 434	26	0.14 566	9.91 033	10	26
35	9.76 484	17	9.85 460	27	0.14 540	9.91 023	9	25
36	9.76 501	18	9.85 487	27	0.14 513	9.91 014	9	24
37	9.76 519	18	9.85 514	26	0.14 486	9.91 005	9	23
38	9.76 537	17	9.85 540	27	0.14 460	9.90 996	9	22
39	9.76 554	18	9.85 567	27	0.14 433	9.90 987	9	21
40	9.76 572	18	9.85 594	26	0.14 406	9.90 978	9	20
41	9.76 590	17	9.85 620	27	0.14 380	9.90 969	9	19
42	9.76 607	18	9.85 647	27	0.14 353	9.90 960	9	18
43	9.76 625	17	9.85 674	26	0.14 326	9.90 951	9	17
44	9.76 642	18	9.85 700	27	0.14 300	9.90 942	9	16
45	9.76 660	17	9.85 727	27	0.14 273	9.90 933	9	15
46	9.76 677	18	9.85 754	26	0.14 246	9.90 924	9	14
47	9.76 695	17	9.85 780	27	0.14 220	9.90 915	9	13
48	9.76 712	18	9.85 807	27	0.14 193	9.90 906	10	12
49	9.76 730	17	9.85 834	26	0.14 166	9.90 896	9	11
50	9.76 747	18	9.85 860	27	0.14 140	9.90 887	9	10
51	9.76 765	17	9.85 887	26	0.14 113	9.90 878	9	9
52	9.76 782	18	9.85 913	27	0.14 087	9.90 869	9	8
53	9.76 800	17	9.85 940	27	0.14 060	9.90 860	9	7
54	9.76 817	18	9.85 967	26	0.14 033	9.90 851	9	6
55	9.76 835	17	9.85 993	27	0.14 007	9.90 842	10	5
56	9.76 852	18	9.86 020	26	0.13 980	9.90 832	9	4
57	9.76 870	17	9.86 046	27	0.13 954	9.90 823	9	3
58	9.76 887	17	9.86 073	27	0.13 927	9.90 814	9	2
59	9.76 904	18	9.86 100.	26	0.13 900	9.90 805	9	1
60	9.76 922		9.86 126		0.13 874	9.90 796		0
	L SIN	D	L TAN	CD	L COT	L COS	D	324°...144°
	L COS		L COT		L TAN	L SIN		234°... 54°

36°...216°		L SIN	D	L TAN	CD	L COT	L COS	D		
126°...306°		L COS		L COT		L TAN	L SIN			
	0	9.76 922	17	9.86 126	27	0.13 874	9.90 796	9	60	
	1	9.76 939	18	9.86 153	26	0.13 847	9.90 787	10	59	
	2	9.76 957	17	9.86 179	27	0.13 821	9.90 777	9	58	
	3	9.76 974	17	9.86 206	26	0.13 794	9.90 768	9	57	
	4	9.76 991	18	9.86 232	27	0.13 768	9.90 759	9	56	
	5	9.77 009	17	9.86 259	26	0.13 741	9.90 750	9	55	
	6	9.77 026	17	9.86 285	27	0.13 715	9.90 741	10	54	
	7	9.77 043	18	9.86 312	26	0.13 688	9.90 731	9	53	
	8	9.77 061	17	9.86 338	27	0.13 662	9.90 722	9	52	
	9	9.77 078	17	9.86 365	27	0.13 635	9.90 713	9	51	
	10	9.77 095	17	9.86 392	26	0.13 608	9.90 704	10	50	
	11	9.77 112	18	9.86 418	27	0.13 582	9.90 694	9	49	
	12	9.77 130	17	9.86 445	26	0.13 555	9.90 685	9	48	
	13	9.77 147	17	9.86 471	27	0.13 529	9.90 676	9	47	
	14	9.77 164	17	9.86 498	26	0.13 502	9.90 667	10	46	
	15	9.77 181	18	9.86 524	27	0.13 476	9.90 657	9	45	
	16	9.77 199	17	9.86 551	26	0.13 449	9.90 648	9	44	
	17	9.77 216	17	9.86 577	26	0.13 423	9.90 639	9	43	
	18	9.77 233	17	9.86 603	27	0.13 397	9.90 630	10	42	
	19	9.77 250	18	9.86 630	26	0.13 370	9.90 620	9	41	
	20	9.77 268	17	9.86 656	27	0.13 344	9.90 611	9	40	
	21	9.77 285	17	9.86 683	26	0.13 317	9.90 602	10	39	
	22	9.77 302	17	9.86 709	27	0.13 291	9.90 592	9	38	
	23	9.77 319	17	9.86 736	26	0.13 264	9.90 583	9	37	
	24	9.77 336	17	9.86 762	27	0.13 238	9.90 574	9	36	
	25	9.77 353	17	9.86 789	26	0.13 211	9.90 565	10	35	
	26	9.77 370	17	9.86 815	27	0.13 185	9.90 555	9	34	
	27	9.77 387	18	9.86 842	26	0.13 158	9.90 546	9	33	
	28	9.77 405	17	9.86 868	26	0.13 132	9.90 537	10	32	
	29	9.77 422	17	9.86 894	27	0.13 106	9.90 527	9	31	
	30	9.77 439	17	9.86 921	26	0.13 079	9.90 518	9	30	
	31	9.77 456	17	9.86 947	27	0.13 053	9.90 509	10	29	
	32	9.77 473	17	9.86 974	26	0.13 026	9.90 499	9	28	
	33	9.77 490	17	9.87 000	27	0.13 000	9.90 490	10	27	
	34	9.77 507	17	9.87 027	26	0.12 973	9.90 480	9	26	
	35	9.77 524	17	9.87 053	26	0.12 947	9.90 471	9	25	
	36	9.77 541	17	9.87 079	27	0.12 921	9.90 462	10	24	
	37	9.77 558	17	9.87 106	26	0.12 894	9.90 452	9	23	
	38	9.77 575	17	9.87 132	26	0.12 868	9.90 443	9	22	
	39	9.77 592	17	9.87 158	27	0.12 842	9.90 434	10	21	
	40	9.77 609	17	9.87 185	26	0.12 815	9.90 424	9	20	
	41	9.77 626	17	9.87 211	27	0.12 789	9.90 415	10	19	
	42	9.77 643	17	9.87 238	26	0.12 762	9.90 405	9	18	
	43	9.77 660	17	9.87 264	26	0.12 736	9.90 396	10	17	
	44	9.77 677	17	9.87 290	27	0.12 710	9.90 386	9	16	
	45	9.77 694	17	9.87 317	26	0.12 683	9.90 377	9	15	
	46	9.77 711	17	9.87 343	26	0.12 657	9.90 368	10	14	
	47	9.77 728	16	9.87 369	27	0.12 631	9.90 358	9	13	
	48	9.77 744	17	9.87 396	26	0.12 604	9.90 349	10	12	
	49	9.77 761	17	9.87 422	26	0.12 578	9.90 339	9	11	
	50	9.77 778	17	9.87 448	27	0.12 552	9.90 330	10	10	
	51	9.77 795	17	9.87 475	26	0.12 525	9.90 320	9	9	
	52	9.77 812	17	9.87 501	26	0.12 499	9.90 311	10	8	
	53	9.77 829	17	9.87 527	27	0.12 473	9.90 301	9	7	
	54	9.77 846	16	9.87 554	26	0.12 446	9.90 292	10	6	
	55	9.77 862	17	9.87 580	26	0.12 420	9.90 282	9	5	
	56	9.77 879	17	9.87 606	27	0.12 394	9.90 273	10	4	
	57	9.77 896	17	9.87 633	26	0.12 367	9.90 263	9	3	
	58	9.77 913	17	9.87 659	26	0.12 341	9.90 254	10	2	
	59	9.77 930	16	9.87 685	26	0.12 315	9.90 244	9	1	
	60	9.77 946		9.87 711		0.12 289	9.90 235		0	
		L SIN	D	L TAN	CD	L COT	L COS	D		323°...143°
		L COS		L COT		L TAN	L SIN			233°... 53°

37°...217°
127°...307°

	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	
0	9.77 946	17	9.87 711	27	0.12 289	9.90 235	10	60
1	9.77 963	17	9.87 738	26	0.12 262	9.90 225	9	59
2	9.77 980	17	9.87 764	26	0.12 236	9.90 216	10	58
3	9.77 997	16	9.87 790	27	0.12 210	9.90 206	9	57
4	9.78 013	17	9.87 817	26	0.12 183	9.90 197	10	56
5	9.78 030	17	9.87 843	26	0.12 157	9.90 187	9	55
6	9.78 047	16	9.87 869	26	0.12 131	9.90 178	10	54
7	9.78 063	17	9.87 895	27	0.12 105	9.90 168	9	53
8	9.78 080	17	9.87 922	26	0.12 078	9.90 159	10	52
9	9.78 097	16	9.87 948	26	0.12 052	9.90 149	10	51
10	9.78 113	17	9.87 974	26	0.12 026	0.90 139	9	50
11	9.78 130	17	9.88 000	27	0.12 000	9.90 130	10	49
12	9.78 147	16	9.88 027	26	0.11 973	9.90 120	9	48
13	9.78 163	17	9.88 053	26	0.11 947	9.90 111	10	47
14	9.78 180	17	9.88 079	26	0.11 921	9.90 101	10	46
15	9.78 197	16	9.88 105	26	0.11 895	9.90 091	9	45
16	9.78 213	17	9.88 131	27	0.11 869	9.90 082	10	44
17	9.78 230	16	9.88 158	26	0.11 842	9.90 072	9	43
18	9.78 246	17	9.88 184	26	0.11 816	9.90 063	10	42
19	9.78 263	17	9.88 210	26	0.11 790	9.90 053	10	41
20	9.78 280	16	9.88 236	26	0.11 764	9.90 043	9	40
21	9.78 296	17	9.88 262	27	0.11 738	9.90 034	10	39
22	9.78 313	16	9.88 289	26	0.11 711	9.90 024	10	38
23	9.78 329	17	9.88 315	26	0.11 685	9.90 014	9	37
24	9.78 346	16	9.88 341	26	0.11 659	9.90 005	10	36
25	9.78 362	17	9.88 367	26	0.11 633	9.89 995	10	35
26	9.78 379	16	9.88 393	27	0.11 607	9.89 985	9	34
27	9.78 395	17	9.88 420	26	0.22 580	9.89 976	10	33
28	9.78 412	16	9.88 446	26	0.11 554	9.89 966	10	32
29	9.78 428	17	9.88 472	26	0.11 528	9.89 956	9	31
30	9.78 445	16	9.88 498	26	0.11 502	9.89 947	10	30
31	9.78 461	17	9.88 524	26	0.11 476	9.89 937	10	29
32	9.78 478	16	9.88 550	27	0.11 450	9.89 927	9	28
33	9.78 494	16	9.88 577	26	0.11 423	9.89 918	10	27
34	9.78 510	17	9.88 603	26	0.11 397	9.89 908	10	26
35	9.78 527	16	9.88 629	26	0.11 371	9.89 898	10	25
36	9.78 543	17	9.88 655	26	0.11 345	9.89 888	9	24
37	9.78 560	16	9.88 681	26	0.11 319	9.89 879	10	23
38	9.78 576	16	9.88 707	26	0.11 293	0.89 869	10	22
39	9.78 592	17	9.88 733	26	0.11 267	9.89 859	10	21
40	9.78 609	16	9.88 759	27	0.11 241	9.89 849	9	20
41	9.78 625	17	9.88 786	26	0.11 214	9.89 840	10	19
42	9.78 642	16	9.88 812	26	0.11 188	9.89 830	10	18
43	9.78 658	16	9.88 838	26	0.11 162	9.89 820	10	17
44	9.78 674	17	9.88 864	26	0.11 136	9.89 810	9	16
45	9.78 691	16	9.88 890	26	0.11 110	9.89 801	10	15
46	9.78 707	16	9.88 916	26	0.11 084	9.89 791	10	14
47	9.78 723	16	9.88 942	26	0.11 058	9.89 781	10	13
48	9.78 739	17	9.88 968	26	0.11 032	9.89 771	10	12
49	9.78 756	16	9.88 994	26	0.11 006	0.89 761	9	11
50	9.78 772	16	0.89 020	26	0.10 980	9.89 752	10	10
51	9.78 788	17	9.89 046	27	0.10 954	9.89 742	10	9
52	9.78 805	16	9.89 073	26	0.10 927	9.89 732	10	8
53	9.78 821	16	9.89 099	26	0.10 901	9.89 722	10	7
54	9.78 837	16	9.89 125	26	0.10 875	9.89 712	10	6
55	9.78 853	16	9.89 151	26	0.10 849	9.89 702	9	5
56	9.78 869	17	9.89 177	26	0.10 823	9.89 693	10	4
57	9.78 886	16	9.89 203	26	0.10 797	9.89 683	10	3
58	9.78 902	16	9.89 229	26	0.10 771	0.89 673	10	2
59	9.78 918	16	9.89 255	26	0.10 745	9.89 663	10	1
60	9.78 934		9.89 281		0.10 719	9.89 653		0
	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	

322°...142°
232°... 52°

38°..218°	L SIN	D	L TAN	CD	L COT	L COS	D	
128°...308°	L COS		L COT		L TAN	L SIN		
0	9.78 934	16	9.89 281	26	0.10 719	9.89 653	10	60
1	9.78 950	17	9.89 307	26	0.10 693	9.89 643	10	59
2	9.78 967	16	9.89 333	26	0.10 667	9.89 633	9	58
3	9.78 983	16	9.89 359	26	0.10 641	9.89 624	10	57
4	9.78 999	16	9.89 385	26	0.10 615	9.89 614	10	56
5	9.79 015	16	9.89 411	26	0.10 589	9.89 604	10	55
6	9.79 031	16	9.89 437	26	0.10 563	9.89 594	10	54
7	9.79 047	16	9.89 463	26	0.10 537	9.89 584	10	53
8	9.79 063	16	9.89 489	26	0.10 511	9.89 574	10	52
9	9.79 079	16	9.89 515	26	0.10 485	9.89 564	10	51
10	9.79 095	16	9.89 541	26	0.10 459	9.89 554	10	50
11	9.79 111	17	9.89 567	26	0.10 433	9.89 544	10	49
12	9.79 128	16	9.89 593	26	0.10 407	9.89 534	10	48
13	9.79 144	16	9.89 619	26	0.10 381	9.89 524	10	47
14	9.79 160	16	9.89 645	26	0.10 355	9.89 514	10	46
15	9.79 176	16	9.89 671	26	0.10 329	9.89 504	9	45
16	9.79 192	16	9.89 697	26	0.10 303	9.89 495	10	44
17	9.79 208	16	9.89 723	26	0.10 277	9.89 485	10	43
18	9.79 224	16	9.89 749	26	0.10 251	9.89 475	10	42
19	9.79 240	16	9.89 775	26	0.10 225	9.89 465	10	41
20	9.79 256	16	9.89 801	26	0.10 199	9.89 455	10	40
21	9.79 272	16	9.89 827	26	0.10 173	9.89 445	10	39
22	9.79 288	16	9.89 853	26	0.10 147	9.89 435	10	38
23	9.79 304	15	9.89 879	26	0.10 121	9.89 425	10	37
24	9.79 319	16	9.89 905	26	0.10 095	9.89 415	10	36
25	9.79 335	16	9.89 931	26	0.10 069	9.89 405	10	35
26	9.79 351	16	9.89 957	26	0.10 043	9.89 395	10	34
27	9.79 367	16	9.89 983	26	0.10 017	9.89 385	10	33
28	9.79 383	16	9.90 009	26	0.09 991	9.89 375	11	32
29	9.79 399	16	9.90 035	26	0.09 965	9.89 364	10	31
30	9.79 415	16	9.90 061	25	0.09 939	9.89 354	10	30
31	9.79 431	16	9.90 086	26	0.09 914	9.89 344	10	29
32	9.79 447	16	9.90 112	26	0.09 888	9.89 334	10	28
33	9.79 463	15	9.90 138	26	0.09 862	9.89 324	10	27
34	9.79 478	16	9.90 164	26	0.09 836	9.89 314	10	26
35	9.79 494	16	9.90 190	26	0.09 810	9.89 304	10	25
36	9.79 510	16	9.90 216	26	0.09 784	9.89 294	10	24
37	9.79 526	16	9.90 242	26	0.09 758	9.89 284	10	23
38	9.79 542	16	9.90 268	26	0.09 732	9.89 274	10	22
39	9.79 558	15	9.90 294	26	0.09 706	9.89 264	10	21
40	9.79 573	16	9.90 320	26	0.09 680	9.89 254	10	20
41	9.79 589	16	9.90 346	25	0.09 654	9.89 244	11	19
42	9.79 605	16	9.90 371	26	0.09 629	9.89 233	10	18
43	9.79 621	15	9.90 397	26	0.09 603	9.89 223	10	17
44	9.79 636	16	9.90 423	26	0.09 577	9.89 213	10	16
45	9.79 652	16	9.90 449	26	0.09 551	9.89 203	10	15
46	9.79 668	16	9.90 475	26	0.09 525	9.89 193	10	14
47	9.79 684	15	9.90 501	26	0.09 499	9.89 183	10	13
48	9.79 699	16	9.90 527	26	0.09 473	9.89 173	11	12
49	9.79 715	16	9.90 553	25	0.09 447	9.89 162	10	11
50	9.79 731	15	9.90 578	26	0.09 422	9.89 152	10	10
51	9.79 746	16	9.90 604	26	0.09 396	9.89 142	10	9
52	9.79 762	16	9.90 630	26	0.09 370	9.89 132	10	8
53	9.79 778	15	9.90 656	26	0.09 344	9.89 122	10	7
54	9.79 793	16	9.90 682	26	0.09 318	9.89 112	11	6
55	9.79 809	16	9.90 708	26	0.09 292	9.89 101	10	5
56	9.79 825	15	9.90 734	25	0.09 266	9.89 091	10	4
57	9.79 840	16	9.90 759	26	0.09 241	9.89 081	10	3
58	9.79 856	16	9.90 785	26	0.09 215	9.89 071	11	2
59	9.79 872	15	9.90 811	26	0.09 189	9.89 060	10	1
60	9.79 887		9.90 837		0.09 163	9.89 050		0
	L SIN	D	L TAN	CD	L COT	L COS	D	321°...141°
	L COS		L COT		L TAN	L SIN		231°... 51°

39°...219°		L SIN	D	L TAN	CD	L COT	L COS	D	
129°...309°		L COS		L COT		L TAN	L SIN		
	0	9.79 887	16	9.90 837	26	0.09 163	9.89 050	10	60
	1	9.79 903	15	9.90 863	26	0.09 137	9.89 040	10	59
	2	9.79 918	16	9.90 889	25	0.09 111	9.89 030	10	58
	3	9.79 934	16	9.90 914	26	0.09 086	9.89 020	11	57
	4	9.79 950	15	9.90 940	26	0.09 060	9.89 009	10	56
	5	9.79 965	16	9.90 966	26	0.09 034	9.88 999	10	55
	6	9.79 981	15	9.90 992	26	0.09 008	9.88 989	11	54
	7	9.79 996	16	9.91 018	25	0.08 982	9.88 978	10	53
	8	9.80 012	15	9.91 043	26	0.08 957	9.88 968	10	52
	9	9.80 027	16	9.91 069	26	0.08 931	9.88 958	10	51
	10	9.80 043	15	9.91 095	26	0.08 905	9.88 948	11	50
	11	9.80 058	16	9.91 121	26	0.08 879	9.88 937	10	49
	12	9.80 074	15	9.91 147	25	0.08 853	9.88 927	10	48
	13	9.80 089	16	9.91 172	26	0.08 828	9.88 917	11	47
	14	9.80 105	15	9.91 198	26	0.08 802	9.88 906	10	46
	15	9.80 120	16	9.91 224	26	0.08 776	9.88 896	10	45
	16	9.80 136	15	9.91 250	26	0.08 750	9.88 886	11	44
	17	9.80 151	15	9.91 276	25	0.08 724	9.88 875	10	43
	18	9.80 166	16	9.91 301	26	0.08 699	9.88 865	10	42
	19	9.80 182	15	9.91 327	26	0.08 673	9.88 855	11	41
	20	9.80 197	16	9.91 353	26	0.08 647	9.88 844	10	40
	21	9.80 213	15	9.91 379	25	0.08 621	9.88 834	10	39
	22	9.80 228	16	9.91 404	26	0.08 596	9.88 824	11	38
	23	9.80 244	15	9.91 430	26	0.08 570	9.88 813	10	37
	24	9.80 259	15	9.91 456	26	0.08 544	9.88 803	10	36
	25	9.80 274	16	9.91 482	25	0.08 518	9.88 793	11	35
	26	9.80 290	15	9.91 507	26	0.08 493	9.88 782	10	34
	27	9.80 305	15	9.91 533	26	0.08 467	9.88 772	11	33
	28	9.80 320	16	9.91 559	26	0.08 441	9.88 761	10	32
	29	9.80 336	15	9.91 585	25	0.08 415	9.88 751	10	31
	30	9.80 351	15	9.91 610	26	0.08 390	9.88 741	11	30
	31	9.80 366	16	9.91 636	26	0.08 364	9.88 730	10	29
	32	9.80 382	15	9.91 662	26	0.08 338	9.88 720	11	28
	33	9.80 397	15	9.91 688	25	0.08 312	9.88 709	10	27
	34	9.80 412	16	9.91 713	26	0.08 287	9.88 699	11	26
	35	9.80 428	15	9.91 739	26	0.08 261	9.88 688	10	25
	36	9.80 443	15	9.91 765	26	0.08 235	9.88 678	10	24
	37	9.80 458	15	9.91 791	25	0.08 209	9.88 668	11	23
	38	9.80 473	16	9.91 816	26	0.08 184	9.88 657	10	22
	39	9.80 489	15	9.91 842	26	0.08 158	9.88 647	11	21
	40	9.80 504	15	9.91 868	25	0.08 132	9.88 636	10	20
	41	9.80 519	15	9.91 893	26	0.08 107	9.88 626	11	19
	42	9.80 534	16	9.91 919	26	0.08 081	9.88 615	10	18
	43	9.80 550	15	9.91 945	26	0.08 055	9.88 605	11	17
	44	9.80 565	15	9.91 971	25	0.08 029	9.88 594	10	16
	45	9.80 580	15	9.91 996	26	0.08 004	9.88 584	11	15
	46	9.80 595	15	9.92 022	26	0.07 978	9.88 573	10	14
	47	9.80 610	15	9.92 048	25	0.07 952	9.88 563	11	13
	48	9.80 625	16	9.92 073	26	0.07 927	9.88 552	10	12
	49	9.80 641	15	9.92 099	26	0.07 901	9.88 542	11	11
	50	9.80 656	15	9.92 125	25	0.07 875	9.88 531	10	10
	51	9.80 671	15	9.92 150	26	0.07 850	9.88 521	11	9
	52	9.80 686	15	9.92 176	26	0.07 824	9.88 510	11	8
	53	9.80 701	15	9.92 202	25	0.07 798	9.88 499	10	7
	54	9.80 716	15	9.92 227	26	0.07 773	9.88 489	11	6
	55	9.80 731	15	9.92 253	26	0.07 747	9.88 478	10	5
	56	9.80 746	16	9.92 279	25	0.07 721	9.88 468	11	4
	57	9.80 762	15	9.92 304	26	0.07 696	9.88 457	10	3
	58	9.80 777	15	9.92 330	26	0.07 670	9.88 447	11	2
	59	9.80 792	15	9.92 356	25	0.07 644	9.88 436	11	1
	60	9.80 807		9.92 381		0.07 619	9.88 425		0
		L SIN	D	L TAN	CD	L COT	L COS	D	320°...140°
		L COS		L COT		L TAN	L SIN		230°... 50°

40°...220° / 130°...310°	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	
0	9.80 807	15	9.92 381	26	0.07 619	9.88 425	10	60
1	9.80 822	15	9.92 407	26	0.07 593	9.88 415	11	59
2	9.80 837	15	9.92 433	25	0.07 567	9.88 404	10	58
3	9.80 852	15	9.92 458	26	0.07 542	9.88 394	11	57
4	9.80 867	15	9.92 484	26	0.07 516	9.88 383	11	56
5	9.80 882	15	9.92 510	25	0.07 490	9.88 372	10	55
6	9.80 897	15	9.92 535	26	0.07 465	9.88 362	11	54
7	9.80 912	15	9.92 561	26	0.07 439	9.88 351	11	53
8	9.80 927	15	9.92 587	25	0.07 413	9.88 340	10	52
9	9.80 942	15	9.92 612	26	0.07 388	9.88 330	11	51
10	9.80 957	15	9.92 638	25	0.07 362	9.88 319	11	50
11	9.80 972	15	9.92 663	26	0.07 337	9.88 308	10	49
12	9.80 987	15	9.92 689	26	0.07 311	9.88 298	11	48
13	9.81 002	15	9.92 715	25	0.07 285	9.88 287	11	47
14	9.81 017	15	9.92 740	26	0.07 260	9.88 276	10	46
15	9.81 032	15	9.92 766	26	0.07 234	9.88 266	11	45
16	9.81 047	14	9.92 792	25	0.07 208	9.88 255	11	44
17	9.81 061	15	9.92 817	26	0.07 183	9.88 244	10	43
18	9.81 076	15	9.92 843	25	0.07 157	9.88 234	11	42
19	9.81 091	15	9.92 868	26	0.07 132	9.88 223	11	41
20	9.81 106	15	9.92 894	26	0.07 106	9.88 212	11	40
21	9.81 121	15	9.92 920	25	0.07 080	9.88 201	10	39
22	9.81 136	15	9.92 945	26	0.07 055	9.88 191	11	38
23	9.81 151	15	9.92 971	25	0.07 029	9.88 180	11	37
24	9.81 166	14	9.92 996	26	0.07 004	9.88 169	11	36
25	9.81 180	15	9.93 022	26	0.06 978	9.88 158	10	35
26	9.81 195	15	9.93 048	25	0.06 952	9.88 148	11	34
27	9.81 210	15	9.93 073	26	0.06 927	9.88 137	11	33
28	9.81 225	15	9.93 099	25	0.06 901	9.88 126	11	32
29	9.81 240	14	9.93 124	26	0.06 876	9.88 115	10	31
30	9.81 254	15	9.93 150	25	0.06 850	9.88 105	11	30
31	9.81 269	15	9.93 175	26	0.06 825	9.88 094	11	29
32	9.81 284	15	9.93 201	26	0.06 799	9.88 083	11	28
33	9.81 299	15	9.93 227	25	0.06 773	9.88 072	11	27
34	9.81 314	14	9.93 252	26	0.06 748	9.88 061	10	26
35	9.81 328	15	9.93 278	25	0.06 722	9.88 051	11	25
36	9.81 343	15	9.93 303	26	0.06 697	9.88 040	11	24
37	9.81 358	14	9.93 329	25	0.06 671	9.88 029	11	23
38	9.81 372	15	9.93 354	26	0.06 646	9.88 018	11	22
39	9.81 387	15	9.93 380	26	0.06 620	9.88 007	11	21
40	9.81 402	15	9.93 406	25	0.06 594	9.87 996	11	20
41	9.81 417	14	9.93 431	26	0.06 569	9.87 985	10	19
42	9.81 431	15	9.93 457	25	0.06 543	9.87 975	11	18
43	9.81 446	15	9.93 482	26	0.06 518	9.87 964	11	17
44	9.81 461	14	9.93 508	25	0.06 492	9.87 953	11	16
45	9.81 475	15	9.93 533	26	0.06 467	9.87 942	11	15
46	9.81 490	15	9.93 559	25	0.06 441	9.87 931	11	14
47	9.81 505	14	9.93 584	26	0.06 416	9.87 920	11	13
48	9.81 519	15	9.93 610	26	0.06 390	9.87 909	11	12
49	9.81 534	15	9.93 636	25	0.06 364	9.87 898	11	11
50	9.81 549	14	9.93 661	26	0.06 339	9.87 887	10	10
51	9.81 563	15	9.93 687	25	0.06 313	9.87 877	11	9
52	9.81 578	14	9.93 712	26	0.06 288	9.87 866	11	8
53	9.81 592	15	9.93 738	25	0.06 262	9.87 855	11	7
54	9.81 607	15	9.93 763	26	0.06 237	9.87 844	11	6
55	9.81 622	14	9.93 789	25	0.06 211	9.87 833	11	5
56	9.81 636	15	9.93 814	26	0.06 186	9.87 822	11	4
57	9.81 651	14	9.93 840	25	0.06 160	9.87 811	11	3
58	9.81 665	15	9.93 865	26	0.06 135	9.87 800	11	2
59	9.81 680	14	9.93 891	25	0.06 109	9.87 789	11	1
60	9.81 694		9.93 916		0.06 084	9.87 778		0
	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	319°...139° / 229°... 49°

41°...221°	L SIN	D	L TAN	CD	L COT	L COS	D	
131°...311°	L COS		L COT		L TAN	L SIN		
0	9.81 694	15	9.93 916	26	0.06 084	9.87 778	11	60
1	9.81 709	14	9.93 942	25	0.06 058	9.87 767	11	59
2	9.81 723	15	9.93 967	26	0.06 033	9.87 756	11	58
3	9.81 738	14	9.93 993	25	0.06 007	9.87 745	11	57
4	9.81 752	15	9.94 018	26	0.05 982	9.87 734	11	56
5	9.81 767	14	9.94 044	25	0.05 956	9.87 723	11	55
6	9.81 781	15	9.94 069	26	0.05 931	9.87 712	11	54
7	9.81 796	14	9.94 095	25	0.05 905	9.87 701	11	53
8	9.81 810	15	9.94 120	26	0.05 880	9.87 690	11	52
9	9.81 825	14	9.94 146	25	0.05 854	9.87 679	11	51
10	9.81 839	15	9.94 171	26	0.05 829	9.87 668	11	50
11	9.81 854	14	9.94 197	25	0.05 803	9.87 657	11	49
12	9.81 868	14	9.94 222	26	0.05 778	9.87 646	11	48
13	9.81 882	15	9.94 248	25	0.05 752	9.87 635	11	47
14	9.81 897	14	9.94 273	26	0.05 727	9.87 624	11	46
15	9.81 911	15	9.94 299	25	0.05 701	9.87 613	12	45
16	9.81 926	14	9.94 324	26	0.05 676	9.87 601	11	44
17	9.81 940	15	9.94 350	25	0.05 650	9.87 590	11	43
18	9.81 955	14	9.94 375	26	0.04 625	9.87 579	11	42
19	9.81 969	14	9.94 401	25	0.05 599	9.87 568	11	41
20	9.81 983	15	9.94 426	26	0.05 574	9.87 557	11	40
21	9.81 998	14	9.94 452	25	0.05 548	9.87 546	11	39
22	9.82 012	14	9.94 477	26	0.05 523	9.87 535	11	38
23	9.82 026	15	9.94 503	25	0.05 497	9.87 524	11	37
24	9.82 041	14	9.94 528	26	0.05 472	9.87 513	12	36
25	9.82 055	14	9.94 554	25	0.05 446	9.87 501	11	35
26	9.82 069	15	9.94 579	25	0.05 421	9.87 490	11	34
27	9.82 084	14	9.94 604	26	0.05 396	9.87 479	11	33
28	9.82 098	14	9.94 630	25	0.05 370	9.87 468	11	32
29	9.82 112	14	9.94 655	26	0.05 345	9.87 457	11	31
30	9.82 126	15	9.94 681	25	0.05 319	9.87 446	12	30
31	9.82 141	14	9.94 706	26	0.05 294	9.87 434	11	29
32	9.82 155	14	9.94 732	25	0.05 268	9.87 423	11	28
33	9.82 169	15	9.94 757	26	0.05 243	9.87 412	11	27
34	9.82 184	14	9.94 783	25	0.05 217	9.87 401	11	26
35	9.82 198	14	9.94 808	26	0.05 192	9.87 390	12	25
36	9.82 212	14	9.94 834	25	0.05 166	9.87 378	11	24
37	9.82 226	14	9.94 859	25	0.05 141	9.87 367	11	23
38	9.82 240	15	9.94 884	26	0.05 116	9.87 356	11	22
39	9.82 255	14	9.94 910	25	0.05 090	9.87 345	11	21
40	9.82 269	14	9.94 935	26	0.05 065	9.87 324	12	20
41	9.82 283	14	9.94 961	25	0.05 039	9.87 322	11	19
42	9.82 297	14	9.94 986	26	0.05 014	9.87 311	11	18
43	9.82 311	15	9.95 012	25	0.04 988	9.87 300	12	17
44	9.82 326	14	9.95 037	25	0.04 963	9.87 288	11	16
45	9.82 340	14	9.95 062	26	0.04 938	9.87 277	11	15
46	9.82 354	14	9.95 088	25	0.04 912	9.87 266	11	14
47	9.82 368	14	9.95 113	26	0.04 887	9.87 255	12	13
48	9.82 382	14	9.95 139	25	0.04 861	9.87 243	11	12
49	9.82 396	14	9.95 164	26	0.04 836	9.87 232	11	11
50	9.82 410	14	9.95 190	25	0.04 810	9.87 221	12	10
51	9.82 424	15	9.95 215	25	0.04 785	9.87 209	11	9
52	9.82 439	14	9.95 240	26	0.04 760	9.87 198	11	8
53	9.82 453	14	9.95 266	25	0.04 734	9.87 187	12	7
54	9.82 467	14	9.95 291	26	0.04 709	9.87 175	11	6
55	9.82 481	14	9.95 317	25	0.04 683	9.87 164	11	5
56	9.82 495	14	9.95 342	26	0.04 658	9.87 153	12	4
57	9.82 509	14	9.95 368	25	0.04 632	0.87 141	11	3
58	9.82 523	14	9.95 393	25	0.04 607	9.87 130	11	2
59	9.82 537	14	9.95 418	26	0.04 582	9.87 119	12	1
60	9.82 551		9.95 444		0.04 556	9.87 107		0
	L SIN	D	L TAN	CD	L COT	L COS	D	318°...138°
	L COS		L COT		L TAN	L SIN		228°... 48°

42°...222°		L SIN	D	L TAN	CD	L COT	L COS	D	
132°...312°		L COS		L COT		L TAN	L SIN		
	0	9.82 551	14	9.95 444	25	0.04 556	9.87 107	11	60
	1	9.82 565	14	9.95 469	26	0.04 531	9.87 096	11	59
	2	9.82 579	14	9.95 495	25	0.04 505	9.87 085	12	58
	3	9.82 593	14	9.95 520	25	0.04 480	9.87 073	11	57
	4	9.82 607	14	9.95 545	26	0.04 455	9.87 062	12	56
	5	9.82 621	14	9.95 571	25	0.04 429	9.87 050	11	55
	6	9.82 635	14	9.95 596	26	0.04 404	9.87 039	11	54
	7	9.82 649	14	9.95 622	25	0.04 378	9.87 028	12	53
	8	9.82 663	14	9.95 647	25	0.04 353	9.87 016	11	52
	9	9.82 677	14	9.95 672	26	0.04 328	9.87 005	12	51
	10	9.82 691	14	9.95 698	25	0.04 302	9.86 993	11	50
	11	9.82 705	14	9.95 723	25	0.04 277	9.86 982	12	49
	12	9.82 719	14	9.95 748	26	0.04 252	9.86 970	11	48
	13	9.82 733	14	9.95 774	25	0.04 226	9.86 959	12	47
	14	9.82 747	14	9.95 799	26	0.04 201	9.86 947	11	46
	15	9.82 761	14	9.95 825	25	0.04 175	9.86 936	12	45
	16	9.82 775	13	9.95 850	25	0.04 150	9.86 924	11	44
	17	9.82 788	14	9.95 875	26	0.04 125	9.86 913	11	43
	18	9.82 802	14	9.95 901	25	0.04 099	9.86 902	12	42
	19	9.82 816	14	9.95 926	26	0.04 074	9.86 890	11	41
	20	9.82 830	14	9.95 952	25	0.04 048	9.86 879	12	40
	21	9.82 844	14	9.95 977	25	0.04 023	9.86 867	12	39
	22	9.82 858	14	9.96 002	26	0.03 998	9.86 855	11	38
	23	9.82 872	13	9.96 028	25	0.03 972	9.86 844	12	37
	24	9.82 885	14	9.96 053	25	0.03 947	9.86 832	11	36
	25	9.82 899	14	9.96 078	26	0.03 922	9.86 821	12	35
	26	9.82 913	14	9.96 104	25	0.03 896	9.86 809	11	34
	27	9.82 927	14	9.96 129	26	0.03 871	9.86 798	12	33
	28	9.82 941	14	9.96 155	25	0.03 845	9.86 786	11	32
	29	9.82 955	13	9.96 180	25	0.03 820	9.86 775	12	31
	30	9.82 968	14	9.96 205	26	0.03 795	9.86 763	11	30
	31	9.82 982	14	9.96 231	25	0.03 769	9.86 752	12	29
	32	9.82 996	14	9.96 256	25	0.03 744	9.86 740	12	28
	33	9.83 010	13	9.96 281	26	0.03 719	9.86 728	11	27
	34	9.83 023	14	9.96 307	25	0.03 693	9.86 717	12	26
	35	9.83 037	14	9.96 332	25	0.03 668	9.86 705	11	25
	36	9.83 051	14	9.96 357	26	0.03 643	9.86 694	12	24
	37	9.83 065	13	9.96 383	25	0.03 617	9.86 682	12	23
	38	9.83 078	14	9.96 408	25	0.03 592	9.86 670	11	22
	39	9.83 092	14	9.96 433	26	0.03 567	9.86 659	12	21
	40	9.83 106	14	9.96 459	25	0.03 541	9.86 647	12	20
	41	9.83 120	13	9.96 484	26	0.03 516	9.86 635	11	19
	42	9.83 133	14	9.96 510	25	0.03 490	9.86 624	12	18
	43	9.83 147	14	9.96 535	25	0.03 465	9.86 612	12	17
	44	9.83 161	13	9.96 560	26	0.03 440	9.86 600	11	16
	45	9.83 174	14	9.96 586	25	0.03 414	9.86 589	12	15
	46	9.83 188	14	9.96 611	25	0.03 389	9.86 577	12	14
	47	9.83 202	13	9.96 636	26	0.03 364	9.86 565	11	13
	48	9.83 215	14	9.96 662	25	0.03 338	9.86 554	12	12
	49	9.83 229	13	9.96 687	25	0.03 313	9.86 542	12	11
	50	9.83 242	14	9.96 712	26	0.03 288	9.86 530	12	10
	51	9.83 256	14	9.96 738	25	0.03 262	9.86 518	11	9
	52	9.83 270	13	9.96 763	25	0.03 237	9.86 507	12	8
	53	9.83 283	14	9.96 788	26	0.03 212	9.86 495	12	7
	54	9.83 297	13	9.96 814	25	0.03 186	9.86 483	11	6
	55	9.83 310	14	9.96 839	25	0.03 161	9.86 472	12	5
	56	9.83 324	14	9.96 864	26	0.03 136	9.86 460	12	4
	57	9.83 338	13	9.96 890	25	0.03 110	9.86 448	12	3
	58	9.83 351	14	9.96 915	25	0.03 085	9.86 436	11	2
	59	9.83 365	13	9.96 940	26	0.03 060	9.86 425	12	1
	60	9.83 378		9.96 966		0.03 034	9.86.413		0
		L SIN	D	L TAN	CD	L COT	L COS	D	317°...137°
		L COS		L COT		L TAN	L SIN		227°... 47°

43°...223° / 133°...313°	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	
0	9.83 378	14	9.96 966	25	0.03 034	9.86 413	12	60
1	9.83 392	13	9.96 991	25	0.03 009	9.86 401	12	59
2	9.83 405	14	9.97 016	26	0.02 984	9.86 389	12	58
3	9.83 419	13	9.97 042	25	0.02 958	9.86 377	11	57
4	9.83 432	14	9.97 067	25	0.02 933	9.86 366	12	56
5	9.83 446	13	9.97 092	26	0.02 908	9.86 354	12	55
6	9.83 459	14	9.97 118	25	0.02 882	9.86 342	12	54
7	9.83 473	13	9.97 143	25	0.02 857	9.86 330	12	53
8	9.83 486	14	9.97 168	25	0.02 832	9.86 318	12	52
9	9.93 500	13	9.97 193	26	0.02 807	9.86 306	11	51
10	9.83 513	14	9.97 219	25	0.02 781	9.86 295	12	50
11	9.83 527	13	9.97 244	25	0.02 756	9.86 283	12	49
12	9.83 540	14	9.97 269	26	0.02 731	9.86 271	12	48
13	9.83 554	13	9.97 295	25	0.02 705	9.86 259	12	47
14	9.83 567	14	9.95 320	25	0.02 680	9.86 247	12	46
15	9.83 581	13	9.97 345	26	0.02 655	9.86 235	12	45
16	9.83 594	14	9.97 371	25	0.02 620	9.86 223	12	44
17	9.83 608	13	9.97 396	25	0.02 601	9.86 211	11	43
18	9.83 621	13	9.97 421	26	0.02 579	9.86 200	12	42
19	9.83 634	14	9.97 447	25	0.02 553	9.86 188	12	41
20	9.83 648	13	9.97 472	25	0.02 528	9.86 176	12	40
21	9.83 661	13	9.97 497	26	0.02 503	9.86 164	12	39
22	9.83 674	14	9.97 523	25	0.02 477	9.86 152	12	38
23	9.83 688	13	9.97 548	25	0.02 452	9.86 140	12	37
24	9.83 701	14	9.97 573	25	0.02 427	9.86 128	12	36
25	9.83 715	13	9.97 598	26	0.02 402	9.86 116	12	35
26	9.83 728	13	9.97 624	25	0.02 376	9.86 104	12	34
27	9.83 741	14	9.97 649	25	0.02 351	9.86 092	12	33
28	9.83 755	13	9.97 674	26	0.02 326	9.86 080	12	32
29	9.83 768	13	9.97 700	25	0.02 300	9.86 068	12	31
30	9.83 781	14	9.97 725	25	0.02 275	9.86 056	12	30
31	9.83 795	13	9.97 750	26	0.02 250	9.86 044	12	29
32	9.83 808	13	9.97 776	25	0.02 224	9.86 032	12	28
33	9.83 821	13	9.97 801	25	0.02 190	9.86 020	12	27
34	9.83 834	14	9.97 826	25	0.02 174	9.86 008	12	26
35	9.83 848	13	9.97 861	26	0.02 149	9.85 996	12	25
36	9.83 861	13	9.97 877	25	0.02 123	9.85 984	12	24
37	9.83 874	13	9.97 902	25	0.02 098	9.85 972	12	23
38	9.83 887	14	9.97 927	26	0.02 073	9.85 960	12	22
39	9.83 901	13	9.97 953	25	0.02 047	9.85 948	12	21
40	9.83 914	13	9.97 978	25	0.02 022	9.85 936	12	20
41	9.83 927	13	9.98 003	26	0.01 997	9.85 924	12	19
42	9.83 940	14	9.98 029	25	0.01 971	9.85 912	12	18
43	9.83 954	13	9.98 054	25	0.01 946	9.85 900	12	17
44	9.83 967	13	9.98 079	25	0.01 921	9.85 888	12	16
45	9.83 980	13	9.98 104	26	0.01 896	9.85 876	12	15
46	9.83 993	13	9.98 130	25	0.01 870	9.85 864	13	14
47	9.84 006	14	9.98 155	25	0.01 845	9.85 851	12	13
48	9.84 020	13	9.98 180	26	0.01 820	9.85 839	12	12
49	9.84 033	13	9.98 206	25	0.01 794	9.85 827	12	11
50	9.84 046	13	9.96 231	25	0.01 769	9.85 815	12	10
51	9.84 059	13	9.98 256	25	0.01 744	9.85 803	12	9
52	9.84 072	13	9.98 281	26	0.01 719	9.85 791	12	8
53	9.83 085	13	9.98 307	25	0.01 693	9.85 779	13	7
54	9.84 098	14	9.98 332	25	0.01 668	9.85 766	12	6
55	9.84 112	13	9.98 357	26	0.01 643	9.85 754	12	5
56	9.84 125	13	9.98 383	25	0.01 617	9.85 742	12	4
57	9.84 138	13	9.98 408	25	0.01 592	9.85 730	12	3
58	9.84 151	13	9.98 433	25	0.01 567	9.85 718	12	2
59	9.84 164	13	9.98 458	26	0.01 542	9.85 706	13	1
60	9.84 177		9.98 484		0.01 516	9.85 693		0
	L SIN / L COS	D	L TAN / L COT	CD	L COT / L TAN	L COS / L SIN	D	316°...136° / 226°... 46°

44°...224°		L SIN	D	L TAN	CD	L COT	L COS	D		
134°...314°		L COS		L COT		L TAN	L SIN			
	0	9.84 177	13	9.98 484	25	0.01 516	9.85 693	12	60	
	1	9.84 190	13	9.98 509	25	0.01 491	9.85 681	12	59	
	2	9.84 203	13	9.98 534	26	0.01 466	9.85 669	12	58	
	3	9.84 216	13	9.98 560	25	0.01 440	9.85 657	12	57	
	4	9.84 229	13	9.98 585	25	0.01 415	9.85 645	13	56	
	5	9.84 242	13	9.98 610	25	0.01 390	9.85 632	12	55	
	6	9.84 255	14	9.98 635	26	0.01 365	9.85 620	12	54	
	7	9.84 269	13	9.98 661	25	0.01 339	9.85 608	12	53	
	8	9.84 282	13	9.98 686	25	0.01 314	9.85 598	13	52	
	9	9.84 295	13	9.98 711	26	0.01 289	9.85 583	12	51	
	10	9.84 308	13	9.98 737	25	0.01 263	9.85 571	12	50	
	11	9.84 321	13	9.98 762	25	0.01 238	9.85 559	12	49	
	12	9.84 334	13	9.98 787	25	0.01 213	9.85 547	13	48	
	13	9.84 347	13	9.98 812	26	0.01 188	9.85 534	12	47	
	14	9.84 360	13	9.98 838	25	0.01 162	9.85 522	12	46	
	15	9.84 373	12	9.98 863	25	0.01 137	9.85 510	13	45	
	16	9.84 385	13	9.98 888	25	0.01 112	9.85 497	12	44	
	17	9.84 398	13	9.98 913	26	0.01 087	9.85 485	12	43	
	18	9.84 411	13	9.98 939	25	0.01 061	9.85 473	13	42	
	19	9.84 424	13	9.98 964	25	0.01 036	9.85 460	12	41	
	20	9.84 437	13	9.98 989	26	0.01 011	9.85 448	12	40	
	21	9.84 450	13	9.99 015	25	0.00 985	9.85 436	13	39	
	22	9.84 463	13	9.99 040	25	0.00.960	9.85 423	12	38	
	23	9.84 476	13	9.99 065	25	0.00 935	9.85 411	12	37	
	24	9.84 489	13	9.99 090	26	0.00 910	9.85 399	13	36	
	25	9.84 502	13	9.99 116	25	0.00 884	9.85 386	12	35	
	26	9.84 515	13	9.99 141	25	0.00 859	9.85 374	13	34	
	27	9.84 528	12	9.99 166	25	0.00 834	9.85 361	12	33	
	28	9.84 540	13	9.99 191	26	0.00 809	9.85 349	12	32	
	29	9.84 553	13	9.99 217	25	0.00 783	9.85 337	13	31	
	30	9.84 566	13	9.99 242	25	0.00 758	9.85 324	12	30	
	31	9.84 579	13	9.99 267	26	0.00 733	9.85 312	13	29	
	32	9.84 592	13	9.99 293	25	0.00 707	9.85 299	12	28	
	33	9.84 605	13	9.99 318	25	0.00 682	9.85 287	13	27	
	34	9.84 618	12	9.99 343	25	0.00 657	9.85 274	12	26	
	35	9.84 630	13	9.99 368	26	0.00 632	9.85 262	12	25	
	36	9.84 643	13	9.99 394	25	0.00 606	9.85 250	13	24	
	37	9.84 656	13	9.99 419	25	0.00 581	9.85 237	12	23	
	38	9.84 669	13	9.99 444	25	0.00 556	9.85 225	13	22	
	39	9.84 682	12	9.99 469	26	0.00 531	9.85 212	12	21	
	40	9.84 694	13	9.99 495	25	0.00 505	9.85 200	13	20	
	41	9.84 707	13	9.99 520	25	0.00 480	9.85 187	12	19	
	42	9.84 720	13	9.99 545	25	0.00 455	9.85 175	13	18	
	43	9.84 733	12	9.99 570	26	0.00 430	9.85 162	12	17	
	44	9.84 745	13	9.99 596	25	0.00 404	9.85 150	13	16	
	45	9.84 758	13	9.99 621	25	0.00 379	9.85 137	12	15	
	46	9.84 771	13	9.99 646	26	0.00 354	9.85 125	13	14	
	47	9.84 784	12	9.99 672	25	0.00 328	9.85 112	12	13	
	48	9.84 796	13	9.99 697	25	0.00 303	9.85 100	13	12	
	49	9.84 809	13	9.99 722	25	0.00 278	9.85 087	13	11	
	50	9.84 822	13	9.99 747	26	0.00 253	9.85 074	12	10	
	51	9.84 835	12	9.99 773	25	0.00 227	9.85 062	13	9	
	52	9.84 847	13	9.99 798	25	0.00 202	9.85 049	12	8	
	53	9.84 860	13	9.99 823	25	0.00 177	9.85 037	13	7	
	54	9.84 873	12	9.99 848	26	0.00 152	9.85 024	12	6	
	55	9.84 885	13	9.99 874	25	0.00 126	9.85 012	13	5	
	56	9.84 898	13	9.99 899	25	0.00 101	9.84 999	13	4	
	57	9.84 911	12	9.99 924	25	0.00 076	9.84 986	12	3	
	58	9.84 923	13	9.99 949	26	0.00 051	9.84 974	13	2	
	59	9.84 936	13	9.99 975	25	0.00 025	9.84 961	12	1	
	60	9.84 949		0.00 000		0.00 000	9.84 949		0	
		L SIN	D	L TAN	CD	L COT	L COS	D		315°...135°
		L COS		L COT		L TAN	L SIN			225°... 45°

APPENDIX B

DEAD-RECKONING ALTITUDE AND AZIMUTH TABLE

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	0°00'	0°30'	1°00'	1°30'	2°00'	
	A B	A B	A B	A B	A B	
0	———.....0.0	205916.....1.7	175814.....6.6	158208....14.9	145718....26.5	30
	383730.....0.0	205198.....1.7	175454.....6.7	157967....15.1	145538....26.7	
1	353627.....0.0	204492.....1.8	175097.....6.8	157728....15.2	145358....26.9	29
	336018.....0.0	203797.....1.8	174742.....7.0	157490....15.4	145179....27.1	
2	323524.....0.0	203113.....1.9	174391.....7.1	157254....15.6	145000....27.3	28
	313833.....0.0	202440.....1.9	174042.....7.2	157019....15.7	144823....27.6	
3	305915.....0.0	201777.....2.0	173696.....7.3	156784....15.9	144646....27.8	27
	299221.....0.0	201124.....2.1	173352.....7.4	156552....16.1	144470....28.0	
4	293421.....0.0	200480.....2.1	173012.....7.5	156320....16.2	144295....28.3	26
	288306.....0.0	199846.....2.2	172674.....7.6	156090....16.4	144120....28.5	
5	283730.....0.0	199221.....2.3	172339.....7.8	155861....16.6	143946....28.7	25
	279591.....0.1	198605.....2.3	172006.....7.9	155633....16.8	143773....28.9	
6	275812.....0.1	197998.....2.4	171676.....8.0	155406....16.9	143600....29.2	24
	272336.....0.1	197399.....2.4	171348.....8.1	155180....17.1	143428....29.4	
7	269118.....0.1	196808.....2.5	171023.....8.2	154956....17.3	143257....29.6	23
	266121.....0.1	196225.....2.6	170700.....8.4	154733....17.5	143086....29.9	
8	263318.....0.1	195650.....2.7	170379.....8.5	154511....17.6	142916....30.1	22
	260685.....0.1	195082.....2.7	170061.....8.6	154290....17.8	142747....30.4	
9	258203.....0.1	194522.....2.8	169745.....8.7	154070....18.0	142579....30.6	21
	255855.....0.2	193969.....2.9	169432.....8.9	153851....18.2	142411....30.8	
10	253627.....0.2	193422.....2.9	169121.....9.0	153633....18.4	142243....31.1	20
	251508.....0.2	192883.....3.0	168811.....9.1	153417....18.6	142077....31.3	
11	249488.....0.2	192350.....3.1	168505.....9.3	153201....18.7	141911....31.5	19
	247558.....0.2	191824.....3.2	168200.....9.4	152987....18.9	141745....31.8	
12	245709.....0.3	191303.....3.2	167897.....9.5	152774....19.1	141581....32.0	18
	243936.....0.3	190790.....3.3	167597.....9.7	152561....19.3	141417....32.3	
13	242233.....0.3	190282.....3.4	167298.....9.8	152350....19.5	141253....32.5	17
	240594.....0.3	189780.....3.5	167002.....9.9	152140....19.7	141090....32.8	
14	239015.....0.4	189283.....3.6	166708....10.1	151931....19.9	140928....33.0	16
	237491.....0.4	188793.....3.6	166415....10.2	151722....20.1	140766....33.3	
15	236018.....0.4	188307.....3.7	166125....10.3	151515....20.3	140605....33.5	15
	234594.....0.4	187827.....3.8	165836....10.5	151309....20.5	140445....33.7	
16	233215.....0.5	187353.....3.9	165550....10.6	151104....20.6	140285....34.0	14
	231879.....0.5	186883.....4.0	165265....10.8	150899....20.8	140125....34.2	
17	230583.....0.5	186419.....4.1	164982....10.9	150696....21.0	139967....34.5	13
	229324.....0.6	185959.....4.1	164701....11.0	150494....21.2	139809....34.7	
18	228100.....0.6	185505.....4.2	164422....11.2	150292....21.4	139651....35.0	12
	226910.....0.6	185055.....4.3	164144....11.3	150092....21.6	139494....35.3	
19	225752.....0.7	184609.....4.4	163868....11.5	149892....21.8	139338....35.5	11
	224624.....0.7	184168.....4.5	163594....11.6	149693....22.0	139182....35.8	
20	223525.....0.7	183732.....4.6	163322....11.8	149495....22.2	139027....36.0	10
	222452.....0.8	183300.....4.7	163052....11.9	149299....22.4	138872....36.3	
21	221406.....0.8	182872.....4.8	162783....12.1	149103....22.6	138718....36.5	9
	220384.....0.9	182448.....4.9	162516....12.2	148907....22.9	138564....36.8	
22	219385.....0.9	182029.....5.0	162250....12.4	148713....23.1	138411....37.1	8
	218409.....0.9	181613.....5.1	161986....12.5	148520....23.3	138258....37.3	
23	217455.....1.0	181201.....5.2	161724....12.7	148327....23.5	138106....37.6	7
	216521.....1.0	180794.....5.3	161463....12.8	148135....23.7	137955....37.9	
24	215607.....1.1	180390.....5.4	161204....13.0	147945....23.9	137804....38.1	6
	214711.....1.1	179990.....5.5	160946....13.1	147755....24.1	137653....38.4	
25	213834.....1.1	179593.....5.6	160690....13.3	147566....24.3	137504....38.6	5
	212974.....1.2	179200.....5.7	160435....13.4	147377....24.5	137354....38.9	
26	212130.....1.2	178810.....5.8	160182....13.6	147190....24.7	137205....39.2	4
	211303.....1.3	178424.....5.9	159930....13.8	147003....24.9	137057....39.4	
27	210491.....1.3	178042.....6.0	159680....13.9	146817....25.2	136909....39.7	3
	209695.....1.4	177663.....6.1	159431....14.1	146632....25.4	136761....40.0	
28	208912.....1.4	177287.....6.2	159184....14.2	146448....25.6	136615....40.3	2
	208143.....1.5	176914.....6.3	158938....14.4	146264....25.8	136468....40.5	
29	207388.....1.5	176544.....6.4	158693....14.6	146081....26.0	136322....40.8	1
	206646.....1.6	176178.....6.5	158450....14.7	145899....26.2	136177....41.1	
30	205916.....1.7	175814.....6.6	158208....14.9	145718....26.5	136032....41.4	0
	A B	A B	A B	A B	A B	
	179°30'	179°00'	178°30'	178°00'	177°30'	

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	2°30'	3°00'	3°30'	4°00'	4°30'	
	A B	A B	A B	A B	A B	
0	136032....41.4	128120....59.6	121432....81.1	115641...105.9	110536...134.1	30
	135888....41.6	128000....59.9	121329....81.5	115551...106.4	110455...134.6	
1	135744....41.9	127880....60.2	121226....81.9	115461...106.8	110375...135.1	29
	135600....42.2	127760....60.6	121124....82.2	115371...107.3	110296...135.6	
2	135457....42.5	127640....60.9	121021....82.6	115282...107.7	110216...136.1	28
	135315....42.7	127521....61.2	120919....83.0	115192...108.1	110136...136.6	
3	135173....43.0	127403....61.6	120817....83.4	115103...108.6	110057...137.1	27
	135031....43.3	127284....61.9	120715....83.8	115014...109.0	109977...137.6	
4	134890....43.6	127166....62.2	120614....84.2	114925...109.5	109898...138.1	26
	134749....43.9	127049....62.6	120513....84.6	114836...109.9	109819...138.6	
5	134609....44.2	126931....62.9	120412....85.0	114747...110.4	109740...139.1	25
	134469....44.4	126814....63.3	120311....85.4	114659...110.8	109662...139.6	
6	134330....44.7	126697....63.6	120211....85.8	114571...111.3	109583...140.1	24
	134191....45.0	126581....63.9	120110....86.2	114483...111.7	109505...140.6	
7	134052....45.3	126465....64.3	120010....86.6	114395...112.2	109426...141.1	23
	133914....45.6	126349....64.6	119910....87.0	114307...112.7	109348...141.7	
8	133777....45.9	126233....65.0	119811....87.4	114220...113.1	109270...142.2	22
	133640....46.2	126118....65.3	119711....87.8	114133...113.6	109192...142.7	
9	133503....46.5	126003....65.7	119612....88.2	114045...114.0	109115...143.2	21
	133367....46.8	125888....66.0	119513....88.6	113958...114.5	109037...143.7	
10	133231....47.1	125774....66.4	119415....89.0	113872...114.9	108960...144.2	20
	133096....47.4	125660....66.7	119316....89.4	113785...115.4	108882...144.7	
11	132961....47.6	125546....67.1	119218....89.8	113699...115.9	108805...145.2	19
	132826....47.9	125433....67.4	119120....90.2	113612...116.3	108728...145.8	
12	132692....48.2	125320....67.8	119022....90.6	113526...116.8	108651...146.3	18
	132558....48.5	125207....68.1	118925....91.0	113440...117.3	108574...146.8	
13	132425....48.8	125094....68.5	118827....91.4	113354...117.7	108498...147.3	17
	132292....49.1	124982....68.8	118730....91.8	113269...118.2	108421...147.8	
14	132159....49.4	124870....69.2	118633....92.3	113183...118.7	108345...148.4	16
	132027....49.7	124759....69.6	118537....92.7	113098...119.1	108269...148.9	
15	131896....50.0	124647....69.9	118440....93.1	113013...119.6	108193...149.4	15
	131764....50.3	124536....70.3	118344....93.5	112928...120.1	108117...149.9	
16	131633....50.7	124425....70.6	118248....93.9	112843...120.5	108041...150.5	14
	131503....51.0	124315....71.0	118152....94.3	112759...121.0	107965...151.0	
17	131373....51.3	124204....71.3	118056....94.7	112674...121.5	107890...151.5	13
	131243....51.6	124095....71.7	117961....95.2	112590...121.9	107814...152.1	
18	131114....51.9	123985....72.1	117866....95.6	112506...122.4	107739...152.6	12
	130985....52.2	123875....72.4	117771....96.0	112422...122.9	107664...153.1	
19	130856....52.5	123766....72.8	117676....96.4	112338...123.4	107589...153.6	11
	130728....52.8	123657....73.2	117581....96.9	112255...123.9	107514...154.2	
20	130600....53.1	123549....73.5	117487....97.3	112171...124.3	107439...154.7	10
	130473....53.4	123441....73.9	117393....97.7	112088...124.8	107364...155.2	
21	130346....53.7	123332....74.3	117299....98.1	112005...125.3	107290...155.8	9
	130219....54.1	123225....74.6	117205....98.5	111922...125.8	107216...156.3	
22	130093....54.4	123117....75.0	117112....99.0	111839...126.2	107141...156.9	8
	129967....54.7	123010....75.4	117018....99.4	111757...126.7	107067...157.4	
23	129841....55.0	122903....75.8	116925....99.8	111674...127.2	106993...157.9	7
	129716....55.3	122796....76.1	116832...100.3	111592...127.7	106919...158.5	
24	129591....55.7	122690....76.5	116739...100.7	111510...128.2	106846...159.0	6
	129466....56.0	122584....76.9	116647...101.1	111428...128.7	106772...159.6	
25	129342....56.3	122478....77.3	116554...101.6	111346...129.2	106698...160.1	5
	129218....56.6	122372....77.6	116462...102.0	111264...129.7	106625...160.6	
26	129095....56.9	122267....78.0	116370...102.4	111183...130.1	106552...161.2	4
	128972....57.3	122161....78.4	116278...102.9	111101...130.6	106479...161.7	
27	128849....57.6	122057....78.8	116187...103.3	111020...131.1	106406...162.3	3
	128727....57.9	121952....79.2	116096...103.7	110939...131.6	106333...162.8	
28	128605....58.2	121848....79.5	116004...104.2	110858...132.1	106260...163.4	2
	128483....58.6	121743....79.9	115913...104.6	110777...132.6	106187...163.9	
29	128362....58.9	121639....80.3	115823...105.0	110696...133.1	106115...164.5	1
	128240....59.2	121536....80.7	115732...105.5	110616...133.6	106043...165.0	
30	128120....59.6	121432....81.1	115641...105.9	110536...134.1	105970...165.6	0
	A B	A B	A B	A B	A B	
	177°00'	176°30'	176°00'	175°30'	175°00'	

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	5°00'	5°30'	6°00'	6°30'	7°00'	
	A B	A B	A B	A B	A B	
0	105970...165.6	101843...200.4	98076.....239	94614.....280	91411.....325	30
	105898...166.1	101777...201.0	98017.....239	94559.....281	91359.....326	
1	105826...166.7	101712...201.6	97957.....240	94503.....281	91308.....326	29
	105754...167.2	101646...202.2	97897.....241	94448.....282	91257.....327	
2	105683...167.8	101581...202.8	97837.....241	94393.....283	91205.....328	28
	105611...168.4	101516...203.5	97777.....242	94338.....284	91154.....329	
3	105539...168.9	101451...204.1	97717.....243	94283.....284	91103.....330	27
	105468...169.4	101386...204.7	97658.....243	94228.....285	91052.....330	
4	105397...170.0	101321...205.3	97598.....244	94173.....286	91001.....331	26
	105325...170.6	101256...205.9	97539.....245	94118.....287	90950.....332	
5	105254...171.1	101192...206.5	97480.....245	94063.....287	90899.....333	25
	105183...171.7	101127...207.1	97420.....246	94009.....288	90848.....333	
6	105113...172.3	101063...207.8	97361.....247	93954.....289	90798.....334	24
	105042...172.8	100998...208.4	97302.....247	93899.....289	90747.....335	
7	104971...173.4	100934...209.0	97243.....248	93845.....290	90696.....336	23
	104901...174.0	100870...209.6	97184.....249	93790.....291	90646.....337	
8	104830...174.5	100806...210.3	97126.....249	93736.....292	90595.....337	22
	104760...175.1	100742...210.9	97067.....250	93682.....292	90545.....338	
9	104690...175.7	100678...211.5	97008.....251	93628.....293	90494.....339	21
	104620...176.2	100614...212.1	96950.....251	93573.....294	90444.....340	
10	104550...176.8	100550...212.8	96891.....252	93519.....295	90394.....341	20
	104480...177.4	100487...213.4	96833.....253	93465.....295	90344.....341	
11	104411...178.0	100423...214.0	96774.....253	93411.....296	90293.....342	19
	104341...178.5	100360...214.6	96716.....254	93358.....297	90243.....343	
12	104272...179.1	100296...215.3	96658.....255	93304.....298	90193.....344	18
	104202...179.7	100233...215.9	96600.....255	93250.....298	90143.....345	
13	104133...180.3	100170...216.5	96542.....256	93196.....299	90093.....345	17
	104064...180.8	100107...217.2	96484.....257	93143.....300	90044.....346	
14	103995...181.4	100044...217.8	96426.....257	93089.....301	89994.....347	16
	103926...182.0	99981....218.4	96368.....258	93036.....301	89944.....348	
15	103857...182.6	99918....219.1	96310.....259	92982.....302	89894.....349	15
	103788...183.2	99856....219.7	96253.....260	92929.....303	89845.....349	
16	103720...183.7	99793....220.3	96195.....260	92876.....304	89795.....350	14
	103651...184.3	99731....221.0	96138.....261	92823.....304	89746.....351	
17	103583...184.9	99668....221.6	96080.....262	92769.....305	89696.....352	13
	103515...185.5	99606....222.3	96023.....262	92716.....306	89647.....353	
18	103447...186.1	99544....222.9	95966.....263	92663.....307	89597.....353	12
	103379...186.7	99481....223.5	95909.....264	92610.....307	89548.....354	
19	103311...187.2	99420....224.2	95851.....264	92558.....308	89499.....355	11
	103243...187.8	99357....224.8	95795.....265	92505.....309	89450.....356	
20	103175...188.4	99296....225.5	95737.....266	93452.....310	89401.....357	10
	103107...189.0	99234....226.1	95681.....267	92399.....310	89352.....357	
21	103040...189.6	99172....226.8	95624.....267	92347.....311	89303.....358	9
	102973...190.2	99110....227.4	95567.....268	92294.....312	89254.....359	
22	102905...190.8	99049....228.1	95510.....269	92242.....313	89205.....360	8
	102838...191.4	98988....228.7	95454.....269	92189.....313	89156.....361	
23	102771...192.0	98926....229.4	95397.....270	92137.....314	89107.....362	7
	102704...192.6	98865....230.0	95341.....271	92085.....315	89059.....362	
24	102637...193.2	98804....230.7	95285.....271	92032.....316	89010.....363	6
	102570...193.8	98743....231.3	95228.....272	91980.....316	88961.....364	
25	102504...194.4	98682....232.0	95172.....273	91928.....317	88913.....365	5
	102437...195.0	98621....232.6	95116.....274	91876.....318	88864.....366	
26	102371...195.6	98560....233.3	95060.....274	91824.....319	88816.....366	4
	102304...196.2	98499....233.9	95004.....275	91772.....319	88767.....367	
27	102238...196.8	98439....234.6	94948.....276	91720.....320	88719.....368	3
	102172...197.4	98378....235.3	94892.....276	91668.....321	88671.....369	
28	102106...198.0	98318....235.9	94836.....277	91617.....322	88623.....370	2
	102040...198.6	98257....236.6	94781.....278	91565.....323	88574.....371	
29	101974...199.2	98197....237.2	94725.....279	91514.....323	88526.....371	1
	101908...199.8	98137....237.9	94670.....279	91462.....324	88478.....372	
30	101843...200.4	98076....238.6	94614.....280	91411.....325	88430.....373	0
	A B	A B	A B	A B	A B	
	174°30'	174°00'	173°30'	173°00'	172°30'	

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	7°30'	8°00'	8°30'	9°00'	9°30'	
	A B	A B	A B	A B	A B	
0	88430......373	85644......425	83030......480	80567.....538	78239.....600	30
	88382......374	85599......426	82987......481	80527.....539	78201.....601	
1	88334......375	85555......426	82945......482	80487.....540	78164.....602	29
	88286......376	85510......427	82903......482	80447.....541	78126.....603	
2	88239......376	85465......428	82861......483	80407.....542	78088.....604	28
	88191......377	85420......429	82819......484	80368.....543	78051.....605	
3	88143......378	85376......430	82777......485	80328.....544	78013.....606	27
	88096......379	85331......431	82735......486	80288.....545	77976.....607	
4	88048......380	85286......432	82693......487	80249.....546	77938.....608	26
	88001......381	85242......433	82651......488	80209.....547	77901.....609	
5	87953......381	85197......434	82609......489	80170.....548	77863.....610	25
	87906......382	85153......434	82567......490	80130.....549	77826.....611	
6	87858......383	85108......435	82526......491	80091.....550	77788.....612	24
	87811......384	85064......436	82484......492	80051.....551	77751.....614	
7	87764......385	85020......437	82442......493	80012.....552	77714.....615	23
	87716......386	84976......438	82400......494	79973.....553	77677.....616	
8	87669......387	84931......439	82359......495	79933.....554	77639.....617	22
	87622......387	84887......440	82317......496	79894.....555	77602.....618	
9	87575......388	84843......441	82276......497	79855.....556	77565.....619	21
	87528......389	84799......442	82234......498	79816.....557	77528.....620	
10	87481......390	84755......443	82193......499	79777.....558	77491.....621	20
	87434......391	84711......444	82151......500	79737.....559	77454.....622	
11	87387......392	84667......444	82110......501	79698.....560	77417.....623	19
	87341......392	84623......445	82069......502	79659.....561	77380.....624	
12	87294......393	84579......446	82027......503	79620.....562	77343.....625	18
	87247......394	84535......447	81986......504	79581.....563	77306.....626	
13	87201......395	84492......448	81945......504	79542.....564	77269.....627	17
	87154......396	84448......449	81904......505	79503.....565	77232.....629	
14	87107......397	84404......450	81863......506	79465.....566	77195.....630	16
	87061......398	84361......451	81821......507	79426.....567	77158.....631	
15	87015......399	84317......452	81780......508	79387.....568	77122.....632	15
	86968......399	84273......453	81739......509	79348.....569	77085.....633	
16	86922......400	84230......454	81698......510	79309.....570	77048.....634	14
	86876......401	84186......454	81657......511	79271.....571	77011.....635	
17	86829......402	84143......455	81617......512	79232.....573	76975.....636	13
	86783......403	84100......456	81576......513	79193.....574	76938.....637	
18	86737......404	84056......457	81535......514	79155.....575	76902.....638	12
	86691......405	84013......458	81494......515	79116.....576	76865.....639	
19	86645......405	83970......459	81453......516	79078.....577	76828.....641	11
	86599......406	83927......460	81413......517	79039.....578	76792.....642	
20	86553......407	83884......461	81372......518	79001.....579	76756.....643	10
	86507......408	83840......462	81331......519	78962.....580	76719.....644	
21	86461......409	83797......463	81291......520	78924.....581	76683.....645	9
	86415......410	83754......464	81250......521	78886.....582	76646.....646	
22	86370......411	83711......465	81210......522	78847.....583	76610.....647	8
	86324......411	83668......466	81169......523	78809.....584	76574.....648	
23	86278......412	83626......467	81129......524	78771.....585	76537.....649	7
	86233......413	83583......467	81088......525	78733.....586	76501.....650	
24	86187......414	83540......468	81048......526	78694.....587	76465.....652	6
	86142......415	83497......469	81008......527	78656.....588	76429.....653	
25	86096......416	83455......470	80967......528	78618.....589	76393.....654	5
	86051......417	83412......471	80927......529	78580.....590	76357.....655	
26	86006......418	83369......472	80887......530	78542.....591	76320.....656	4
	85960......418	83327......473	80847......531	78504.....592	76284.....657	
27	85915......419	83284......474	80807......532	78466.....593	76248.....658	3
	85870......420	83242......475	80767......533	78428.....594	76212.....659	
28	85825......421	83199......476	80727......534	78390.....595	76176.....660	2
	85779......422	83157......477	80687......535	78352.....597	76141.....661	
29	85734......423	83114......478	80647......536	78315.....598	76105.....663	1
	85689......424	83072......479	80607......537	78277.....599	76069.....664	
30	85644......425	83030......480	80567......538	78239.....600	76033.....665	0
	A B	A B	A B	A B	A B	
	172°00'	171°30'	171°00'	170°30'	170°00'	

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	10°00'	10°30'	11°00'	11°30'	12°00'	
	A B	A B	A B	A B	A B	
0	76033......665	73937......733	71940......805	70034.....881	68212.....960	30
	75997......666	73903......735	71908......807	70003.....882	68182.....961	
1	75961......667	73869......736	71875......808	69972.....883	68153.....962	29
	75926......668	73835......737	71843......809	66941.....885	68123.....964	
2	75890......669	73801......738	71810......810	69910.....886	68093.....965	28
	75854......670	73767......739	71778......811	69879.....887	68064.....966	
3	75819......672	73733......740	71746......813	69849.....888	68034.....968	27
	75783......673	73699......742	71713......814	69818.....890	68005.....969	
4	75747......674	73665......743	71681......815	69787.....891	67975.....970	26
	75712......675	73631......744	71649......816	69756.....892	67945.....972	
5	75676......676	73597......745	71616......818	69725.....894	67916.....973	25
	75641......677	73563......746	71584......819	69694.....895	67886.....974	
6	75605......678	73530......747	71552......820	69664.....896	67857.....976	24
	75570......679	73496......749	71520......821	69633.....897	67828.....977	
7	75534......680	73462......750	71488......823	69602.....899	67796.....978	23
	75499......682	73429......751	71455......824	69571.....900	67769.....980	
8	75464......683	73395......752	71423......825	69541.....901	67739.....981	22
	75428......684	73361......753	71391......826	69510.....903	67710.....982	
9	75393......685	73328......755	71359......828	69479.....904	67681.....984	21
	75358......686	73294......756	71327......829	69449.....905	67651.....985	
10	75322......687	73260......757	71295......830	69418.....907	67622.....987	20
	75287......688	73227......758	71263......831	69387.....908	67593.....988	
11	75252......690	73193......759	71231......833	69357.....909	67563.....989	19
	75217......691	73160......761	71199......834	69326.....910	67534.....991	
12	75182......692	73127......762	71167......835	69296.....912	67505.....992	18
	75147......693	73093......763	71135......836	69265.....913	67476.....993	
13	75112......694	73060......764	71104......838	69235.....914	67447.....995	17
	75077......695	73026......765	71072......839	69204.....916	67417.....996	
14	75042......696	72993......766	71040......840	69174.....917	67388.....997	16
	75007......698	72960......768	71008......841	69144.....918	67359.....999	
15	74972......699	72926......769	70976......843	69113.....920	67330....1000	15
	74937......700	72893......770	70945......844	69083.....921	67301....1002	
16	74902......701	72860......771	70913......845	69053.....922	67272....1003	14
	74867......702	72827......772	70881......846	69022.....924	67243....1004	
17	74832......703	72794......774	70850......848	68992.....925	67214....1006	13
	74797......704	72760......775	70818......849	68962.....926	67185....1007	
18	74763......706	72727......776	70786......850	68931.....928	67156....1008	12
	74728......707	72694......777	70755......851	68901.....929	67127....1010	
19	74693......708	72661......779	70723......853	68871.....930	67098....1011	11
	74659......709	72628......780	70692......854	68841.....932	67069....1013	
20	74624......710	72595......781	70660......855	68811.....933	67040....1014	10
	74589......711	72562......782	70629......856	68781.....934	67011....1015	
21	74555......712	72529......783	70597......858	68750.....935	66982....1017	9
	74520......714	72496......785	70566......859	68720.....937	66953....1018	
22	74486......715	72463......786	70534......860	68690.....938	66925....1020	8
	74451......716	72430......787	70503......862	68660.....939	66896....1021	
23	74417......717	72397......788	70471......863	68630.....941	66867....1022	7
	74382......718	72365......790	70440......864	68600.....942	66838....1024	
24	74348......719	72332......791	70409......865	68570.....943	66810....1025	6
	74313......721	72299......792	70377......867	68540.....945	66781....1026	
25	74279......722	72266......793	70346......868	68510.....946	66752....1028	5
	74245......723	72234......794	70315......869	68480.....947	66724....1029	
26	74210......724	72201......796	70284......870	68450.....949	66695....1031	4
	74176......725	72168......797	70252......872	68421.....950	66666....1032	
27	74142......726	72135......798	70221......873	68391.....951	66638....1033	3
	74107......728	72103......799	70190......874	68361.....953	66609....1035	
28	74073......729	72070......800	70159......876	68331.....954	66580....1036	2
	74039......730	72038......802	70128......877	68301.....955	66552....1038	
29	74005......731	72005......803	70097......878	68272.....957	66523....1039	1
	73971......732	71973......804	70065......879	68242.....958	66495....1040	
30	73937......733	71940......805	70034......881	68212.....960	66466....1042	0
	A B	A B	A B	A B	A B	
	169°30'	169°00'	168°30'	168°00'	167°30'	

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	12°30'	13°00'	13°30'	14°00'	14°30'	
	A B	A B	A B	A B	A B	
0	66466.....1042	64791.....1128	63181.....1217	61632....1310	60140....1406	30
	66438.....1043	64764.....1129	63155.....1218	61607....1311	60116....1407	
1	66409.....1045	64736.....1130	63129.....1220	61582....1313	60091....1409	29
	66381.....1046	64709.....1132	63103.....1221	61556....1314	60067....1411	
2	66352.....1047	64682.....1133	63076.....1223	61531....1316	60042....1412	28
	66324.....1049	64655.....1135	63050.....1224	61506....1317	60018....1414	
3	66296.....1050	64627.....1136	63024.....1226	61481....1319	59994....1416	27
	66267.....1052	64600.....1138	62998.....1227	61455....1321	59969....1417	
4	66239.....1053	64573.....1139	62971.....1229	61430....1322	59945....1419	26
	66211.....1054	64546.....1141	62945.....1230	61405....1324	59921....1421	
5	66182.....1056	64518.....1142	62919.....1232	61380....1325	59896....1422	25
	66154.....1057	64491.....1144	62893.....1234	61355....1327	59872....1424	
6	66126.....1059	64464.....1145	62867.....1235	61330....1329	59848....1425	24
	66098.....1060	64437.....1147	62841.....1237	61304....1330	59824....1427	
7	66069.....1061	64410.....1148	62815.....1238	61279....1332	59800....1429	23
	66041.....1063	64383.....1150	62789.....1240	61254....1333	59775....1430	
8	66013.....1064	64356.....1151	62763.....1241	61229....1335	59751....1432	22
	65985.....1066	64329.....1152	62737.....1243	61204....1336	59727....1434	
9	65957.....1067	64302.....1154	62711.....1244	61179....1338	59703....1435	21
	65928.....1069	64275.....1155	62685.....1246	61154....1340	59679....1437	
10	65900.....1070	64248.....1157	62659.....1247	61129....1341	59654....1439	20
	65872.....1071	64221.....1158	62633.....1249	61104....1343	59630....1440	
11	65844.....1073	64194.....1160	62607.....1250	61079....1344	59606....1442	19
	65816.....1074	64167.....1161	62581.....1252	61054....1346	59582....1444	
12	65788.....1076	64140.....1163	62555.....1253	61029....1348	59558....1445	18
	65760.....1077	64113.....1164	62529.....1255	61004....1349	59534....1447	
13	65732.....1079	64086.....1166	62503.....1257	60979....1351	59510....1449	17
	65704.....1080	64059.....1167	62477.....1258	60954....1352	59486....1450	
14	65676.....1081	64032.....1169	62451.....1260	60929....1354	59462....1452	16
	65648.....1083	64005.....1170	62425.....1261	60904....1356	59438....1454	
15	65620.....1084	63978.....1172	62400.....1263	60879....1357	59414....1455	15
	65592.....1086	63952.....1173	62374.....1264	60855....1359	59390....1457	
16	65564.....1087	63925.....1175	62348.....1266	60830....1360	59366....1459	14
	65537.....1089	63898.....1176	62322.....1267	60805....1362	59342....1460	
17	65509.....1090	63871.....1178	62296.....1269	60780....1364	59318....1462	13
	65481.....1091	63845.....1179	62271.....1270	60755....1365	59294....1464	
18	65453.....1093	63818.....1181	62245.....1272	60730....1367	59270....1465	12
	65425.....1094	63791.....1182	62219.....1274	60706....1368	59246....1467	
19	65398.....1096	63764.....1184	62194.....1275	60681....1370	59222....1469	11
	65370.....1097	63738.....1185	62168.....1277	60656....1372	59198....1470	
20	65342.....1099	63711.....1187	62142.....1278	60631....1373	59175....1472	10
	65314.....1100	63684.....1188	62117.....1280	60607....1375	59151....1474	
21	65287.....1101	63658.....1190	62091.....1281	60582....1377	59127....1475	9
	65259.....1103	63631.....1191	62065.....1283	60557....1378	59103....1477	
22	65231.....1104	63605.....1193	62040.....1284	60533....1380	59079....1479	8
	65204.....1106	63578.....1194	62014.....1286	60508....1381	59055....1480	
23	65176.....1107	63551.....1196	61989.....1288	60483....1383	59032....1482	7
	65148.....1109	63525.....1197	61963.....1289	60459....1385	59008....1484	
24	65121.....1110	63498.....1199	61938.....1291	60434....1386	58984....1485	6
	65093.....1112	63472.....1200	61912.....1292	60410....1388	58960....1487	
25	65066.....1113	63445.....1202	61887.....1294	60385....1390	58937....1489	5
	65038.....1114	63419.....1203	61861.....1295	60360....1391	58913....1490	
26	65011.....1116	63392.....1205	61836.....1297	60336....1393	58889....1492	4
	64983.....1117	63366.....1206	61810.....1299	60311....1394	58866....1494	
27	64956.....1119	63340.....1208	61785.....1300	60287....1396	58842....1495	3
	64928.....1120	63313.....1209	61759.....1301	60262....1398	58818....1497	
28	64901.....1122	63287.....1211	61734.....1303	60238....1399	58795....1499	2
	64873.....1123	63260.....1212	61709.....1305	60213....1401	58771....1500	
29	64846.....1125	63234.....1214	61683.....1306	60189....1403	58748....1502	1
	64819.....1126	63208.....1215	61658.....1308	60164....1404	58724....1504	
30	64791.....1128	63181.....1217	61632.....1310	60140....1406	58700....1506	0
	A B	A B	A B	A B	A B	
	167°00'	166°30'	166°00'	165°30'	165°00'	

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	15°00'	15°30'	16°00'	16°30'	17°00'	
	A B	A B	A B	A B	A B	
0	58700.....1506	57310.....1609	55966.....1716	54666....1826	53406....1940	30
	58677.....1507	57287.....1611	55944.....1718	54644....1828	53386....1942	
1	58653.....1509	57265.....1612	55922.....1719	54623....1830	53365....1944	29
	58630.....1511	57242.....1614	55900.....1721	54602....1832	53344....1946'	
2	58606.....1512	57219.....1616	55878.....1723	54581....1834	53324....1948	28
	58583.....1514	57196.....1618	55856.....1725	54559....1836	53303....1950	
3	58559.....1516	57174.....1619	55834.....1727	54538....1837	53283....1952	27
	58536.....1517	57151.....1621	55812.....1728	54517....1839	53262....1954	
4	58512.....1519	57128.....1623	55790.....1730	54496....1841	53241....1956	26
	58489.....1521	57106.....1625	55768.....1732	54474....1843	53221....1958	
5	58465.....1523	57083.....1627	55746.....1734	54453....1845	53200....1960	25
	58442.....1524	57060.....1628	55725.....1736	54432....1847	53180....1962	
6	58418.....1526	57038.....1630	55703.....1738	54411....1849	53159....1964	24
	58395.....1528	57015.....1632	55681.....1739	54390....1851	53139....1966	
7	58372.....1529	56992.....1634	55659.....1741	54368....1853	53118....1967	23
	58348.....1531	56970.....1935	55637.....1743	54347....1854	53098....1969	
8	58325.....1533	56947.....1637	55615.....1745	54326....1856	53077....1971	22
	58302.....1534	56925.....1639	55593.....1747	54305....1858	53057....1973	
9	58278.....1536	56902.....1641	55572.....1749	54284....1860	53036....1975	21
	58255.....1538	56880.....1642	55550.....1750	54263....1862	53016....1977	
10	58232.....1540	56857.....1644	55528.....1752	54242....1864	52995....1979	20
	58208.....1541	56835.....1646	55506.....1754	54220....1866	52975....1981	
11	58185.....1543	56812.....1648	55484.....1756	54199....1868	52954....1983	19
	58162.....1545	56790.....1649	55463.....1758	54178....1870	52934....1985	
12	58138.....1546	56767.....1651	55441.....1760	54157....1871	52914....1987	18
	58115.....1548	56745.....1653	55419.....1761	54136....1873	52893....1989	
13	58092.....1550	56722.....1655	55397.....1763	54115....1875	52873....1991	17
	58069.....1552	56700.....1657	55376.....1765	54094....1877	52852....1993	
14	58046.....1553	56677.....1658	55354.....1767	54073....1879	52832....1995	16
	58022.....1555	56655.....1660	55332.....1769	54052....1881	52812....1997	
15	57999.....1557	56632.....1662	55311.....1771	54031....1883	52791....1999	15
	57976.....1559	56610.....1664	55289.....1772	54010....1885	52771....2001	
16	57953.....1560	56588.....1665	55267.....1774	53989....1887	52751....2003	14
	57930.....1562	56565.....1667	55246.....1776	53968....1889	52730....2005	
17	57907.....1564	56543.....1669	55224.....1778	53947....1890	52710....2007	13
	57884.....1565	56521.....1671	55202.....1780	53926....1892	52690....2009	
18	57860.....1567	56498.....1673	55181.....1782	53905....1894	52670....2010	12
	57837.....1569	56476.....1674	55159.....1783	53884....1896	52649....2012	
19	57814.....1571	56454.....1676	55138.....1785	53864....1898	52629....2014	11
	57791.....1572	56431.....1678	55116.....1787	53843....1900	52609....2016	
20	57768.....1574	56409.....1680	55095.....1789	53822....1902	52588,...2018	10
	57745.....1576	56387.....1682	55073.....1791	53801....1904	52568....2020	
21	57722.....1578	56365.....1683	55051.....1793	53780....1906	52548....2022	9
	57699.....1579	56342.....1685	55030.....1795	53759....1908	52528....2024	
22	57676.....1581	56320.....1687	55008.....1796	53738....1910	52508....2026	8
	57653.....1583	56298.....1689	54987.....1798	53718....1911	52487....2028	
23	57630.....1584	56276.....1691	54965.....1800	53697....1913	52467....2030	7
	57607.....1586	56254.....1692	54944.....1802	53676....1915	52447....2032	
24	57584.....1588	56231.....1694	54922.....1804	53655....1917	52427....2034	6
	57561.....1590	56209.....1696	54901.....1806	53634....1919	52407....2036	
25	57538.....1591	56187.....1698	54880.....1808	53614....1921	52387....2038	5
	57516.....1593	56165.....1700	54858.....1809	53593....1923	52366....2040	
26	57493.....1595	56143.....1701	54837.....1811	53572....1925	52346....2042	4
	57470.....1597	56121.....1703	54815.....1813	53551....1927	52326....2044	
27	57447.....1598	56099.....1705	54794.....1815	53531....1929	52306....2046	3
	57424.....1600	56076.....1707	54773.....1817	53510....1931	52286....2048	
28	57401.....1602	56054.....1709	54751.....1819	53489....1933	52266....2050	2
	57378.....1604	56032.....1710	54730.....1821	53468....1935	52246....2052	
29	57356.....1605	56010.....1712	54708.....1823	53448....1936	52226....2054	1
	57333.....1607	55988.....1714	54687.....1824	53427....1938	52206....2056	
30	57310.....1609	55966.....1716	54666.....1826	53406....1940	52186....2058	0
	A B	A B	A B	A B	A B	
	164°30'	164°00'	163°30'	163°00'	162°30'	

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	17°30'	18°00'	18°30'	19°00'	19°30'	
	A B	A B	A B	A B	A B	
0	52186.....2058	51002.....2179	49852.....2304	48736....2433	47650....2565	30
	52166.....2060	50982.....2181	49833.....2306	48717....2435	47633....2568	
1	52146.....2062	50963.....2183	49815.....2309	48699....2437	47615....2570	29
	52126.....2064	50943.....2185	49796.....2311	48681....2439	47597....2572	
2	52106.....2066	50924.....2188	49777.....2313	48662....2442	47579....2574	28
	52086.....2068	50905.....2190	49758.....2315	48644....2444	47561....2576	
3	52066.....2070	50885.....2192	49739.....2317	48626....2446	47544....2579	27
	52046.....2072	50866.....2194	49720.....2319	48608....2448	47526....2581	
4	52026.....2074	50846.....2196	49702.....2321	48589....2450	47508....2583	26
	52006.....2076	50827.....2198	49683.....2323	48571....2453	47490....2585	
5	51986.....2078	50808.....2200	49664.....2325	48553....2456	47472....2588	25
	51966.....2080	50788.....2202	49645.....2328	48534....2457	47455....2590	
6	51946.....2082	50769.....2204	49626.....2330	48516....2459	47437....2592	24
	51926.....2084	50750.....2206	49608.....2332	48498....2461	47419....2594	
7	51906.....2086	50730.....2208	49589.....2334	48480....2463	47402....2597	23
	51886.....2088	50711.....2210	49570.....2336	48462....2466	47384....2599	
8	51867.....2090	50692.....2212	49551.....2338	48443....2468	47366....2601	22
	51847.....2092	50673.....2214	49533.....2340	48425....2470	47348....2603	
9	51827.....2094	50653.....2216	49514.....2343	48407....2472	47331....2606	21
	51807.....2096	50634.....2218	49495.....2345	48389....2474	47313....2608	
10	51787.....2098	50615.....2221	49477.....2347	48371....2477	47295....2610	20
	51767.....2100	50596.....2223	49458.....2349	48352....2479	47278....2613	
11	51747.....2102	50576.....2225	49439.....2351	48334....2481	47260....2515	19
	51728.....2104	50557.....2227	49421.....2353	48316....2483	47242....2617	
12	51708.....2106	50538.....2229	49402.....2355	48298....2485	47225....2619	18
	51688.....2108	50519.....2231	49383.....2357	48280....2488	47207....2622	
13	51668.....2110	50499.....2233	49365.....2360	48262....2490	47189....2624	17
	51649.....2112	50480.....2235	49346.....2362	48244....2492	47172....2626	
14	51629.....2114	50461.....2237	49327.....2364	48225....2494	47154....2628	16
	51609.....2116	50442.....2239	49309.....2366	48207....2496	47137....2631	
15	51589.....2118	50423.....2241	49290.....2368	48189....2499	47119....2633	15
	51570.....2120	50404.....2243	49271.....2370	48171....2501	47101....2635	
16	51550.....2122	50385.....2246	49253.....2372	48153....2503	47084....2637	14
	51530.....2124	50365.....2248	49234.....2375	48135....2505	47066....2640	
17	51510.....2126	50346.....2250	49216.....2377	48117....2507	47049....2642	13
	51491.....2128	50327.....2252	49197.....2379	48099....2510	47031....2644	
18	51471.....2130	50308.....2254	49179.....2381	48081....2512	47014....2646	12
	51451.....2132	50289.....2256	49160.....2383	48063....2514	46996....2649	
19	51432.....2134	50270.....2258	49141.....2385	48045....2516	46978....2651	11
	51412.....2136	50251.....2260	49123.....2387	48027....2519	46961....2653	
20	51392.....2138	50232.....2262	49104.....2390	48009....2521	46943....2656	10
	51373.....2141	50213.....2264	49086.....2392	47991....2523	46926....2658	
21	51353.....2143	50194.....2266	49067.....2394	47973....2525	46908....2660	9
	51334.....2145	50175.....2269	49049.....2396	47955....2527	46891....2662	
22	51314.....2147	50156.....2271	49030.....2398	47937....2530	46873....2665	8
	51294.....2149	50137.....2273	49012.....2400	47919....2532	46856....2667	
23	51275.....2151	50117.....2275	48993.....2403	47901....2534	46839....2669	7
	51255.....2153	50098.....2277	48975.....2405	47883....2536	46821....2672	
24	51236.....2155	50080.....2279	48957.....2407	47865....2539	46804....2674	6
	51216.....2157	50061.....2281	48938.....2409	47847....2541	46786....2676	
25	51197.....2159	50042.....2283	48920.....2411	47829....2543	46769....2678	5
	51177.....2161	50023.....2285	48901.....2413	47811....2545	46751....2681	
26	51158.....2163	50004.....2287	48883.....2416	47793....2547	46734....2683	4
	51138.....2165	49985.....2290	48864.....2418	47775....2550	46716....2685	
27	51119.....2167	49966.....2292	48846.....2420	47758....2552	46699....2688	3
	51099.....2169	49947.....2294	48828.....2422	47740....2554	46682....2690	
28	51080.....2171	49928.....2296	48809.....2424	47722....2556	46664....2692	2
	51060.....2173	49909.....2298	48791.....2426	47704....2559	46647....2694	
29	51041.....2175	49890.....2300	48772.....2429	47686....2561	46630....2697	1
	51021.....2177	49871.....2302	48754.....2431	47668....2563	46612....2699	
30	51002.....2179	49852.....2304	48736.....2433	47650....2565	46595....2701	0
	A B	A B	A B	A B	A B	
	162°00'	161°30'	161°00'	160°30'	160°00'	

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	20°00'	20°30'	21°00'	21°30'	22°00'	
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0	46595.....2701	45567.....2841	44567.....2985	43592....3132	42642....3283	30
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	46543.....2708	45517.....2848	44518.....2992	43544....3140	42596....3291	
2	46525.....2711	45500.....2851	44501.....2994	43528....3142	42580....3294	28
	46508.....2713	45483.....2853	44485.....2997	43512....3145	42564....3296	
3	46491.....2715	45466.....2855	44468.....2999	43496....3147	42549....3299	27
	46473.....2717	45449.....2858	44452.....3002	43480....3150	42533....3301	
4	46456.....2720	45433.....2860	44436.....3004	43464....3152	42518....3304	26
	46439.....2722	45416.....2862	44419.....3007	43448....3155	42502....3306	
5	46422.....2724	45399.....2865	44403.....3009	43432....3157	42486....3309	25
	46404.....2727	45382.....2867	44386.....3012	43416....3160	42471....3312	
6	46387.....2729	45365.....2870	44370.....3014	43400....3162	42455....3314	24
	46370.....2731	45348.....2872	44354.....3016	43385....3165	42449....3317	
7	46353.....2734	45332.....2874	44337.....3019	43369....3167	42424....3319	23
	46335.....2736	45315.....2877	44321.....3021	43353....3170	42409....3322	
8	46318.....2738	45298.....2879	44305.....3024	43337....3172	42393....3324	22
	46301.....2741	45281.....2881	44288.....3026	43321....3175	42378....3327	
9	46284.....2743	45265.....2884	44272.....3029	43305....3177	42362....3329	21
	46266.....2745	45248.....2886	44256.....3031	43289....3180	42347....3332	
10	46249.....2748	45231.....2889	44239.....3033	43273....3182	42331....3335	20
	46232.....2750	45214.....2891	44223.....3036	43257....3185	42316....3337	
11	46215.....2752	45198.....2893	44207.....3038	43241....3187	42300....3340	19
	46198.....2755	45181.....2896	44190.....3041	43225....3190	42285....3342	
12	46181.....2757	45164.....2898	44174.....3043	43210....3192	42269....3345	18
	46163.....2759	45147.....2901	44158.....3046	43194....3195	42254....3347	
13	46146.....2761	45131.....2903	44142.....3048	43178....3197	42238....3350	17
	46129.....2764	45114.....2905	44125.....3051	43162....3200	42223....3353	
14	46112.....2766	45097.....2908	44109.....3053	43146....3202	42207....3355	16
	46095.....2768	45081.....2910	44093.....3056	43130....3205	42192....3358	
15	46078.....2771	45064.....2913	44077.....3058	43114....3207	42176....3360	15
	46061.....2773	45047.....2915	44060.....3060	43099....3210	42161....3363	
16	46043.....2775	45031.....2917	44044.....3063	43083....3212	42145....3366	14
	46026.....2778	45014.....2920	44028.....3065	43067....3215	42130....3368	
17	46009.....2780	44997.....2922	44012.....3068	43051....3217	42115....3371	13
	45992.....2782	44981.....2924	43995.....3070	43035....3220	42099....3373	
18	45975.....2785	44964.....2927	43979.....3073	43020....3222	42084....3376	12
	45958.....2787	44947.....2929	43963.....3075	43004....3225	42068....3379	
19	45941.....2789	44931.....2932	43947.....3078	42988....3227	42053....3381	11
	45924.....2792	44914.....2934	43931.....3080	42972....3230	42038....3384	
20	45907.....2794	44898.....2936	43914.....3083	42956....3233	42022....3386	10
	45890.....2797	44881.....2939	43898.....3085	42941....3235	42007....3389	
21	45873.....2799	44864.....2941	43882.....3088	42925....3238	41991....3391	9
	45856.....2801	44848.....2944	43866.....3090	42909....3240	41976....3394	
22	45839.....2804	44831.....2946	43850.....3092	42893....3243	41961....3387	8
	45822.....2806	44815.....2949	43834.....3095	42878....3245	41945....3399	
23	45805.....2808	44798.....2951	43818.....3097	42862....3248	41930....3402	7
	45788.....2811	44782.....2953	43801.....3100	42846....3250	41915....3404	
24	45771.....2813	44765.....2956	43785.....3102	42830....3253	41899....3407	6
	45754.....2815	44748.....2958	43769.....3105	42815....3255	41884....3410	
25	45737.....2818	44732.....2961	43753.....3107	42799....3258	41869....3412	5
	45720.....2820	44715.....2963	43737.....3110	42783....3260	41853....3415	
26	45703.....2822	44699.....2965	43721.....3112	42768....3263	41838....3418	4
	45686.....2825	44682.....2968	43705.....3115	42752....3266	41823....3420	
27	45669.....2827	44666.....2970	43689.....3117	42736....3268	41808....3423	3
	45652.....2829	44649.....2973	43673.....3120	42721....3271	41792....3425	
28	45635.....2832	44633.....2975	43657.....3122	42705....3273	41777....3428	2
	45618.....2834	44616.....2978	43641.....3125	42689....3276	41762....3431	
29	45601.....2836	44600.....2980	43624.....3127	42674....3278	41746....3433	1
	45584.....2839	44583.....2982	43908.....3130	43658....3281	41731....3436	
30	45567.....2841	44567.....2985	43592.....3132	42642....3283	41716....3438	0
	A B	A B	A B	A B	A B	
	159°30'	159°00'	158°30'	158°00'	157°30'	

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	22°30'	23°00'	23°30'	24°00'	24°30'	
	A B	A B	A B	A B	A B	
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1	41685.....3444	40782.....3603	39901.....3766	39040....3932	38200....4103	29
	41670....3446	40768.....3605	39886.....3768	39026....3935	38186....4106	
2	41655.....3449	40753.....3608	39872.....3771	39012....3938	38172....4109	28
	41640.....3452	40738.....3611	39857.....3774	38998....3941	38158....4112	
3	41625.....3454	40723.....3613	39843.....3777	38984....3944	38144....4115	27
	41609.....3457	40708.....3616	39828.....3779	38969....3947	38130....4118	
4	41594.....3459	40693.....3619	39814.....3782	38955....3949	38117....4121	26
	41579.....3462	40678.....3622	39799.....3785	38941....3952	38103....4124	
5	41564.....3465	40664.....3624	39785.....3788	38927....3955	38089....4127	25
	41549.....3467	40649.....3627	39771.....3790	38913....3958	38075....4129	
6	41533.....3470	40634.....3630	39756.....3793	38899....3961	38061....4132	24
	41518.....3473	40619.....3632	39742.....3796	38885....3964	38048....4135	
7	41503.....3475	40604.....3635	39727.....3799	38871....3966	38034....4138	23
	41488.....3478	40590.....3638	39713.....3801	38856....3969	38020....4141	
8	41473.....3480	40575.....3640	39698.....3804	38842....3972	38006....4144	22
	41458.....3483	40560.....3643	39684.....3807	38828....3975	37992....4147	
9	41443.....3486	40545.....3646	39669.....3810	38814....3978	37979....4150	21
	41427.....3488	40530.....3648	39655.....3813	38800....3981	37965....4153	
10	41412.....3491	40516.....3651	39641.....3815	38786....3983	37951....4155	20
	41397.....3494	40501.....3654	39626.....3818	38772....3986	37937....4158	
11	41382.....3496	40486.....3657	39612.....3821	38758....3989	37924....4161	19
	41367.....3499	40471.....3659	39597.....3824	38744....3992	37910....4164	
12	41352.....3502	40457.....3662	39583.....3826	38730....3995	37896....4167	18
	41337....3504	40442.....3665	39569.....3829	38716....3998	37882....4170	
13	41322.....3507	40427.....3667	39554.....3832	38702....4000	37869....4173	17
	41307.....3509	40413.....3670	39540.....3835	38688....4003	37855....4176	
14	41291.....3512	40398.....3673	39525.....3838	38674....4006	37841....4179	16
	41276.....3515	40383.....3676	39511.....3840	38660....4009	37828....4182	
15	41261.....3517	40368.....3678	39497.....3843	38645....4012	37814....4185	15
	41246.....3520	40354.....3681	39482.....3846	38631....4015	37800....4187	
16	41231.....3523	40339.....3684	39468.....3849	38617....4017	37786....4190	14
	41216.....3525	40324.....3686	39454.....3851	38603....4020	37773....4193	
17	41201.....3528	40310.....3689	39439.....3854	38589....4023	37759....4196	13
	41186.....3531	40295.....3692	39425.....3857	38575....4026	37745....4199	
18	41171.....3533	40280.....3695	39411.....3860	38561....4029	37732....4202	12
	41156.....3536	40266.....3697	39396.....3863	38547....4032	37718....4235	
19	41141.....3539	40251.....3700	39382.....3865	38533....4035	37704....4208	11
	41126.....3541	40236.....3703	39368.....3868	38520....4037	37691....4211	
20	41111.....3544	40222.....3705	39353.....3871	38506....4040	37677....4214	10
	41096.....3547	40207.....3708	39339.....3874	38492....4043	37663....4217	
21	41081.....3549	40192.....3711	39325.....3876	38478....4046	37650....4220	9
	41066.....3552	40178.....3714	39311.....3879	38464....4049	37636....4222	
22	41051.....3555	40163.....3716	39296.....3882	38450....4052	37623....4225	8
	41036.....3557	40149.....3719	39282.....3885	38436....4055	37609....4228	
23	41021.....3560	40134.....3722	39268.....3888	38422....4057	37595....4231	7
	41006.....3563	40119.....3725	39254.....3890	38408....4060	37582....4234	
24	40991.....3565	40105.....3727	39239.....3893	38394....4063	37568....4237	6
	40976.....3568	40090.....3730	39225.....3896	38380....4066	37554....4240	
25	40961.....3571	40076.....3733	39211.....3899	38366....4069	37541....4243	5
	40946.....3573	40061.....3735	39197.....3902	38352....4072	37527....4246	
26	40931.....3576	40046.....3738	39182.....3904	38338....4075	37514....4249	4
	40916.....3579	40032.....3741	39168.....3907	38324....4078	37500....4252	
27	40902.....3581	40017.....3744	39154.....3910	38311....4080	37486....4255	3
	40887.....3584	40003.....3746	39140.....3913	38297....4083	37473....4258	
28	40872.....3587	39988.....3749	39125.....3916	38283....4086	37459....4261	2
	40857.....3589	39974.....3752	39111.....3918	38269....4089	37446....4264	
29	40842.....3592	39959.....3755	39097.....3921	38255....4092	37432....4266	1
	40827.....3595	39945.....3757	39083.....3924	38241....4095	37419....4269	
30	40812.....3597	39930.....3760	39069.....3927	38227....4098	37405....4272	0
	A B	A B	A B	A B	A B	
	157°00'	156°30'	156°00'	155°30'	155°00'	

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	25°00'	25°30'	26°00'	26°30'	27°00'	
	A B	A B	A B	A B	A B	
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	37392.....4275	36588.....4454	35803.....4637	35035....4824	34283....5015	
1	37378.....4278	36575.....4457	35790.....4640	35022....4827	34270....5018	29
	37365.....4281	36562.....4460	35777.....4643	35009....4830	34258....5022	
2	37351.....4284	36549.....4463	35764.....4646	34997....4833	34246....5025	28
	37337.....4287	36535.....4466	35751.....4649	34984....4837	34233....5028	
3	37324.....4290	36522.....4469	35738.....4651	34971....4840	34221....5031	27
	37310.....4293	36509.....4472	35725.....4656	34959....4843	34209....5034	
4	37297.....4296	36496.....4475	35712.....4659	34946....4846	34196....5038	26
	37283.....4299	36483.....4478	35699.....4662	34933....4849	34184....5041	
5	37270.....4302	36469.....4481	35686.....4665	34921....4852	34172....5044	25
	37256.....4305	36456.....4484	35674.....4668	34908....4856	34159....5047	
6	37243.....4308	36443.....4487	35661.....4671	34896....4859	34147....5051	24
	37229.....4311	36430.....4490	35648.....4674	34883....4862	34134....5054	
7	37216.....4314	36417.....4493	35635.....4677	34870....4865	34122....5057	23
	37203.....4317	36403.....4496	35622.....4680	34858....4868	34110....5060	
8	37189.....4320	36390.....4499	35609.....4683	34845....4871	34097....5064	22
	37176.....4323	36377.....4503	35596.....4686	34832....4875	34085....5067	
9	37162.....4326	36364.....4506	35583.....4690	34820....4878	34073....5070	21
	37149.....4329	36351.....4509	35571.....4693	34807....4881	34061....5073	
10	37135.....4332	36338.....4512	35558.....4696	34795....4884	34048....5076	20
	37122.....4334	36325.....4515	35545.....4699	34782....4887	34036....5080	
11	37108.....4337	36311.....4518	35532.....4702	34770....4890	34024....5083	19
	37095.....4340	36298.....4521	35519.....4705	34757....4894	34011....5086	
12	37081.....4343	36285.....4524	35506.....4708	34744....4897	33999....5089	18
	37068.....4346	36272.....4527	35493.....4711	34732....4900	33987....5093	
13	37055.....4349	36259.....4530	35481.....4714	34719....4903	33974....5096	17
	37041.....4352	36246.....4533	35468.....4718	34707....4906	33962....5099	
14	37028.....4355	36233.....4536	35455.....4721	34694....4910	33950....5102	16
	37014.....4358	36220.....4539	35442.....4724	34682....4913	33938....5106	
15	37001.....4361	36206.....4542	35429.....4727	34669....4916	33925....5109	15
	36988.....4364	36193.....4545	35417.....4730	34657....4919	33913....5112	
16	36974.....4367	36180.....4548	35404.....4733	34644....4922	33901....5115	14
	36961.....4370	36167.....4551	35391.....4736	34632....4925	33889....5119	
17	36948.....4373	36154.....4554	35378.....4739	34619....4929	33876....5122	13
	36934.....4376	36141.....4557	35365.....4742	34607....4932	33864....5125	
18	36921.....4379	36128.....4560	35353.....4746	34594....4935	33852....5128	12
	36907.....4382	36115.....4563	35340.....4749	34582....4938	33840....5132	
19	36894.....4385	36102.....4566	35327.....4752	34569....4941	33827....5135	11
	36881.....4388	36089.....4569	35314.....4755	34557....4945	33815....5138	
20	36867.....4391	36076.....4573	35302.....4758	34544....4948	33803....5142	10
	36854.....4394	36063.....4576	35289.....4761	34532....4951	33791....5145	
21	36841.....4397	36050.....4579	35276.....4764	34519....4954	33779....5148	9
	36827.....4400	36037.....4582	35263.....4769	34507....4957	33766....5151	
22	36814.....4403	36024.....4585	35251.....4771	34494....4961	33754....5155	8
	36801.....4406	36011.....4588	35238.....4774	34482....4964	33742....5158	
23	36787.....4409	35998.....4591	35225.....4777	34469....4967	33730....5161	7
	36774.....4412	35985.....4594	35212.....4780	34457....4970	33717....5164	
24	36761.....4415	35972.....4597	35200.....4783	34445....4973	33705....5168	6
	36747.....4418	35959.....4600	35187.....4786	34432....4977	33693....5171	
25	36734.....4421	35946.....4603	35174.....4789	34420....4980	33681....5174	5
	36721.....4424	35933.....4606	35161.....4793	34407....4983	33669....5178	
26	36708.....4427	35920.....4609	35149.....4796	34395....4986	33657....5181	4
	36694.....4430	35907.....4612	35136.....4799	34382....4989	33644....5184	
27	36681.....4433	35894.....4615	35123.....4802	34370....4993	33632....5187	3
	36668.....4436	35881.....4619	35111.....4805	34357....4996	33620....5191	
28	36655.....4439	35868.....4622	35098.....4808	34345....4999	33608....5194	2
	36641.....4442	35855.....4625	35085.....4811	34332....5002	33596....5197	
29	36628.....4445	35842.....4628	35073.....4815	34320....5005	33584....5200	1
	36615.....4448	35829.....4631	35060.....4818	34308....5009	33572....5204	
30	36602.....4451	35816.....4634	35047.....4821	34295....5012	33559....5207	0
	A B	A B	A B	A B	A B	
	154°30'	154°00'	153°30'	153°00'	152°30'	

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	27°30'	28°00'	28°30'	29°00'	29°30'	
	A B	A B	A B	A B	A B	
0	33559.....5207	32839.....5406	32134.....5610	31443....5818	30766....6030	30
	33547.....5210	32827.....5410	32122.....5614	31431....5822	30755....6034	
1	33535.....5214	32815.....5413	32110.....5617	31420....5825	30744....6038	29
	33523.....5217	32803.....5417	32099.....5620	31409....5829	30733....6041	
2	33511.....5220	32792.....5420	32087.....5624	31397....5832	30721....6045	28
	33499.....5224	32780.....5423	32076.....5627	31386....5836	30710....6048	
3	33487.....5227	32768.....5426	32064.....5631	31375....5839	30699....6052	27
	33475.....5230	32756.....5430	32052.....5634	31363....5843	30688....6055	
4	33462.....5233	32744.....5433	32041.....5638	31352....5846	30677....6059	26
	33450.....5237	32732.....5437	32029.....5641	31340....5850	30666....6062	
5	33438.....5240	32720.....5440	32018.....5645	31329....5853	30655....6066	25
	33426.....5243	32709.....5443	32006.....5648	31318....5857	30643....6070	
6	33414.....5247	32697.....5447	31994.....5651	31306....5860	30632....6073	24
	33402.....5250	32685.....5450	31983.....5655	31295....5864	30621....6077	
7	33390.....5253	32673.....5454	31971.....5658	31284....5867	30610....6080	23
	33378.....5257	32661.....5457	31960.....5662	31272....5871	30599....6084	
8	33366.....5260	32649.....5460	31948.....5665	31261....5874	30588....6088	22
	33354.....5263	32638.....5464	31936.....5669	31250....5878	30577....6091	
9	33342.....5266	32625.....5467	31925.....5672	31238....5881	30566....6095	21
	33330.....5270	32614.....5470	31913.....5675	31227....5885	30555....6098	
10	33318.....5273	32602.....5474	31902.....5679	31216....5888	30544....6102	20
	33306.....5277	32590.....5477	31890.....5682	31204....5892	30532....6106	
11	33293.....5280	32579.....5481	31879.....5686	31193....5895	30521....6109	19
	33281.....5283	32567.....5484	31867.....5689	31182....5899	30510....6113	
12	33269.....5287	32555.....5487	31856.....5693	31170....5902	30499....6116	18
	33257.....5290	32543.....5491	31844.....5696	31159....5906	30488....6120	
13	33245.....5293	32532.....5494	31833.....5700	31148....5909	30477....6124	17
	33233.....5296	32520.....5498	31821.....5703	31137....5913	30466....6127	
14	33221.....5300	32508.....5501	31809.....5707	31125....5917	30455....6131	16
	33209.....5303	32496.....5504	31798.....5710	31114....5920	30444....6134	
15	33197.....5306	32484.....5508	31786.....5714	31103....5924	30433....6138	15
	33185.....5310	32473.....5511	31775.....5717	31091....5927	30422....6142	
16	33173.....5313	32461.....5515	31763.....5720	31080....5931	30411....6145	14
	33161.....5316	32449.....5518	31752.....5724	31069....5934	30400....6149	
17	33149.....5320	32438.....5521	31740.....5727	31058....5938	30389....6153	13
	33137.....5323	32426.....5525	31729.....5731	31046....5941	30378....6156	
18	33125.....5326	32414.....5528	31717.....5734	31035....5945	30367....6160	12
	33113.....5330	32402.....5532	31706.....5738	31024....5948	30356....6163	
19	33101.....5333	32391.....5535	31694.....5741	31013....5952	30345....6167	11
	33089.....5336	32379.....5538	31683.....5745	31001....5955	30334....6171	
20	33077.....5340	32367.....5542	31672.....5748	30990....5959	30322....6174	10
	33065.....5343	32355.....5545	31660.....5752	30979....5963	30311....6178	
21	33054.....5346	32344.....5549	31648.....5755	30968....5966	30300....6181	9
	33042.....5350	32332.....5552	31637.....5759	30956....5970	30289....6185	
22	33030.....5353	32320.....5555	31626.....5762	30945....5973	30278....6189	8
	33018.....5356	32309.....5559	31614.....5766	30934....5977	30267....6192	
23	33006.....5360	32297.....5562	31603.....5769	30923....5980	30256....6196	7
	32994.....5363	32285.....5566	31591.....5773	30912....5984	30245....6200	
24	32982.....5366	32274.....5569	31580.....5776	30900....5988	30235....6203	6
	32970.....5370	32262.....5572	31569.....5780	30889....5991	30224....6207	
25	32958.....5373	32250.....5576	31557.....5783	30878....5995	30213....6210	5
	32946.....5376	32239.....5579	31546.....5787	30867....5998	30202....6214	
26	32934.....5380	32227.....5583	31534.....5790	30856....6002	30191....6218	4
	32922.....5383	32215.....5586	31523.....5794	30844....6005	30180....6221	
27	32910.....5386	32204.....5590	31511.....5797	30833....6009	30169....6225	3
	32898.....5390	32192.....5593	31500.....5801	30822....6012	30158....6229	
28	32887.....5393	32180.....5596	31488.....5804	30811....6016	30147....6232	2
	32875.....5396	32169.....5600	31477.....5808	30800....6020	30136....6236	
29	32863.....5400	32157.....5603	31466.....5811	30788....6023	30125....6240	1
	32851.....5403	32145.....5607	31454.....5815	30777....6027	30114....6243	
30	32839.....5406	32134.....5610	31443.....5818	30766....6030	30103....6247	0
	A B	A B	A B	A B	A B	
	152°00'	151°30'	151°00'	150°30'	150°00'	

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	30°00'	30°30'	31°00'	31°30'	32°00'	
	A B	A B	A B	A B	A B	
0	30103.....6247	29453.....6468	28816.....6693	28191....6923	27579....7158	30
	30092.....6251	29442.....6472	28806.....6697	28181....6927	27569....7162	
1	30081.....6254	29432.....6475	28795.....6701	28171....6931	27559....7166	29
	30070.....6258	29421.....6479	28785.....6705	28161....6935	27549....7170	
2	30059.....6262	29410.....6483	28774.....6709	28150....6939	27539....7174	28
	30048.....6265	29399.....6487	28763.....6712	28140....6943	27528....7178	
3	30037.....6269	29389.....6490	28753.....6716	28130....6947	27518....7182	27
	30026.....6273	29378.....6494	28743.....6720	28119....6951	27508....7186	
4	30016.....6276	29367.....6498	28732.....6724	28109....6954	27498....7190	26
	30005.....6280	29357.....6501	28722.....6728	28099....6958	27488....7193	
5	29994.....6284	29346.....6505	28711.....6731	28089....6962	27478....7197	25
	29983.....6287	29335.....6509	28701.....6735	28078....6966	27468....7201	
6	29972.....6291	29325.....6513	28690.....6739	28068....6970	27458....7205	24
	29961.....6294	29314.....6516	28680.....6743	28058....6974	27448....7209	
7	29950.....6298	29303.....6520	28669.....6747	28047....6978	27438....7213	23
	29939.....6302	29293.....6524	28659.....6750	28037....6982	27428....7217	
8	29928.....6305	29282.....6528	28648.....6754	28027....6985	27418....7221	22
	29917.....6309	29271.....6531	28638.....6758	28017....6989	27408....7225	
9	29907.....6313	29261.....6535	28627.....6762	28006....6993	27398....7229	21
	29896.....6316	29250.....6539	28617.....6766	27996....6997	27387....7233	
10	29885.....6320	29239.....6543	28606.....6770	27986....7001	27377....7237	20
	29874.....6324	29229.....6546	28596.....6773	27976....7005	27367....7241	
11	29863.....6328	29218.....6550	28586.....6777	27965....7009	27357....7245	19
	29852.....6331	29207.....6554	28575.....6781	27955....7013	27347....7249	
12	29841.....6335	29197.....6558	28565.....6785	27945....7017	27337....7253	18
	29831.....6339	29186.....6561	28554.....6789	27935....7021	27327....7257	
13	29820.....6342	29175.....6565	28544.....6793	27925....7024	27317....7261	17
	29809.....6346	29165.....6569	28533.....6796	27914....7028	27307....7265	
14	29798.....6350	29154.....6573	28523.....6800	27904....7032	27297....7269	16
	29787.....6353	29144.....6576	28513.....6804	27894....7036	27287....7273	
15	29776.....6357	29133.....6580	28502.....6808	27884....7040	27277....7277	15
	29766.....6361	29122.....6584	28492.....6812	27874....7044	27267....7281	
16	29755.....6364	29112.....6588	28481.....6815	27863....7048	27257....7285	14
	29744.....6368	29101.....6591	28471.....6819	27853....7052	27247....7289	
17	29733.....6372	29091.....6595	28461.....6823	27843....7056	27237....7293	13
	29722.....6375	29080.....6599	28450.....6827	27833....7060	27227....7297	
18	29711.....6379	29069.....6603	28440.....6831	27823....7064	27217....7301	12
	29701.....6383	29059.....6606	28429.....6835	27812....7067	27207....7305	
19	29690.....6386	29048.....6610	28419.....6839	27802....7071	27197....7309	11
	29679.....6390	29038.....6614	28409.....6842	27792....7075	27187....7313	
20	29668.....6394	29027.....6618	28398.....6846	27782....7079	27177....7317	10
	29657.....6398	29016.....6622	28388.....6850	27772....7083	27167....7321	
21	29647.....6401	29006.....6625	28378.....6854	27761....7087	27157....7325	9
	29636.....6405	28995.....6629	28367.....6858	27751....7091	27147....7329	
22	29625.....6409	28985.....6633	28357.....6862	27741....7095	27137....7333	8
	29614.....6412	28974.....6637	28346.....6865	27731....7099	27127....7337	
23	29604.....6416	28964.....6640	28336.....6869	27721....7103	27117....7341	7
	29593.....6420	28953.....6644	28326.....6873	27711....7107	27107....7345	
24	29582.....6423	28942.....6648	28315.....6877	27701....7111	27098....7349	6
	29571.....6427	28932.....6652	28305.....6881	27690....7115	27088....7353	
25	29560.....6431	28921.....6655	28295.....6885	27680....7118	27078....7357	5
	29550.....6435	28911.....6659	28284.....6889	27670....7122	27068....7361	
26	29539.....6438	28900.....6663	28274.....6893	27660....7126	27058....7365	4
	29528.....6442	28890.....6667	28264.....6896	27650....7130	27048....7369	
27	29517.....6446	28879.....6671	28253.....6900	27640....7134	27038....7373	3
	29507.....6449	28869.....6674	28243.....6904	27630....7138	27028....7377	
28	29496.....6453	28858.....6678	28233.....6908	27619....7142	27018....7381	2
	29485.....6457	28848.....6682	28222.....6912	27609....7146	27008....7385	
29	29475.....6461	28837.....6686	28212.....6916	27599....7150	26998....7389	1
	29464.....6464	28827.....6690	28202.....6920	27589....7154	26988....7393	
30	29453.....6468	28816.....6693	28191.....6923	27579....7158	26978....7397	0
	A B	A B	A B	A B	A B	
	149°30'	149°00'	148°30'	148°00'	147°30'	

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	32°30'	33°00'	33°30'	34°00'	34°30'	
	A B	A B	A B	A B	A B	
0	26978.....7397	26389.....7641	25811.....7889	25244....8143	24687....8401	30
	26968.....7401	26379.....7645	25801.....7893	25235....8147	24678....8405	
1	26958.....7405	26370.....7649	25792.....7898	25225....8151	24669....8409	29
	26949.....7409	26360.....7653	25782.....7902	25216....8155	24660....8414	
2	26939.....7413	26350.....7657	25773.....7906	25206....8160	24650....8418	28
	26929.....7417	26340.....7661	25763.....7910	25197....8164	24641....8422	
3	26919.....7421	26331.....7665	25754.....7914	25188....8168	24632....8427	27
	26909.....7425	26321.....7670	25744.....7919	25178....8172	24623....8431	
4	26899.....7429	26311.....7674	25735.....7923	25169....8177	24614....8435	26
	26889.....7433	26302.....7678	25725.....7927	25160....8181	24605....8440	
5	26879.....7437	26292.....7682	25716.....7931	25150....8185	24595....8444	25
	26869.....7441	26282.....7686	25706.....7935	25141....8189	24586....8448	
6	26860.....7445	26273.....7690	25697.....7940	25132....8194	24577....8453	24
	26850.....7449	26263.....7694	25687.....7944	25122....8198	24568....8457	
7	26840.....7453	26253.....7698	25678.....7948	25113....8202	24559....8461	23
	26830.....7458	26244.....7702	25668.....7952	25104....8207	24550....8466	
8	26820.....7462	26234.....7707	25659.....7956	25094....8211	24540....8470	22
	26810.....7466	26224.....7711	25649.....7961	25085....8215	24531....8475	
9	26800.....7470	26214.....7715	25640.....7965	25076....8219	24522....8479	21
	26790.....7474	26205.....7719	25630.....7969	25066....8224	24513....8483	
10	26781.....7478	26195.....7723	25621.....7973	25057....8228	24504....8488	20
	26771.....7482	26185.....7727	25611.....7977	25048....8232	24495....8492	
11	26761.....7486	26175.....7731	25602.....7982	25038....8237	24486....8496	19
	26751.....7490	26166.....7736	25592.....7986	25029....8241	24477....8501	
12	26741.....7494	26157.....7740	25583.....7990	25020....8245	24467....8505	18
	26731.....7498	26147.....7744	25573.....7994	25011....8249	24458....8510	
13	26722.....7502	26137.....7748	25564.....7998	25001....8254	24449....8514	17
	26712.....7506	26128.....7752	25554.....8003	24992....8258	24440....8518	
14	26702.....7510	26118.....7756	25545.....8007	24983....8262	24431....8523	16
	26692.....7514	26108.....7760	25536.....8011	24973....8267	24422....8527	
15	26682.....7518	26099.....7764	25526.....8015	24964....8271	24413....8531	15
	26672.....7522	26089.....7769	25517.....8020	24955....8275	24404....8536	
16	26663.....7526	26079.....7773	25507.....8024	24946....8280	24395....8540	14
	26653.....7531	26070.....7777	25498.....8028	24936....8284	24385....8545	
17	26643.....7535	26060.....7781	25488.....8032	24927....8288	24376....8549	13
	26633.....7539	26051.....7785	25479.....8037	24918....8292	24367....8553	
18	26623.....7543	26041.....7789	25469.....8041	24909....8297	24358....8558	12
	26614.....7547	26031.....7793	25460.....8045	24899....8301	24349....8562	
19	26604.....7551	26022.....7798	25451.....8049	24890....8305	24340....8567	11
	26594.....7555	26012.....7802	25441.....8053	24881....8310	24331....8571	
20	26584.....7559	26002.....7806	25432.....8058	24872....8314	24322....8575	10
	26574.....7563	25993.....7810	25422.....8062	24862....8318	24313....8580	
21	26565.....7567	25983.....7814	25413.....8066	24853....8323	24304....8584	9
	26555.....7571	25974.....7818	25403.....8070	24844....8327	24295....8589	
22	26545.....7575	25964.....7823	25394.....8075	24835....8331	24286....8593	8
	26535.....7579	25954.....7827	25385.....8079	24825....8336	24276....8597	
23	26526.....7584	25945.....7831	25375.....8083	24816....8340	24267....8602	7
	26516.....7588	25935.....7835	25366.....8087	24807....8344	24258....8606	
24	26506.....7592	25926.....7839	25356.....8091	24798....8349	24249....8611	6
	26496.....7596	25916.....7843	25347.....8096	24788....8353	24240....8615	
25	26486.....7600	25907.....7848	25338.....8100	24779....8357	24231....8619	5
	26477.....7604	25897.....7852	25328.....8104	24770....8362	24222....8624	
26	26467.....7608	25887.....7856	25319.....8108	24761....8366	24213....8628	4
	26457.....7612	25878.....7860	25309.....8113	24752....8370	24204....8633	
27	26447.....7616	25868.....7864	25300.....8117	24742....8375	24195....8637	3
	26438.....7620	25859.....7868	25291.....8121	24733....8379	24186....8641	
28	26428.....7625	25849.....7873	25281.....8125	24724....8383	24177....8646	2
	26418.....7629	25840.....7877	25272.....8130	24715....8388	24168....8650	
29	26409.....7633	25830.....7881	25263.....8134	24706....8392	24159....8655	1
	26399.....7637	25821.....7885	25253.....8138	24696....8396	24150....8659	
30	26389.....7641	25811.....7889	25244.....8143	24687....8401	24141....8663	0
	A B	A B	A B	A B	A B	
	147°00'	146°30'	146°00'	145°30'	145°00'	

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	35°00'	35°30'	36°00'	36°30'	37°00'	
	A B	A B	A B	A B	A B	
0	24141.....8663	23605.....8931	23078.....9204	22561....9482	22054....9765	30
	24132.....8668	23596.....8936	23069.....9209	22553....9487	22045....9770	
1	24123.....8672	23587.....8940	23061.....9213	22544....9492	22037....9775	29
	24114.....8677	23578.....8945	23052.....9218	22536....9496	22029....9779	
2	24105.....8681	23569.....8949	23043.....9223	22527....9501	22020....9784	28
	24096.....8686	23560.....8954	23035.....9227	22519....9505	22012....9789	
3	24087.....8690	23551.....8958	23026.....9232	25510....9510	22003....9794	27
	24078.....8694	23543.....8963	23017.....9236	22501....9515	21995....9798	
4	24069.....8699	23534.....8967	23009.....9241	22493....9520	21987....9803	26
	24060.....8703	23525.....8972	23000.....9246	22484....9524	21978....9808	
5	24051.....8708	23516.....8976	22991.....9250	22476....9529	21970....9813	25
	24042.....8712	23507.....8981	22983.....9255	22467....9534	21962....9818	
6	24033.....8717	23498.....8986	22974.....9259	22459....9538	21953....9822	24
	24024.....8721	23490.....8990	22965.....9264	22450....9543	21945....9827	
7	24015.....8726	23481.....8995	29957.....9269	22442....9548	21937....9832	23
	24006.....8730	23472.....8999	22948.....9273	22433....9552	21928....9837	
8	23997.....8734	23463.....9004	22939.....9278	22425....9557	21920....9841	22
	23988.....8739	23454.....9008	22931.....9282	22416....9562	21912....9846	
9	23979.....8743	23446.....9013	22922.....9287	22408....9566	21903....9851	21
	23970.....8748	23437.....9017	22913.....9292	22399....9571	21895....9856	
10	23961.....8752	23428.....9022	22905.....9296	22391....9576	21887....9861	20
	23952.....8757	23419.....9026	22896.....9301	22382....9581	21878....9865	
11	23943.....8761	23410.....9031	22887.....9305	22374....9585	21870....9870	19
	23934.....8766	23402.....9035	22879.....9310	22366....9590	21862....9875	
12	23925.....8770	23393.....9040	22870.....9315	22357....9595	21853....9880	18
	23916.....8775	23384.....9044	22862.....9319	22349....9599	21845....9885	
13	23907.....8779	23375.....9049	22853.....9324	22340....9604	21837....9889	17
	23898.....8783	23366.....9054	22844.....9329	22332....9609	21828....9894	
14	23889.....8788	23358.....9058	22836.....9333	22323....9614	21820....9899	16
	23880.....8792	23349.....9063	22827.....9338	22315....9618	21812....9904	
15	23871.....8797	23340.....9067	22818.....9342	22306....9623	21803....9909	15
	23863.....8801	23331.....9072	22810.....9347	22298....9628	21795....9913	
16	23854.....8806	23323.....9076	22801.....9352	22289....9632	21787....9918	14
	23845.....8810	23314.....9081	22793.....9356	22281....9637	21778....9923	
17	23836.....8815	23305.....9085	22784.....9361	22272....9642	21770....9928	13
	23827.....8819	23296.....9090	22775.....9366	22264....9647	21762....9933	
18	23818.....8824	23288.....9094	22767.....9370	22256....9651	21754....9937	12
	23809.....8828	23279.....9099	22758.....9375	22247....9656	21745....9942	
19	23800.....8833	23270.....9104	22750.....9380	22239....9661	21737....9947	11
	23791.....8837	23261.....9108	22741.....9384	22230....9665	21729....9952	
20	23782.....8842	23252.....9113	22732.....9389	22222....9670	21720....9957	10
	23773.....8846	23244.....9117	22724.....9394	22213....9675	21712....9962	
21	23764.....8850	23235.....9122	22715.....9398	22205....9680	21704....9966	9
	23755.....8855	23226.....9126	22707.....9403	22197....9684	21696....9971	
22	23747.....8859	23218.....9131	22698.....9407	22188....9689	21687....9976	8
	23738.....8864	23209.....9136	22690.....9412	22180....9694	21679....9981	
23	23729.....8868	23200.....9140	22681.....9417	22171....9699	21671....9986	7
	23720.....8873	23191.....9145	22672.....9421	22168....9703	21662....9990	
24	23711.....8877	23183.....9149	22664.....9426	22154....9708	21654....9995	6
	23702.....8882	23174.....9154	22655.....9431	22146....9713	21646...10000	
25	23693.....8886	23165.....9158	22647.....9435	22138....9718	21638...10005	5
	23684.....8891	23156.....9163	22638.....9440	22129....9722	21629...10010	
26	23675.....8895	23148.....9168	22630.....9445	22121....9727	21621...10015	4
	23667.....8900	23139.....9172	22621.....9449	22112....9732	21613...10019	
27	23658.....8904	23130.....9177	22612.....9454	22104....9737	21605...10024	3
	23649.....8909	23122.....9181	22604.....9459	22096....9741	21596...10029	
28	23640.....8913	23113.....9186	22595.....9463	22087....9746	21588...10034	2
	23631.....8918	23104.....9190	22587.....9468	22079....9751	21580...10039	
29	23622.....8922	23095.....9195	22578.....9473	22070....9756	21572...10044	1
	23613.....8927	23087.....9200	22570.....9477	22062....9760	21563...10049	
30	23605.....8931	23078.....9204	22561.....9482	22054....9765	21555...10053	0
	A B	A B	A B	A B	A B	
	144°30'	144°00'	143°30'	143°00'	142°30'	

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	37°30'	38°00'	38°30'	39°00'	39°30'	
	A B	A B	A B	A B	A B	
0	21555....10053	21066....10347	20585....10646	20113....10950	19649....11259	30
	21547....10058	21058....10352	20577....10651	20105....10955	19641....11265	
1	21539....10063	21050....10357	20569....10656	20097....10960	19634....11270	29
	21531....10068	21042....10362	20561....10661	20089....10965	19626....11275	
2	21522....10073	21033....10367	20553....10666	20082....10970	19618....11280	28
	21514....10078	21025....10372	20545....10671	20074....10975	19611....11285	
3	21506....10082	21017....10376	20537....10676	20066....10980	19603....11291	27
	21498....10087	21009....10381	20529....10681	20058....10986	19595....11296	
4	21489....10092	21001....10386	20522....10686	20050....10991	19588....11301	26
	21481....10097	20993....10391	20514....10691	20043....10996	19580....11306	
5	21473....10102	20985....10396	20506....10696	20035....11001	19572....11311	25
	21465....10107	20977....10401	20498....10701	20027....11006	19565....11317	
6	21457....10112	20969....10406	20490....10706	20019....11011	19557....11322	24
	21448....10116	20961....10411	20482....10711	20012....11016	19549....11327	
7	21440....10121	20953....10416	20474....10716	20004....11021	19541....11332	23
	21432....10126	20945....10421	20466....10721	19996....11027	19534....11338	
8	21424....10131	20937....10426	20458....10726	19988....11032	19527....11343	22
	21416....10136	20929....10431	20450....10731	19980....11037	19519....11348	
9	21407....10141	20921....10436	20442....10736	19973....11042	19511....11353	21
	21399....10146	20913....10441	20435....10741	19965....11047	19504....11359	
10	21391....10151	20905....10446	20427....10746	19957....11052	19496....11364	20
	21383....10155	20897....10451	20419....10751	19949....11057	19488....11369	
11	21375....10160	20888....10456	20411....10756	19942....11063	19481....11374	19
	21367....10165	20880....10461	20403....10761	19934....11068	19473....11380	
12	21358....10170	20872....10466	20395....10767	19926....11073	19466....11385	18
	21350....10175	20864....10471	20387....10772	19919....11078	19458....11390	
13	21342....10180	20856....10476	20379....10777	19911....11083	19450....11395	17
	21334....10185	20848....10481	20371....10782	19903....11088	19443....11400	
14	21326....10190	20840....10486	20364....10787	19895....11094	19435....11406	16
	21318....10195	20832....10491	20356....10792	19888....11099	19428....11411	
15	21309....10199	20824....10496	20348....10797	19880....11104	19420....11416	15
	21301....10204	20816....10500	20340....10802	19872....11109	19412....11422	
16	21293....10209	20808....10505	20332....10807	19864....11114	19405....11427	14
	21285....10214	20800....10510	20324....10812	19857....11119	19397....11432	
17	21277....10219	20792....10515	20316....10817	19849....11124	19390....11437	13
	21269....10224	20784....10520	20309....10822	19841....11130	19382....11443	
18	21260....10229	20776....10525	20301....10827	19834....11135	19375....11448	12
	21252....10234	20768....10530	20293....10832	19826....11140	19367....11453	
19	21244....10239	20760....10535	20285....10838	19818....11145	19359....11458	11
	21236....10243	20752....10540	20277....10843	19810....11150	19352....11464	
20	21228....10248	20744....10545	20269....10848	19803....11156	19344....11469	10
	21220....10253	20736....10550	20261....10853	19795....11161	19337....11474	
21	21212....10258	20728....10555	20254....10858	19787....11166	19329....11479	9
	21204....10263	20720....10560	20246....10863	19779....11171	19321....11485	
22	21195....10268	20712....10565	20238....10868	19772....11176	19314....11490	8
	21187....10273	20704....10570	20230....10873	19764....11181	19306....11495	
23	21179....10278	20696....10575	20222....10878	19756....11187	19299....11501	7
	21171....10283	20688....10580	20214....10883	19749....11192	19291....11506	
24	21163....10288	20680....10585	20207....10888	19741....11197	19284....11511	6
	21155....10293	20672....10590	20199....10894	19733....11202	19276....11516	
25	21147....10298	20665....10595	20191....10899	19726....11207	19269....11522	5
	21139....10302	20657....10600	20183....10904	19718....11213	19261....11527	
26	21131....10307	20649....10605	20175....10909	19710....11218	19253....11532	4
	21122....10312	20641....10610	20167....10914	19703....11223	19246....11537	
27	21114....10317	20633....10615	20160....10919	19695....11228	19238....11543	3
	21106....10322	20625....10620	20152....10924	19687....11233	19231....11548	
28	21098....10327	20617....10625	20144....10929	19680....11239	19223....11553	2
	21090....10332	20609....10630	20136....10934	19672....11244	19216....11559	
29	21082....10337	20601....10635	20128....10939	19664....11249	19208....11564	1
	21074....10342	20593....10640	20121....10945	19657....11254	19201....11569	
30	21066....10347	20585....10646	20113....10950	19649....11259	19193....11575	0
	A B	A B	A B	A B	A B	
	142°00'	141°30'	141°00'	140°30'	140°00'	

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	40°00'	40°30'	41°00'	41°30'	42°00'	
	A B	A B	A B	A B	A B	
0	19193....11575	18746....11895	18306....12222	17873....12554	17449....12893	30
	19186....11580	18738....11901	18298....12228	17866....12560	17442....12898	
1	19178....11585	18731....11906	18291....12233	17859....12566	17435....12904	29
	19171....11590	18723....11912	18284....12238	17852....12571	17428....12910	
2	19163....11596	18716....11917	18277....12244	17845....12577	17421....12915	28
	19156....11601	18709....11922	18269....12249	17838....12582	17414....12921	
3	19148....11606	18701....11928	18262....12255	17831....12588	17407....12927	27
	19141....11612	18694....11933	18255....12260	17824....12593	17400....12932	
4	19133....11617	18686....11939	18248....12266	17816....12599	17393....12938	26
	19126....11622	18679....11944	19240....12271	17809....12605	17286....12944	
5	19118....11628	18672....11949	18233....12277	17802....12610	17379....12950	25
	19111....11633	18664....11955	18226....12282	17795....12616	17372....12955	
6	19103....11638	18657....11960	18219....12288	17788....12622	17365....12961	24
	19096....11644	18650....11966	18211....12293	17781....12627	17358....12967	
7	19088....11649	18642....11971	18204....12299	17774....12633	17351....12972	23
	19081....11654	18635....11977	18197....12305	17767....12638	17344....12978	
8	19073....11660	18627....11982	18190....12310	17760....12644	17337....12984	22
	19066....11665	18620....11987	18182....12316	17752....12650	17330....12990	
9	19058....11670	18613....11993	18175....12321	17745....12655	17323....12995	21
	19051....11676	18605....11998	18168....12327	17738....12661	17316....13001	
10	19043....11681	18598....12004	18161....12332	17731....12667	17309....13007	20
	19036....11686	18591....12009	18154....12338	17724....12672	17302....13012	
11	19028....11692	18583....12014	18146....12343	17717....12678	17295....13018	19
	19021....11697	18576....12020	18139....12349	17710....12683	17288....13024	
12	19013....11702	18569....12025	18132....12354	17703....12689	17281....13030	18
	19006....11708	18561....12031	18125....12360	17696....12695	17274....13035	
13	18998....11713	18554....12036	18117....12365	17689....12700	17267....13041	17
	18991....11718	18547....12042	18110....12371	17681....12706	17260....13047	
14	18983....11724	18539....12047	18103....12376	17674....12711	17253....13053	16
	18976....11729	18532....12053	18096....12382	17667....12717	17246....13058	
15	18968....11734	18525....12058	18089....12387	17660....12723	17239....13064	15
	18961....11740	18517....12063	18081....12393	17653....12728	17232....13070	
16	18953....11745	18510....12069	18074....12398	17646....12734	17225....13075	14
	18946....11750	18503....12074	18067....12404	17639....12740	17218....13081	
17	18939....11756	18495....12080	18060....12410	17632....12745	17212....13087	13
	18931....11761	18488....12085	18053....12415	17625....12751	17205....13093	
18	18924....11766	18481....12091	18045....12421	17618....12757	17198....13098	12
	18916....11772	18473....12096	18038....12426	17611....12762	17191....13104	
19	18909....11777	18466....12102	18031....12432	17604....12768	17184....13110	11
	18901....11782	18459....12107	18024....12437	17597....12774	17177....13116	
20	18894....11788	18451....12112	18017....12443	17590....12779	17170....13121	10
	18886....11793	18444....12118	18010....12448	17583....12785	17163....13127	
21	18879....11799	18437....12123	18002....12454	17575....12790	17156....13133	9
	18872....11804	18429....12129	17995....12460	17568....12796	17149....13139	
22	18864....11809	18422....12134	17988....12465	17561....12802	17142....13144	8
	18857....11815	18415....12140	17981....12471	17554....12807	17135....13150	
23	18849....11820	18408....12145	17974....12476	17547....12813	17128....13156	7
	18842....11825	18400....12151	17966....12482	17540....12819	17121....13162	
24	18834....11831	18393....12156	17959....12487	17533....12824	17114....13168	6
	18827....11836	18386....12162	17952....12493	17526....12830	17108....13173	
25	18820....11842	18378....12167	17945....12499	17519....12836	17107....13179	5
	18812....11847	18371....12173	17938....12504	17512....12841	17094....13185	
26	18805....11852	18364....12178	17931....12510	17505....12847	17087....13191	4
	18797....11858	18357....12184	17924....12515	17498....12853	17080....13196	
27	18790....11863	18349....12189	17916....12521	17491....12859	17073....13202	3
	18783....11868	18342....12195	17909....12526	17484....12864	17066....13208	
28	18775....11874	18335....12200	17902....12532	17477....12870	17059....13214	2
	18768....11879	18327....12205	17895....12538	17470....12876	17052....13220	
29	18760....11885	18320....12211	17888....12543	17463....12881	17046....13225	1
	18753....11890	18313....12216	17881....12549	17456....12887	17039....13231	
30	18746....11895	18306....12222	17873....12554	17449....12893	17032....13237	0
	A B	A B	A B	A B	A B	
	139°30'	139°00'	138°30'	138°00'	137°30'	

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	42°30'	43°00'	43°30'	44°00'	44°30'	
	A B	A B	A B	A B	A B	
0	17032....13237	16622....13587	16219....13944	15823....14307	15434....14676	30
	17025....13243	16615....13593	16212....13950	15816....14313	15427....14682	
1	17018....13248	16608....13599	16205....13956	15810....14319	15421....14688	29
	17011....13254	16601....13605	16199....13962	15803....14325	15414....14694	
2	17004....13260	16595....13611	16192....13968	15797....14331	15408....14701	28
	16997....13266	16588....13617	16186....13974	15790....14337	15402....14707	
3	16990....13272	16581....13623	16179....13980	15784....14343	15395....14713	27
	16983....13277	16574....13628	16172....13986	15777....14349	15389....14719	
4	16977....13283	16567....13634	16166....13992	15771....14355	15382....14726	26
	16970....13289	16561....13640	16159....13998	15764....14362	15376....14732	
5	16963....13295	16554....13646	16152....14004	15758....14368	15370....14738	25
	16956....13301	16547....13652	16146....14010	15751....14374	15363....14744	
6	16949....13306	16540....13658	16139....14016	15744....14380	15357....14750	24
	16942....13312	16534....13664	16132....14022	15738....14386	15350....14757	
7	16935....13318	16527....13670	16126....14028	15731....14392	15344....14763	23
	16928....13324	16520....13676	16119....14034	15725....14398	15338....14769	
8	16922....13330	16513....13682	16112....14040	15718....14404	15331....14775	22
	16915....13336	16507....13688	16106....14046	15712....14411	15325....14782	
9	16908....13341	16500....13694	16099....14052	15705....14417	15318....14788	21
	16901....13347	16493....13700	16093....14058	15699....14423	15312....14794	
10	16894....13353	16487....13705	16086....14064	15692....14429	15306....14800	20
	16887....13359	16480....13711	16079....14070	15686....14435	15299....14807	
11	16880....13365	16473....13717	16073....14076	15679....14441	15293....14813	19
	16874....13370	16466....13723	16066....14082	15673....14447	15286....14819	
12	16867....13376	16460....13729	16060....14088	15666....14453	15280....14825	18
	16860....13382	16453....13735	16053....14094	15660....14460	15274....14831	
13	16853....13388	16446....13741	16046....14100	15653....14466	15267....14838	17
	16846....13394	16439....13747	16040....14106	15647....14472	15261....14844	
14	16839....13400	16433....13753	16033....14112	15640....14478	15255....14850	16
	16833....13405	16426....13759	16027....14118	15634....14484	15248....14857	
15	16826....13411	16419....13765	16020....14124	15627....14490	15242....14863	15
	16819....13417	16413....13771	16013....14130	15621....14496	15235....14869	
16	16812....13423	16406....13777	16007....14136	15614....14503	15229....14875	14
	16805....13429	16399....13783	16000....14142	15608....14509	15223....14882	
17	16798....13435	16392....13789	15994....14149	15602....14515	15216....14888	13
	16792....13440	16386....13794	15987....14155	15595....14521	15210....14894	
18	16785....13446	16379....13800	15980....14161	15589....14527	15204....14900	12
	16778....13452	16372....13806	15974....14167	15582....14533	15197....14907	
19	16771....13458	16366....13812	15967....14173	15576....14540	15191....14913	11
	16764....13464	16359....13818	15961....14179	15569....14546	15184....14919	
20	16757....13470	16352....13824	15954....14185	15563....14552	15178....14925	10
	16751....13476	16346....13830	15947....14191	15556....14558	15172....14932	
21	16744....13481	16339....13836	15941....14197	15550....14564	15165....14938	9
	16737....13487	16332....13842	15934....14203	15543....14570	15159....14944	
22	16730....13493	16325....13848	15928....14209	15537....14577	15153....14951	8
	16723....13499	16319....13854	15921....14215	15530....14583	15146....14957	
23	16717....13505	16312....13860	15915....14221	15524....14589	15140....14963	7
	16710....13511	16305....13866	15908....14227	15517....14595	15134....14969	
24	16703....13517	16299....13872	15901....14233	15511....14601	15127....14976	6
	16696....13523	16292....13878	15895....14240	15505....14608	15121....14982	
25	16689....13528	16285....13884	15888....14246	15498....14614	15115....14988	5
	16683....13534	16279....13890	15882....14252	15492....14620	15108....14995	
26	16676....13540	16272....13896	15875....14258	15485....14626	15102....15001	4
	16669....13546	16265....13902	15869....14264	15479....14632	15096....15007	
27	16662....13552	16259....13908	15862....14270	15472....14639	15089....15014	3
	16656....13558	16252....13914	15856....14276	15466....14645	15083....15020	
28	16649....13564	16245....13920	15849....14282	15459....14651	15077....15026	2
	16642....13570	16239....13926	15842....14288	15453....14657	15070....15033	
29	16635....13575	16232....13932	15836....14294	15447....14663	15064....15039	1
	16628....13581	16225....13938	15829....14300	15440....14670	15058....15045	
30	16622....13587	16219....13944	15823....14307	15434....14676	15051....15051	0
	A B	A B	A B	A B	A B	
	137°00'	136°30'	136°00'	135°30'	135°00'	

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	45°00'	45°30'	46°00'	46°30'	47°00'	
	A B	A B	A B	A B	A B	
0	15051....15051	14676....15434	14307....15823	13944....16219	13587....16622	30
	15045....15058	14670....15440	14300....15829	13938....16225	13581....16628	
1	15039....15064	14663....15447	14294....15836	13932....16232	13575....16635	29
	15033....15070	14657....15453	14288....15842	13926....16239	13570....16642	
2	15026....15077	14651....15459	14282....15849	13920....16245	13564....16649	28
	15020....15083	14645....15466	14276....15856	13914....16252	13558....16656	
3	15014....15089	14639....15472	14270....15862	13908....16259	13552....16662	27
	15007....15096	14632....15479	14264....15869	13902....16265	13546....16669	
4	15001....15102	14626....15485	14258....15875	13896....16272	13540....16676	26
	14995....15108	14620....15492	14252....15882	13890....16279	13534....16683	
5	14988....15115	14614....15498	14246....15888	13884....16285	13528....16689	25
	14982....15121	14608....15505	14240....15895	13878....16292	13523....16696	
6	14976....15127	14601....15511	14233....15901	13872....16299	13517....16703	24
	14969....15134	14595....15517	14227....15908	13866....16305	13511....16710	
7	14963....15140	14589....15524	14221....15915	13860....16312	13505....16717	23
	14957....15146	14583....15530	14215....15921	13854....16319	13499....16723	
8	14951....15153	14577....15537	14209....15928	13848....16325	13493....16730	22
	14944....15159	14570....15543	14203....15934	13842....16332	13487....16737	
9	14938....15165	14564....15550	14197....15941	13836....16339	13481....16744	21
	14932....15172	14558....15556	14191....15947	13830....16346	13476....16751	
10	14925....15178	14552....15563	14185....15954	13824....16352	13470....16757	20
	14919....15184	14546....15569	14179....15961	13818....16359	13464....16764	
11	14913....15191	14540....15576	14173....15967	13812....16366	13458....16771	19
	14907....15197	14533....15582	14167....15974	13806....16372	13452....16778	
12	14900....15204	14527....15589	14161....15980	13800....16379	13446....16785	18
	14894....15210	14521....15595	14155....15987	13794....16386	13440....16792	
13	14888....15216	14515....15602	14149....15994	13788....16392	13435....16798	17
	14882....15223	14509....15608	14142....16000	13783....16399	13429....16805	
14	14875....15229	14503....15614	14136....16007	13777....16406	13423....16812	16
	14869....15235	14496....15621	14130....16013	13771....16413	13417....16819	
15	14863....15242	14490....15627	14124....16020	13765....16419	13411....16826	15
	14857....15248	14484....15634	14118....16027	13759....16426	13405....16833	
16	14850....15255	14478....15640	14112....16033	13753....16433	13400....16839	14
	14844....15261	14472....15647	14106....16040	13747....16439	13394....16846	
17	14838....15267	14466....15653	14100....16046	13741....16446	13388....16853	13
	14831....15274	14460....15660	14094....16053	13735....16453	13382....16860	
18	14825....15280	14453....15666	14088....16060	13729....16460	13376....16867	12
	14819....15286	14447....15673	14082....16066	13723....16466	13370....16874	
19	14813....15293	14441....15679	14076....16073	13717....16473	13365....16880	11
	14807....15299	14435....15686	14070....16079	13711....16480	13359....16887	
20	14800....15306	14429....15692	14064....16086	13705....16487	13353....16894	10
	14794....15312	14423....15699	14058....16093	13699....16493	13347....16901	
21	14788....15318	14417....15705	14052....16099	13694....16500	13341....16908	9
	14782....15325	14411....15712	14046....16105	13688....16507	13336....16915	
22	14775....15331	14404....15718	14040....16112	13682....16513	13330....16922	8
	14769....15338	14398....15725	14034....16119	13676....16520	13324....16928	
23	14763....15344	14392....15731	14028....16126	13670....16527	13318....16935	7
	14757....15350	14386....15738	14022....16132	13664....16534	13312....16942	
24	14750....15357	14380....15744	14016....16139	13658....16540	13306....16949	6
	14744....15363	14374....15751	14010....16146	13652....16547	13301....16956	
25	14738....15370	14368....15758	14004....16152	13646....16554	13295....16963	5
	14732....15376	14362....15764	13998....16159	13640....16561	13289....16970	
26	14725....15382	14355....15771	13992....16166	13634....16567	13283....16977	4
	14719....15389	14349....15777	13986....16172	13628....16574	13277....16983	
27	14713....15395	14343....15784	13980....16179	13623....16581	13272....16990	3
	14707....15402	14337....15790	13974....16185	13617....16588	13266....16997	
28	14701....15408	14331....15797	13968....16192	13611....16595	13260....17004	2
	14694....15414	14325....15803	13962....16199	13605....16601	13254....17011	
29	14688....15421	14319....15810	13956....16205	13599....16608	13248....17018	1
	14682....15427	14313....15816	13950....16212	13593....16615	13243....17025	
30	14676....15434	14307....15823	13944....16219	13587....16622	13237....17032	0
	A B	A B	A B	A B	A B	
	134°30'	134°00'	133°30'	133°00'	132°30'	

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	47°30'	48°00'	48°30'	49°00'	49°30'	
	A B	A B	A B	A B	A B	
0	13237....17032	12893....17449	12554....17873	12222....18306	11895....18746	30
	13231....17039	12887....17456	12549....17881	12216....18313	11890....18753	
1	13225....17045	12881....17463	12543....17888	12211....18320	11885....18760	29
	13220....17052	12876....17470	12538....17895	12205....18327	11879....18768	
2	13214....17059	12870....17477	12532....17902	12200....18335	11874....18775	28
	13208....17066	12864....17484	12526....17909	12195....18342	11868....18783	
3	13202....17073	12859....17491	12521....17916	12189....18349	11863....18790	27
	13196....17080	12853....17498	12515....17924	12184....18357	11858....18797	
4	13191....17087	12847....17505	12510....17931	12178....18364	11852....18805	26
	13185....17094	12841....17512	12504....17938	12173....18371	11847....18812	
5	13179....17101	12836....17519	12499....17945	12167....18378	11842....18820	25
	13173....17108	12830....17526	12493....17952	12162....18386	11836....18827	
6	13168....17114	12824....17533	12487....17959	12156....18393	11831....18834	24
	13162....17121	12819....17540	12482....17966	12151....18400	11825....18842	
7	13156....17128	12813....17547	12476....17974	12145....18408	11820....18849	23
	13150....17135	12807....17554	12471....17981	12140....18415	11815....18857	
8	13144....17142	12802....17561	12465....17988	12134....18422	11809....18864	22
	13139....17149	12796....17568	12460....17995	12129....18429	11804....18872	
9	13133....17156	12790....17576	12454....18002	12123....18437	11799....18879	21
	13127....17163	12785....17583	12448....18010	12118....18444	11793....18886	
10	13121....17170	12779....17590	12443....18017	12112....18451	11788....18894	20
	13116....17177	12774....17597	12437....18024	12107....18459	11782....18901	
11	13110....17184	12768....17604	12432....18031	12102....18466	11777....18909	19
	13104....17191	12762....17611	12426....18038	12096....18473	11772....18916	
12	13098....17198	12757....17618	12421....18045	12091....18481	11766....18924	18
	13093....17205	12751....17625	12415....18053	12085....18488	11761....18931	
13	13087....17212	12745....17632	12410....18060	12080....18495	11756....18939	17
	13081....17218	12740....17639	12404....18067	12074....18503	11750....18946	
14	13075....17225	12734....17646	12398....18074	12069....18510	11745....18953	16
	13070....17232	12728....17653	12393....18081	12063....18517	11740....18961	
15	13064....17239	12723....17660	12387....18089	12058....18525	11734....18968	15
	13058....17246	12717....17667	12382....18096	12053....18532	11729....18976	
16	13053....17253	12711....17674	12376....18103	12047....18539	11724....18983	14
	13047....17260	12706....17681	12371....18110	12042....18547	11718....18991	
17	13041....17267	12700....17689	12365....18117	12036....18554	11713....18998	13
	13035....17274	12695....17696	12360....18125	12031....18561	11708....19006	
18	13030....17281	12689....17703	12354....18132	12025....18569	11702....19013	12
	13024....17288	12683....17710	12349....18139	12020....18576	11697....19021	
19	13018....17295	12678....17717	12343....18146	12014....18583	11692....19028	11
	13012....17302	12672....17724	12338....18154	12009....18591	11686....19036	
20	13007....17309	12666....17731	12332....18161	12004....18598	11681....19043	10
	13001....17316	12661....17738	12327....18168	11998....18605	11676....19051	
21	12995....17323	12655....17745	12321....18175	11993....18613	11670....19058	9
	12990....17330	12650....17752	12316....18182	11987....18620	11665....19066	
22	12984....17337	12644....17760	12310....18190	11982....18627	11660....19073	8
	12978....17344	12638....17767	12305....18197	11976....18635	11654....19081	
23	12972....17351	12633....17774	12299....18204	11971....18642	11649....19088	7
	12967....17358	12627....17781	12293....18211	11966....18650	11644....19096	
24	12961....17365	12622....17788	12288....18219	11960....18657	11638....19103	6
	12955....17372	12616....17795	12282....18226	11955....18664	11633....19111	
25	12950....17379	12610....17802	12277....18233	11949....18672	11628....19118	5
	12944....17386	12605....17809	12271....18240	11944....18679	11622....19126	
26	12938....17393	12599....17816	12266....18248	11939....18686	11617....19133	4
	12932....17400	12593....17824	12260....18255	11933....18694	11612....19141	
27	12927....17407	12588....17831	12255....18262	11928....18701	11606....19148	3
	12921....17414	12582....17838	12249....18269	11922....18709	11601....19156	
28	12915....17421	12577....17845	12244....18277	11917....18716	11596....19163	2
	12910....17428	12571....17852	12238....18284	11912....18723	11590....19171	
29	12904....17435	12566....17859	12233....18291	11906....18731	11585....19178	1
	12898....17442	12560....17866	12227....18298	11901....18738	11580....19186	
30	12893....17449	12554....17873	12222....18306	11895....18746	11575....19193	0
	A B	A B	A B	A B	A B	
	132°00'	131°30'	131°00'	130°30'	130°00'	

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	50°00'	50°30'	51°00'	51°30'	52°00'	
	A B	A B	A B	A B	A B	
0	11575....19193	11259....19649	10950....20113	10646....20585	10347....21066	30
	11569....19201	11254....19657	10945....20121	10640....20593	10342....21074	
1	11564....19208	11249....19664	10939....20128	10635....20601	10337....21082	29
	11559....19216	11244....19672	10934....20136	10630....20609	10332....21090	
2	11553....19223	11239....19680	10929....20144	10625....20617	10327....21098	28
	11548....19231	11233....19687	10924....20152	10620....20625	10322....21106	
3	11543....10238	11228....19695	10919....20160	10615....20633	10317....21114	27
	11537....19246	11223....19703	10914....20167	10610....20641	10312....21122	
4	11532....19253	11218....19710	10909....20175	10605....20649	10307....21131	26
	11527....19261	11213....19718	10904....20183	10600....20657	10302....21139	
5	11522....19269	11207....19726	10899....20191	10595....20665	10298....21147	25
	11516....19276	11202....19733	10894....20199	10590....20672	10293....21155	
6	11511....19284	11197....19741	10888....20207	10585....20680	10288....21163	24
	11506....19291	11192....19749	10883....20214	10580....20688	10283....21171	
7	11501....19299	11187....19756	10878....20222	10575....20696	10278....21179	23
	11495....19306	11181....19764	10873....20230	10570....20704	10273....21187	
8	11490....19314	11176....19772	10868....20238	10565....20712	10268....21195	22
	11485....19321	11171....19779	10863....20246	10560....20720	10263....21204	
9	11479....19329	11166....19787	10858....20254	10555....20728	10258....21212	21
	11474....19337	11161....19795	10853....20261	10550....20736	10253....21220	
10	11469....19344	11156....19803	10848....20269	10545....20744	10248....21228	20
	11464....19352	11150....19810	10843....20277	10540....20752	10243....21236	
11	11458....19359	11145....19818	10838....20285	10535....20760	10239....21244	19
	11453....19367	11140....19826	10832....20293	10530....20768	10234....21252	
12	11448....19375	11135....19834	10827....20301	10525....20776	10229....21260	18
	11443....19382	11130....19841	10822....20308	10520....20784	10224....21269	
13	11437....19390	11124....19849	10817....20316	10515....20792	10219....21277	17
	11432....19397	11119....19857	10812....20324	10510....20800	10214....21285	
14	11427....19405	11114....19864	10807....20332	10505....20808	10209....21293	16
	11421....19412	11109....19872	10802....20340	10500....20816	10204....21301	
15	11416....19420	11104....19880	10797....20348	10496....20824	10199....21309	15
	11411....19428	11099....19888	10792....20356	10491....20832	10195....21318	
16	11406....19435	11094....19895	10787....20364	10486....20840	10190....21326	14
	11400....19443	11088....19903	10782....20371	10481....20848	10185....21334	
17	11395....19450	11083....19911	10777....20379	10476....20856	10180....21342	13
	11390....19458	11078....19918	10772....20387	10471....20864	10175....21350	
18	11385....19466	11073....19926	10767....20395	10466....20872	10170....21358	12
	11380....19473	11068....19934	10761....20403	10461....20880	10165....21367	
19	11374....19481	11063....19942	10756....20411	10456....20888	10160....21375	11
	11369....19488	11057....19949	10751....20419	10451....20897	10155....21383	
20	11364....19496	11052....19957	10746....20427	10446....20905	10151....21391	10
	11359....19504	11047....19965	10741....20435	10441....20913	10146....21399	
21	11353....19511	11042....19973	10736....20442	10436....20921	10141....21407	9
	11348....19519	11037....19980	10731....20450	10431....20929	10136....21416	
22	11343....19527	11032....19988	10726....20458	10426....20937	10131....21424	8
	11338....19534	11027....19996	10721....20466	10421....20945	10126....21432	
23	11332....19542	11021....20004	10716....20474	10416....20953	10121....21440	7
	11327....19549	11016....20012	10711....20482	10411....20961	10116....21448	
24	11322....19557	11011....20019	10706....20490	10406....20969	10112....21457	6
	11317....19565	11006....20027	10701....20498	10401....20977	10107....21465	
25	11311....19572	11001....20035	10696....20506	10396....20985	10102....21473	5
	11306....19580	10996....20043	10691....20514	10391....20993	10097....21481	
26	11301....19588	10991....20050	10686....20522	10386....21001	10092....21489	4
	11296....19595	10986....20058	10681....20529	10381....21009	10087....21498	
27	11291....19603	10980....20066	10676....20537	10376....21017	10082....21506	3
	11285....19611	10975....20074	10671....20545	10372....21025	10078....21514	
28	11280....19618	10970....20082	10666....20553	10367....21033	10073....21522	2
	11275....19626	10965....20089	10661....20561	10362....21042	10068....21531	
29	11270....19634	10960....20097	10656....20569	10357....21050	10063....21539	1
	11265....19641	10955....20105	10651....20577	10352....21058	10058....21547	
30	11259....19649	10950....20113	10646....20585	10347....21066	10053....21555	0
	A B	A B	A B	A B	A B	
	129°30'	129°00'	128°30'	128°00'	127°30'	

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	52°30'	53°00'	53°30'	54°00'	54°30'	
	A B	A B	A B	A B	A B	
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	10049....21563	9760.....22062	9477.....22570	9200.....23087	8927.....23613	
1	10044....21572	9756.....22070	9473.....22578	9195.....23095	8922.....23622	29
	10039....21580	9751.....22079	9468.....22587	9190.....23104	8918.....23631	
2	10034....21588	9746.....22087	9463.....22595	9186.....23113	8913.....23640	28
	10029....21596	9741.....22096	9459.....22604	9181.....23122	8909.....23649	
3	10024....21605	9737.....22104	9454.....22612	9177.....23130	8904.....23658	27
	10019....21613	9732.....22112	9449.....22621	9172.....23139	8900.....23667	
4	10015....21621	9727.....22121	9445.....22630	9168.....23148	8895.....23675	26
	10010....21629	9722.....22129	9440.....22638	9163.....23156	8891.....23684	
5	10005....21638	9718.....22138	9435.....22647	9158.....23165	8886.....23693	25
	10000....21646	9713.....22146	9431.....22655	9154.....23174	8882.....23702	
6	9995.....21654	9708.....22154	9426.....22664	9149.....23183	8877.....23711	24
	9990.....21662	9703.....22163	9421.....22672	9145.....23191	8873.....23720	
7	9986.....21671	9699.....22171	9417.....22681	9140.....23200	8868.....23729	23
	9981.....21679	9694.....22180	9412.....22690	9136.....23209	8864.....23738	
8	9976.....21687	9689.....22188	9407.....22698	9131.....23218	8859.....23747	22
	9971.....21696	9684.....22197	9403.....22707	9126.....23226	8855.....23755	
9	9966.....21704	9680.....22205	9398.....22715	9122.....23235	8850.....23764	21
	9962.....21712	9675.....22213	9394.....22724	9117.....23244	8846.....23773	
10	9957.....21720	9670.....22222	9389.....22732	9113.....23252	8842.....23782	20
	9952.....21729	9665.....22230	9384.....22741	9108.....23261	8837.....23791	
11	9947.....21737	9661.....22239	9380.....22750	9104.....23270	8833.....23800	19
	9942.....21745	9656.....22247	9375.....22758	9099.....23279	8828.....23809	
12	9937.....21754	9651.....22256	9370.....22767	9094.....23288	8824.....23818	18
	9933.....21762	9647.....22264	9366.....22775	9090.....23296	8819.....23827	
13	9928.....21770	9642.....22272	9361.....22784	9085.....23305	8815.....23836	17
	9923.....21778	9637.....22281	9356.....22793	9081.....23314	8810.....23845	
14	9918.....21787	9632.....22289	9352.....22801	9076.....23323	8806.....23854	16
	9913.....21795	9628.....22298	9347.....22810	9072.....23331	8801.....23863	
15	9909.....21803	9623.....22306	9342.....22818	9067.....23340	8797.....23871	15
	9904.....21812	9618.....22315	9338.....22827	9063.....23349	8792.....23880	
16	9899.....21820	9614.....22323	9333.....22836	9058.....23358	8788.....23889	14
	9894.....21828	9609.....22332	9329.....22844	9054.....23366	8783.....23898	
17	9889.....21837	9604.....22340	9324.....22853	9049.....23375	8779.....23907	13
	9885.....21845	9599.....22349	9319.....22862	9044.....23384	8775.....23916	
18	9880.....21853	9595.....22357	9315.....22870	9040.....23393	8770.....23925	12
	9875.....21862	9590.....22366	9310.....22879	9035.....23402	8766.....23934	
19	9870.....21870	9585.....22374	9305.....22887	9031.....23410	8761.....23943	11
	9865.....21878	9581.....22382	9301.....22896	9026.....23419	8757.....23952	
20	9861.....21887	9576.....22391	9296.....22905	9022.....23428	8752.....23961	10
	9856.....21895	9571.....22399	9292.....22913	9017.....23437	8748.....23970	
21	9851.....21903	9566.....22408	9287.....22922	9013.....23446	8743.....23979	9
	9846.....21912	9562.....22416	9282.....22931	9008.....23454	8739.....23988	
22	9841.....21920	9557.....22425	9278.....22939	9004.....23463	8734.....23997	8
	9837.....21928	9552.....22433	9273.....22948	8999.....23472	8730.....24006	
23	9832.....21937	9548.....22442	9269.....22957	8995.....23481	8726.....24015	7
	9827.....21945	9543.....22450	9264.....22965	8990.....23490	8721.....24024	
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	9818.....21962	9534.....22467	9255.....22983	8981.....23507	8712.....24042	
25	9813.....21970	9529.....22476	9250.....22991	8976.....23516	8708.....24051	5
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26	9803.....21987	9520.....22493	9241.....23009	8967.....23534	8699.....24069	4
	9798.....21995	9515.....22501	9236.....23017	8963.....23543	8694.....24078	
27	9794.....22003	9510.....22510	9232.....23026	8958.....23551	8690.....24087	3
	9789.....22012	9505.....22519	9227.....23035	8954.....23560	8686.....24096	
28	9784.....22020	9501.....22527	9223.....23043	8949.....23569	8681.....24105	2
	9779.....22029	9496.....22536	9218.....23052	8945.....23578	8677.....24114	
29	9775.....22037	9491.....22544	9213.....23061	8940.....23587	8672.....24123	1
	9770.....22045	9487.....22553	9209.....23069	8936.....23596	8668.....24132	
30	9765.....22054	9482.....22561	9204.....23078	8931.....23605	8663.....24141	0
	A B	A B	A B	A B	A B	
	127°00'	126°30'	126°00'	125°30'	125°00'	

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	55°00'	55°30'	56°00'	56°30'	57°00'	
	A B	A B	A B	A B	A B	
0	8663.....24141	8401.....24687	8143.....25244	7889.....25811	7641.....26389	30
	8659.....24150	8396.....24696	8138.....25253	7885.....25821	7637.....26399	
1	8655.....24159	8392.....24706	8134.....25263	7881.....25830	7633.....26409	29
	8650.....24168	8388.....24715	8130.....25272	7877.....25840	7629.....26418	
2	8646.....24177	8383.....24724	8125.....25281	7873.....25849	7624.....26428	28
	8641.....24186	8379.....24733	8121.....25291	7868.....25859	7620.....26438	
3	8637.....24195	8375.....24742	8117.....25300	7864.....25868	7616.....26447	27
	8633.....24204	8370.....24752	8113.....25309	7860.....25878	7612.....26457	
4	8628.....24213	8366.....24761	8108.....25319	7856.....25887	7608.....26467	26
	8624.....24222	8362.....24770	8104.....25328	7852.....25897	7604.....26477	
5	8619.....24231	8357.....24779	8100.....25338	7848.....25907	7600.....26486	25
	8615.....24240	8353.....24788	8096.....25347	7843.....25916	7596.....26496	
6	8611.....24249	8349.....24798	8092.....25356	7839.....25926	7592.....26506	24
	8606.....24258	8344.....24807	8087.....25366	7835.....25935	7588.....26516	
7	8602.....24267	8340.....24816	8083.....25375	7831.....25945	7584.....26526	23
	8597.....24276	8336.....24825	8079.....25385	7827.....25954	7579.....26535	
8	8593.....24286	8331.....24835	8075.....25394	7823.....25964	7575.....26545	22
	8589.....24295	8327.....24844	8070.....25403	7818.....25974	7571.....26555	
9	8584.....24304	8323.....24853	8066.....25413	7814.....25983	7567.....26565	21
	8580.....24313	8318.....24862	8062.....25422	7810.....25993	7563.....26574	
10	8575.....24322	8314.....24872	8058.....25432	7806.....26002	7559.....26584	20
	8571.....24331	8310.....24881	8053.....25441	7802.....26012	7555.....26594	
11	8567.....24340	8305.....24890	8049.....25451	7798.....26022	7551.....26604	19
	8562.....24349	8301.....24899	8045.....25460	7793.....26031	7547.....26614	
12	8558.....24358	8297.....24909	8041.....25469	7789.....26041	7543.....26623	18
	8553.....24367	8292.....24918	8036.....25479	7785.....26051	7539.....26633	
13	8549.....24376	8288.....24927	8032.....25488	7781.....26060	7535.....26643	17
	8545.....24385	8284.....24936	8028.....25498	7777.....26070	7531.....26653	
14	8540.....24395	8280.....24946	8024.....25507	7773.....26079	7526.....26663	16
	8536.....24404	8275.....24955	8020.....25517	7769.....26089	7522.....26672	
15	8531.....24413	8271.....24964	8015.....25526	7764.....26099	7518.....26682	15
	8527.....24422	8267.....24973	8011.....25536	7760.....26108	7514.....26692	
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	8518.....24440	8258.....24992	8003.....25554	7752.....26128	7506.....26712	
17	8514.....24449	8254.....25001	7998.....25564	7748.....26137	7502.....26722	13
	8510.....24458	8249.....25011	7994.....25573	7744.....26147	7498.....26731	
18	8505.....24467	8245.....25020	7990.....25583	7740.....26157	7494.....26741	12
	8501.....24477	8241.....25029	7986.....25592	7736.....26166	7490.....26751	
19	8496.....24486	8237.....25038	7982.....25602	7731.....26176	7486.....26761	11
	8492.....24495	8232.....25048	7977.....25611	7727.....26185	7482.....26771	
20	8488.....24504	8228.....25057	7973.....25621	7723.....26195	7478.....26781	10
	8483.....24513	8224.....25066	7969.....25630	7719.....26205	7474.....26790	
21	8479.....24522	8219.....25076	7965.....25640	7715.....26214	7470.....26800	9
	8475.....24531	8215.....25085	7961.....25649	7711.....26224	7466.....26810	
22	8470.....24540	8211.....25094	7956.....25659	7707.....26234	7462.....26820	8
	8466.....24550	8207.....25104	7952.....25668	7702.....26244	7458.....26830	
23	8461.....24559	8202.....25113	7948.....25678	7698.....26253	7453.....26840	7
	8457.....24568	8198.....25122	7944.....25687	7694.....26263	7449.....26850	
24	8453.....24577	8194.....25132	7940.....25697	7690.....26273	7445.....26860	6
	8448.....24586	8189.....25141	7935.....25706	7686.....26282	7441.....26869	
25	8444.....24595	8185.....25150	7931.....25716	7682.....26292	7437.....26879	5
	8440.....24605	8181.....25160	7927.....25725	7678.....26302	7433.....26889	
26	8435.....24614	8177.....25169	7923.....25735	7674.....26311	7429.....26899	4
	8431.....24623	8172.....25178	7919.....25744	7670.....26321	7425.....26909	
27	8427.....24632	8168.....25188	7914.....25754	7665.....26331	7421.....26919	3
	8422.....24641	8164.....25197	7910.....25763	7661.....26340	7417.....26929	
28	8418.....24650	8160.....25206	7906.....25773	7657.....26350	7413.....26939	2
	8414.....24660	8155.....25216	7902.....25782	7653.....26360	7409.....26949	
29	8409.....24669	8151.....25225	7898.....25792	7649.....26370	7405.....26958	1
	8405.....24678	8147.....25234	7893.....25801	7645.....26379	7401.....26968	
30	8401.....24687	8143.....25244	7889.....25811	7641.....26389	7397.....26978	0
	A B	A B	A B	A B	A B	
	124°30'	124°00'	123°30'	123°00'	122°30'	

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	57°30'	58°00'	58°30'	59°00'	59°30'	
	A B	A B	A B	A B	A B	
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1	7389.....26998	7150.....27599	6916.....28212	6686.....28837	6460.....29475	29
	7385.....27008	7146.....27609	6912.....28222	6682.....28848	6457.....29485	
2	7381.....27018	7142.....27619	6908.....28233	6678.....28858	6453.....29496	28
	7377.....27028	7138.....27630	6904.....28243	6674.....28869	6449.....29507	
3	7373.....27038	7134.....27640	6900.....28253	6671.....28879	6446.....29517	27
	7369.....27048	7130.....27650	6896.....28264	6667.....28890	6442.....29528	
4	7365.....27058	7126.....27660	6892.....28274	6663.....28900	6438.....29539	26
	7361.....27068	7122.....27670	6889.....28284	6659.....28911	6434.....29550	
5	7357.....27078	7118.....27680	6885.....28295	6655.....28921	6431.....29560	25
	7353.....27088	7115.....27690	6881.....28305	6652.....28932	6427.....29571	
6	7349.....27098	7111.....27701	6877.....28315	6648.....28942	6423.....29582	24
	7345.....27107	7107.....27711	6873.....28326	6644.....28953	6420.....29593	
7	7341.....27117	7103.....27721	6869.....28336	6640.....28964	6416.....29604	23
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8	7333.....27137	7095.....27741	6862.....28357	6633.....28985	6409.....29625	22
	7329.....27147	7091.....27751	6858.....28367	6629.....28995	6405.....29636	
9	7325.....27157	7087.....27761	6854.....28378	6625.....29006	6401.....29647	21
	7321.....27167	7083.....27772	6850.....28388	6622.....29016	6397.....29657	
10	7317.....27177	7079.....27782	6846.....28398	6618.....29027	6394.....29668	20
	7313.....27187	7075.....27792	6842.....28409	6614.....29038	6390.....29679	
11	7309.....27197	7071.....27802	6839.....28419	6610.....29048	6386.....29690	19
	7305.....27207	7068.....27812	6835.....28429	6607.....29059	6383.....29701	
12	7301.....27217	7064.....27823	6831.....28440	6603.....29069	6379.....29711	18
	7297.....27227	7060.....27833	6827.....28450	6599.....29080	6375.....29722	
13	7293.....27237	7056.....27843	6823.....28461	6595.....29091	6372.....29733	17
	7289.....27247	7052.....27853	6819.....28471	6591.....29101	6368.....29744	
14	7285.....27257	7048.....27863	6815.....28481	6588.....29112	6364.....29755	16
	7281.....27267	7044.....27874	6812.....28492	6584.....29122	6361.....29766	
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	7273.....27287	7036.....27894	6804.....28513	6576.....29144	6353.....29787	
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	7265.....27307	7028.....27914	6796.....28533	6569.....29165	6346.....29809	
17	7261.....27317	7024.....27925	6792.....28544	6565.....29175	6342.....29820	13
	7257.....27327	7021.....27935	6789.....28554	6561.....29186	6338.....29831	
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	7249.....27347	7013.....27955	6781.....28575	6554.....29207	6331.....29852	
19	7245.....27357	7009.....27965	6777.....28586	6550.....29218	6327.....29863	11
	7241.....27367	7005.....27976	6773.....28596	6546.....29229	6324.....29874	
20	7237.....27377	7001.....27986	6770.....28607	6543.....29239	6320.....29885	10
	7233.....27387	6997.....27996	6766.....28617	6539.....29250	6316.....29896	
21	7229.....27398	6993.....28006	6762.....28627	6535.....29261	6313.....29907	9
	7225.....27408	6989.....28017	6758.....28638	6531.....29271	6309.....29917	
22	7221.....27418	6985.....28027	6754.....28648	6528.....29282	6305.....29929	8
	7217.....27428	6982.....28037	6750.....28659	6524.....29293	6302.....29939	
23	7213.....27438	6978.....28047	6747.....28669	6520.....29303	6298.....29950	7
	7209.....27448	6974.....28058	6743.....28680	6516.....29314	6294.....29961	
24	7205.....27458	6970.....28068	6739.....28690	6513.....29325	6291.....29972	6
	7201.....27468	6966.....28078	6735.....28701	6509.....29335	6287.....29983	
25	7197.....27478	6962.....28089	6731.....28711	6505.....29346	6283.....29994	5
	7193.....27488	6958.....28099	6728.....28722	6502.....29357	6280.....30005	
26	7190.....27498	6954.....28109	6724.....28732	6498.....29367	6276.....30015	4
	7186.....27508	6951.....28119	6720.....28743	6494.....29378	6272.....30026	
27	7182.....27518	6947.....28130	6716.....28753	6490.....29389	6269.....30037	3
	7178.....27528	6943.....28140	6712.....28763	6487.....29399	6265.....30048	
28	7174.....27539	6939.....28150	6709.....28774	6483.....29410	6261.....30059	2
	7170.....27549	6935.....28161	6705.....28784	6479.....29421	6258.....30070	
29	7166.....27559	6931.....28171	6701.....28795	6475.....29432	6254.....30081	1
	7162.....27569	6927.....28181	6697.....28806	6472.....29442	6251.....30092	
30	7158.....27579	6923.....28191	6693.....28816	6468.....29453	6247.....30103	0
	A B	A B	A B	A B	A B	
	122°00'	121°30'	121°00'	120°30'	120°00'	

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	60°00'	60°30'	61°00'	61°30'	62°00'	
	A B	A B	A B	A B	A B	
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	6243.....30114	6027.....30777	5815.....31454	5607.....32145	5403.....32851	
1	6240.....30125	6023.....30788	5811.....31466	5603.....32157	5400.....32863	29
	6236.....30136	6020.....30800	5808.....31477	5600.....32169	5396.....32875	
2	6232.....30147	6016.....30811	5804.....31488	5596.....32180	5393.....32887	28
	6229.....30158	6012.....30822	5801.....31500	5593.....32192	5390.....32898	
3	6225.....30169	6009.....30833	5797.....31511	5590.....32204	5386.....32910	27
	6221.....30180	6005.....30844	5794.....31523	5586.....32215	5383.....32922	
4	6218.....30191	6002.....30856	5790.....31534	5583.....32227	5380.....32934	26
	6214.....30202	5998.....30867	5787.....31546	5579.....32239	5376.....32946	
5	6210.....30213	5995.....30878	5783.....31557	5575.....32250	5373.....32958	25
	6207.....30224	5991.....30889	5780.....31569	5572.....32262	5370.....32970	
6	6203.....30235	5987.....30900	5776.....31580	5569.....32274	5366.....32982	24
	6200.....30245	5984.....30912	5773.....31591	5566.....32285	5363.....32994	
7	6196.....30256	5980.....30923	5769.....31603	5562.....32297	5360.....33006	23
	6192.....30267	5977.....30934	5766.....31614	5559.....32309	5356.....33018	
8	6189.....30278	5973.....30945	5762.....31626	5555.....32320	5353.....33030	22
	6185.....30289	5970.....30956	5759.....31637	5552.....32332	5350.....33042	
9	6181.....30300	5966.....30968	5755.....31649	5549.....32344	5346.....33054	21
	6178.....30311	5963.....30979	5752.....31660	5545.....32355	5343.....33065	
10	6174.....30322	5959.....30990	5748.....31672	5542.....32367	5340.....33077	20
	6171.....30334	5955.....31001	5745.....31683	5538.....32379	5336.....33089	
11	6167.....30345	5952.....31013	5741.....31694	5535.....32391	5333.....33101	19
	6163.....30355	5948.....31024	5738.....31706	5532.....32402	5330.....33113	
12	6160.....30367	5945.....31035	5734.....31717	5528.....32414	5326.....33125	18
	6156.....30378	5941.....31046	5731.....31729	5525.....32426	5323.....33137	
13	6152.....30389	5938.....31058	5727.....31740	5521.....32438	5320.....33149	17
	6149.....30400	5934.....31069	5724.....31752	5518.....32449	5316.....33161	
14	6145.....30411	5931.....31080	5720.....31763	5515.....32461	5313.....33173	16
	6142.....30422	5927.....31091	5717.....31775	5511.....32473	5310.....33185	
15	6138.....30433	5924.....31103	5714.....31786	5508.....32484	5306.....33197	15
	6134.....30444	5920.....31114	5710.....31798	5504.....32496	5303.....33209	
16	6131.....30455	5917.....31125	5707.....31809	5501.....32508	5300.....33221	14
	6127.....30466	5913.....31137	5703.....31821	5498.....32520	5296.....33233	
17	6124.....30477	5609.....31148	5700.....31833	5494.....32532	5293.....33245	13
	6120.....30488	5906.....31159	5696.....31844	5491.....32543	5290.....33257	
18	6116.....30499	5902.....31170	5693.....31856	5487.....32555	5286.....33269	12
	6113.....30510	5899.....31182	5689.....31867	5484.....32567	5283.....33281	
19	6109.....30521	5895.....31193	5686.....31879	5481.....32579	5280.....33293	11
	6106.....30532	5892.....31204	5682.....31890	5477.....32590	5276.....33306	
20	6102.....30544	5888.....31216	5679.....31902	5474.....32602	5273.....33318	10
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21	6095.....30566	5881.....31238	5672.....31925	5467.....32625	5266.....33342	9
	6091.....30577	5878.....31250	5669.....31936	5464.....32638	5263.....33354	
22	6088.....30588	5874.....31261	5665.....31948	5460.....32649	5260.....33366	8
	6084.....30599	5871.....31272	5662.....31960	5457.....32661	5257.....33378	
23	6080.....30610	5867.....31284	5658.....31971	5454.....32673	5253.....33390	7
	6077.....30621	5864.....31295	5655.....31983	5450.....32685	5250.....33402	
24	6073.....30632	5860.....31306	5651.....31994	5447.....32697	5247.....33414	6
	6070.....30643	5857.....31318	5648.....32006	5443.....32709	5243.....33426	
25	6066.....30655	5853.....31329	5644.....32018	5440.....32720	5240.....33438	5
	6062.....30666	5850.....31340	5641.....32029	5437.....32732	5237.....33450	
26	6059.....30677	5846.....31352	5638.....32041	5433.....32744	5233.....33462	4
	6055.....30688	5843.....31363	5634.....32052	5430.....32756	5230.....33475	
27	6052.....30699	5839.....31375	5631.....32064	5427.....32768	5227.....33487	3
	6048.....30710	5836.....31386	5627.....32076	5423.....32780	5224.....33499	
28	6045.....30721	5832.....31397	5624.....32087	5420.....32792	5220.....33511	2
	6041.....30733	5829.....31409	5620.....32099	5417.....32803	5217.....33523	
29	6937.....30744	5825.....31420	5617.....32110	5413.....32815	5214.....33535	1
	6034.....30755	5822.....31431	5614.....32122	5410.....32827	5210.....33547	
30	6030.....30766	5818.....31443	5610.....32134	5406.....32839	5207.....33559	0
	A B	A B	A B	A B	A B	
	119°30'	119°00'	118°30'	118°00'	117°30'	

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	62°30'	63°00'	63°30'	64°00'	64°30'	
	A B	A B	A B	A B	A B	
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1	5200.....33584	5005.....34320	4815.....35073	4628.....35842	4445.....36628	29
	5197.....33596	5002.....34332	4811.....35085	4625.....35855	4442.....36641	
2	5194.....33608	4999.....34345	4808.....35098	4622.....35868	4439.....36655	28
	5191.....33620	4996.....34357	4805.....35111	4619.....35881	4436.....36668	
3	5187.....33632	4993.....34370	4802.....35123	4615.....35894	4433.....36681	27
	5184.....33644	4989.....34382	4799.....35136	4612.....35907	4430.....36694	
4	5181.....33657	4986.....34395	4796.....35149	4609.....35920	4427.....36708	26
	5178.....33669	4983.....34407	4793.....35161	4606.....35933	4424.....36721	
5	5174.....33681	4980.....34420	4789.....35174	4603.....35946	4421.....36734	25
	5171.....33693	4977.....34432	4786.....35187	4600.....35959	4418.....36747	
6	5168.....33705	4973.....34444	4783.....35200	4597.....35972	4415.....36761	24
	5164.....33717	4970.....34457	4780.....35212	4594.....35985	4412.....36774	
7	5161.....33730	4967.....34469	4777.....35225	4591.....35998	4409.....36787	23
	5158.....33742	4964.....34482	4774.....35238	4588.....36011	4406.....36801	
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11	5135.....33827	4941.....34569	4752.....35327	4566.....36102	4385.....36894	19
	5132.....33840	4938.....34582	4749.....35340	4563.....36115	4382.....36907	
12	5128.....33852	4935.....34594	4746.....35353	4560.....36128	4379.....36921	18
	5125.....33864	4932.....34607	4742.....35365	4557.....36141	4376.....36934	
13	5122.....33876	4929.....34619	2739.....35378	4554.....36154	4373.....36948	17
	5119.....33889	4925.....34632	4736.....35391	4551.....36167	4370.....36961	
14	5115.....33901	4922.....34644	4733.....35404	4548.....36180	4367.....36974	16
	5112.....33913	4919.....34657	4730.....35417	4545.....36193	4364.....36988	
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	5106.....39938	4913.....34682	4724.....35442	4529.....36220	4358.....37014	
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	5099.....33962	4906.....34707	4718.....35468	4533.....36246	4352.....37041	
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	5093.....33987	4900.....34732	4711.....35493	4527.....36272	4346.....37068	
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	5086.....34011	4894.....34757	4705.....35519	4521.....36298	4340.....37095	
19	5083.....34024	4890.....34770	4702.....35532	4518.....36311	4337.....37108	11
	5080.....34036	4887.....34782	4699.....35545	4515.....36325	4334.....37122	
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	5073.....34061	4881.....34807	4693.....35571	4509.....36351	4329.....37149	
21	5070.....34073	4878.....34820	4690.....35583	4506.....36364	4326.....37162	9
	5067.....34085	4875.....34832	4686.....35596	4503.....36377	4323.....37176	
22	5064.....34097	4871.....34845	4683.....35609	4500.....36390	4320.....37189	8
	5060.....34110	4968.....34858	4680.....35622	4497.....36403	4317.....37203	
23	5057.....34122	4865.....34870	4677.....35635	4493.....36417	4314.....37216	7
	5054.....34134	4862.....34883	4674.....35648	4490.....36430	4311.....37229	
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	5047.....34159	4856.....34908	4668.....35674	4484.....36456	4305.....37256	
25	5044.....34172	4852.....34921	4665.....35686	4481.....36469	4302.....37270	5
	5041.....34184	4849.....34933	4662.....35699	4478.....36483	4299.....37283	
26	5038.....34196	4846.....34946	4659.....35712	4475.....36496	4296.....37297	4
	5034.....34209	4843.....34959	4656.....35725	4472.....36509	4293.....37310	
27	5031.....34221	4840.....34971	4652.....35738	4469.....36522	4290.....37324	3
	5028.....34233	4837.....34984	4649.....35751	4466.....36535	4287.....37337	
28	5025.....34246	4833.....34997	4646.....35764	4463.....36549	4284.....37351	2
	5022.....34258	4830.....35009	4643.....35777	4460.....36562	4281.....37365	
29	5018.....34270	4827.....35022	4640.....35790	4457.....36575	4278.....37378	1
	5015.....34283	4824.....35035	4637.....35803	4454.....36588	4275.....37392	
30	5012.....34295	4821.....35047	4634.....35816	4451.....36602	4272.....37405	0
	A B	A B	A B	A B	A B	
	117°00'	116°30'	116°00'	115°30'	115°00'	

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	65°00'	65°30'	66°00'	66°30'	67°00'	
	A B	A B	A B	A B	A B	
0	4272.....37405	4098.....38227	3927.....39069	3760.....39930	3597.....40812	30
	4269.....37419	4095.....38241	3924.....39083	3757.....39945	3595.....40827	
1	4266.....37432	4092.....38255	3921.....39097	3755.....39959	3592.....40842	29
	4264.....37446	4089.....38269	3918.....39111	3752.....39974	3589.....40857	
2	4261.....37459	4086.....38283	3916.....39125	3749.....39988	3587.....40872	28
	4258.....37473	4083.....38297	3913.....39140	3746.....40003	3584.....40887	
3	4255.....37487	4080.....38311	3910.....39154	3744.....40017	3581.....40902	27
	4252.....37500	4078.....38324	3907.....39168	3741.....40032	3579.....40916	
4	4249.....37514	4075.....38338	3904.....39182	3738.....40046	3576.....40931	26
	4246.....37527	4072.....38352	3902.....39197	3735.....40061	3573.....40946	
5	4243.....37541	4069.....38366	3899.....39211	3733.....40076	3571.....40961	25
	4240.....37554	4066.....38380	3896.....39225	3730.....40090	3568.....40976	
6	4237.....37568	4063.....38394	3893.....39239	3727.....40105	3565.....40991	24
	4234.....37582	4060.....38408	3890.....39254	3725.....40119	3563.....41006	
7	4231.....37595	4057.....38422	3888.....39268	3722.....40134	3560.....41021	23
	4228.....37609	3055.....38436	3885.....39282	3719.....40149	3557.....41036	
8	4225.....37623	4052.....38450	3882.....39296	3716.....40163	3555.....41051	22
	4222.....37636	4049.....38464	3879.....39311	3714.....40178	3552.....41066	
9	4220.....37650	4046.....38478	3876.....39325	3711.....40192	3549.....41081	21
	4217.....37663	4043.....38492	3874.....39339	3708.....40207	3547.....41096	
10	4214.....37677	4040.....38506	3871.....39353	3705.....40222	3544.....41111	20
	4211.....37691	4037.....38520	3868.....39368	3703.....40236	3541.....41126	
11	4208.....37704	4035.....38533	3865.....39382	3700.....40251	3539.....41141	19
	4205.....37718	4032.....38547	3863.....39396	3697.....40266	3536.....41156	
12	4202.....37732	4029.....38561	3860.....39411	3695.....40280	3533.....41171	18
	4199.....37745	4026.....38575	3857.....39425	3692.....40295	3531.....41186	
13	4196.....37759	4023.....38589	3854.....39439	3689.....40310	3528.....41201	17
	4193.....37773	4020.....38603	3851.....39454	3686.....40324	3525.....41216	
14	4190.....37786	4017.....38617	3849.....39468	3684.....40339	3523.....41231	16
	4187.....37800	4015.....38631	3846.....39482	3681.....40354	3520.....41246	
15	4185.....37814	4012.....38645	3843.....39497	3678.....40368	3517.....41261	15
	4182.....37828	4009.....38660	3840.....39511	3676.....40383	3515.....41276	
16	4179.....37841	4006.....38674	3838.....39525	3673.....40398	3512.....41291	14
	4176.....37855	4003.....38688	3835.....39540	3670.....40413	3509.....41307	
17	4173.....37869	4000.....38702	3832.....39554	3667.....40427	3507.....41322	13
	4170.....37882	3998.....38716	3829.....39569	3665.....40442	3504.....41337	
18	4167.....37896	3995.....38730	3826.....39583	3662.....40457	3502.....41352	12
	4164.....37910	3992.....38744	3824.....39597	3659.....40471	3499.....41367	
19	4161.....37924	3989.....38758	3821.....39612	3657.....40486	3496.....41382	11
	4158.....37937	3986.....38772	3818.....39626	3654.....40501	3494.....41397	
20	4155.....37951	3983.....38786	3815.....39641	3651.....40516	3491.....41412	10
	4153.....37965	3981.....38800	3813.....39655	3648.....40530	3488.....41427	
21	4150.....37979	3978.....38814	3810.....39669	3646.....40545	3486.....41443	9
	4147.....37992	3975.....38828	3807.....39684	3643.....40560	3483.....41458	
22	4144.....38006	3972.....38842	3804.....39698	3640.....40575	3480.....41473	8
	4141.....38020	3969.....38856	3801.....39713	3638.....40590	3478.....41488	
23	4138.....38034	3966.....38871	3799.....39727	3635.....40604	3475.....41503	7
	4135.....38048	3964.....38885	3796.....39742	3632.....40619	3473.....41518	
24	4132.....38061	3961.....38899	3793.....39756	3630.....40634	3470.....41533	6
	4129.....38075	3958.....38913	3790.....39771	3627.....40649	3467.....41549	
25	4127.....38089	3955.....38927	3788.....39785	3624.....40664	3465.....41564	5
	4124.....38103	3952.....38941	3785.....39799	3622.....40678	3462.....41579	
26	4121.....38117	3949.....38955	3782.....39814	3619.....40693	3459.....41594	4
	4118.....38130	3947.....38969	3779.....39828	3616.....40708	3457.....41609	
27	4115.....38144	3944.....38984	3777.....39843	3613.....40723	3454.....41625	3
	4112.....38158	3941.....38998	3774.....39857	3611.....40738	3452.....41640	
28	4109.....38172	3938.....39012	3771.....39872	3608.....40753	3449.....41655	2
	4106.....38186	3935.....39026	3768.....39886	3605.....40768	3446.....41670	
29	4103.....38200	3933.....39040	3766.....39901	3603.....40782	3444.....41685	1
	4101.....38213	3930.....39054	3763.....39915	3600.....40797	3441.....41701	
30	4098.....38227	3927.....39069	3760.....39930	3597.....40812	3438.....41716	0
	A B	A B	A B	A B	A B	
	114°30'	114°00'	113°30'	113°00'	112°30'	

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	67°30'	68°00'	68°30'	69°00'	69°30'	
	A B	A B	A B	A B	A B	
0	3438.....41716	3283.....42642	3132.....43592	2985.....44567	2841.....45567	30
	3436.....41731	3281.....42658	3130.....43608	2982.....44583	2839.....45584	
1	3433.....41746	3278.....42674	3127.....43624	2980.....44600	2836.....45601	29
	3431.....41762	3276.....42689	3125.....43641	2978.....44616	2834.....45618	
2	3428.....41777	3273.....42705	3122.....43657	2975.....44633	2832.....45635	28
	3425.....41792	3271.....42721	3120.....43673	2973.....44649	2829.....45652	
3	3423.....41808	3268.....42736	3117.....43689	2970.....44666	2827.....45669	27
	3420.....41823	3266.....42752	3115.....43705	2968.....44682	2825.....45686	
4	3418.....41838	3263.....42768	3112.....43721	2965.....44699	2822.....45703	26
	3415.....41853	3260.....42783	3110.....43737	2963.....44715	2820.....45720	
5	3412.....41869	3258.....42799	3107.....43753	2961.....44732	2818.....45737	25
	3410.....41884	3255.....42815	3105.....43769	2958.....44748	2815.....45754	
6	3407.....41899	3253.....42830	3102.....43785	2956.....44765	2813.....45771	24
	3404.....41915	3250.....42846	3100.....43801	2953.....44782	2811.....45788	
7	3402.....41930	3248.....42862	3097.....43818	2951.....44798	2808.....45805	23
	3399.....41945	3245.....42878	3095.....43834	2949.....44815	2806.....45822	
8	3397.....41961	3243.....42893	3092.....43850	2946.....44831	2804.....45839	22
	3394.....41976	3240.....42909	3090.....43866	2944.....44848	2801.....45856	
9	3391.....41991	3237.....42925	3088.....43882	2941.....44864	2799.....45873	21
	3389.....42007	3235.....42941	3085.....43898	2939.....44881	2797.....45890	
10	3386.....42022	3233.....42956	3083.....43914	2936.....44898	2794.....45907	20
	3384.....42038	3230.....42972	3080.....43931	2934.....44914	2792.....45924	
11	3381.....42053	3227.....42988	3078.....43947	2932.....44931	2789.....45941	19
	3379.....42068	3225.....43004	3075.....43963	2929.....44947	2787.....45958	
12	3376.....42084	3222.....43020	3073.....43979	2927.....44964	2785.....45975	18
	3373.....42099	3220.....43035	3070.....43995	2924.....44981	2782.....45992	
13	3371.....42115	3217.....43051	3068.....44012	2922.....44997	2780.....46009	17
	3368.....42130	3215.....43067	3065.....44028	2920.....45014	2778.....46026	
14	3366.....42145	3212.....43083	3063.....44044	2917.....45031	2775.....46043	16
	3363.....42161	3210.....43099	3060.....44060	2915.....45047	2773.....46061	
15	3360.....42176	3207.....43114	3058.....44077	2913.....45064	2771.....46078	15
	3358.....42192	3205.....43130	3056.....44093	2910.....45081	2768.....46095	
16	3355.....42207	3202.....43146	3053.....44109	2908.....45097	2766.....46112	14
	3353.....42223	3200.....43162	3051.....44125	2905.....45114	2764.....46129	
17	3350.....42238	3197.....43178	3048.....44142	2903.....45131	2761.....46146	13
	3348.....42254	3195.....43194	3046.....44158	2901.....45147	2759.....46163	
18	3345.....42269	3192.....43210	3043.....44174	2898.....45164	2757.....46181	12
	3342.....42285	3190.....43225	3041.....44190	2896.....45181	2755.....46198	
19	3340.....42300	3187.....43241	3038.....44207	2893.....45198	2752.....46215	11
	3337.....42316	3185.....43257	3036.....44223	2891.....45214	2750.....46232	
20	3335.....42331	3182.....43273	3033.....44239	2889.....45231	2748.....46249	10
	3332.....42347	3180.....43289	3031.....44256	2886.....45248	2745.....46266	
21	3329.....42362	3177.....43305	3029.....44272	2884.....45265	2743.....46284	9
	3327.....42378	3175.....43321	3026.....44288	2881.....45281	2741.....46301	
22	3324.....42393	3172.....43337	3024.....44305	2879.....45298	2738.....46318	8
	3322.....42409	3170.....43353	3021.....44321	2877.....45315	2736.....46335	
23	3319.....42424	3167.....43369	3019.....44337	2874.....45332	2734.....46353	7
	3317.....42440	3165.....43385	3016.....44354	2872.....45348	2731.....46370	
24	3314.....42455	3162.....43400	3014.....44370	2870.....45365	2729.....46387	6
	3312.....42471	3160.....43416	3012.....44386	2867.....45382	2727.....46404	
25	3309.....42486	3157.....43432	3009.....44403	2865.....45399	2724.....46422	5
	3306.....42502	3155.....43448	3007.....44419	2862.....45416	2722.....46439	
26	3304.....42518	3152.....43464	3004.....44436	2860.....45433	2720.....46456	4
	3301.....42533	3150.....43480	3002.....44452	2858.....45449	2717.....46473	
27	3299.....42549	3147.....43496	2999.....44468	2855.....45466	2715.....46491	3
	3296.....42564	3145.....43512	2997.....44485	2853.....45483	2713.....46508	
28	3294.....42580	3142.....43528	2994.....44501	2851.....45500	2711.....46525	2
	3291.....42596	3140.....43544	2992.....44518	2848.....45517	2708.....46543	
29	3289.....42611	3137.....43560	2990.....44534	2846.....45534	2706.....46560	1
	3286.....42627	3135.....43576	2987.....44551	2844.....45551	2704.....46577	
30	3283.....42642	3132.....43592	2985.....44567	2841.....45567	2701.....46595	0
	A B	A B	A B	A B	A B	
	112°00'	111°30'	111°00'	110°30'	110°00'	

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	70°00'		70°30'		71°00'		71°30'		72°00'		
	A	B	A	B	A	B	A	B	A	B	
0	2701	46595	2565	47650	2433	48736	2304	49852	2179	51002	30
	2699	46612	2563	47668	2431	48754	2302	49871	2177	51021	
1	2697	46630	2561	47686	2429	48772	2300	49890	2175	51041	29
	2694	46647	2559	47704	2427	48791	2298	49909	2173	51060	
2	2692	46664	2556	47722	2424	48809	2296	49928	2171	51080	28
	2690	46682	2554	47740	2422	48828	2294	49947	2169	51099	
3	2688	46699	2552	47758	2420	48846	2292	49966	2167	51119	27
	2685	46716	2550	47775	2418	48864	2290	49985	2165	51138	
4	2683	46734	2547	47793	2416	48883	2287	50004	2163	51158	26
	2681	46751	2545	47811	2413	48901	2285	50023	2161	51177	
5	2678	46769	2543	47829	2411	48920	2283	50042	2159	51197	25
	2676	46786	2541	47847	2409	48938	2281	50061	2157	51216	
6	2674	46804	2539	47865	2407	48957	2279	50080	2155	51236	24
	2672	46821	2536	47883	2405	48975	2277	50098	2153	51255	
7	2669	46839	2534	47901	2403	48993	2275	50117	2151	51275	23
	2667	46856	2532	47919	2400	49012	2273	50137	2149	51294	
8	2665	46873	2530	47937	2398	49030	2271	50156	2147	51314	22
	2662	46891	2528	47955	2396	49049	2269	50175	2145	51334	
9	2660	46908	2525	47973	2394	49067	2266	50194	2143	51353	21
	2658	46926	2523	47991	2392	49086	2264	50213	2141	51373	
10	2656	46943	2521	48009	2390	49104	2262	50232	2138	51392	20
	2653	46961	2519	48027	2387	49123	2260	50251	2136	51412	
11	2651	46978	2516	48045	2385	49141	2258	50270	2134	51432	19
	2649	46996	2514	48063	2383	49160	2256	50289	2132	51451	
12	2646	47014	2512	48081	2381	49179	2254	50308	2130	51471	18
	2644	47031	2510	48099	2379	49197	2252	50327	2128	51491	
13	2642	47049	2507	48117	2377	49216	2250	50346	2126	51510	17
	2640	47066	2505	48135	2375	49234	2248	50365	2124	51530	
14	2637	47084	2503	48153	2372	49253	2246	50385	2122	51550	16
	2635	47101	2501	48171	2370	49271	2243	50404	2120	51570	
15	2633	47119	2499	48189	2368	49290	2241	50423	2118	51589	15
	2631	47137	2496	48207	2366	49309	2239	50442	2116	51609	
16	2628	47154	2494	48226	2364	49327	2237	50461	2114	51629	14
	2626	47172	2492	48244	2362	49346	2235	50480	2112	51649	
17	2624	47189	2490	48262	2360	49365	2233	50499	2110	51668	13
	2622	47207	2488	48280	2358	49383	2231	50519	2108	51688	
18	2619	47225	2485	48298	2355	49402	2229	50538	2106	51708	12
	2617	47242	2483	48316	2353	49421	2227	50557	2104	51728	
19	2615	47269	2481	48334	2351	49439	2225	50576	2102	51747	11
	2613	47278	2479	48352	2349	49458	2223	50596	2100	51767	
20	2610	47295	2477	48371	2347	49477	2221	50615	2098	51787	10
	2608	47313	2474	48389	2345	49495	2218	50634	2096	51807	
21	2606	47331	2472	48407	2343	49514	2216	50653	2094	51827	9
	2604	47348	2470	48425	2340	49533	2214	50673	2092	51847	
22	2601	47366	2468	48443	2338	49551	2212	50692	2090	51867	8
	2599	47384	2466	48462	2336	49570	2210	50711	2088	51886	
23	2597	47402	2463	48480	2334	49589	2208	50730	2086	51906	7
	2594	47419	2461	48498	2332	49608	2206	50750	2084	51926	
24	2592	47437	2459	48516	2330	49626	2204	50769	2082	51946	6
	2590	47455	2457	48534	2328	49645	2202	50788	2080	51966	
25	2588	47472	2455	48553	2325	49664	2200	50808	2078	51986	5
	2585	47490	2453	48571	2323	49683	2198	50827	2076	52006	
26	2583	47508	2450	48589	2321	49702	2196	50846	2074	52026	4
	2581	47526	2448	48608	2319	49720	2194	50866	2072	52046	
27	2579	47544	2446	48626	2317	49739	2192	50885	2070	52066	3
	2576	47561	2444	48644	2315	49758	2190	50905	2068	52086	
28	2574	47579	2442	48662	2313	49777	2188	50924	2066	52106	2
	2572	47597	2439	48681	2311	49796	2185	50943	2064	52126	
29	2570	47615	2437	48699	2309	49815	2183	50963	2062	52146	1
	2568	47633	2435	48717	2306	49833	2181	50982	2060	52166	
30	2565	47650	2433	48736	2304	49852	2179	51002	2058	52186	0
	A	B	A	B	A	B	A	B	A	B	
	109°30'		109°00'		108°30'		108°00'		107°30'		

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	72°30'	73°00'	73°30'	74°00'	74°30'	
	A B	A B	A B	A B	A B	
0	2058.....52186	1940.....53406	1826.....54666	1716.....55966	1609.....57310	30
	2056.....52206	1938.....53427	1824.....54687	1714.....55988	1607.....57333	
1	2054.....52226	1936.....53448	1823.....54708	1712.....56010	1605.....57356	29
	2052.....52246	1935.....53468	1821.....54730	1710.....56032	1604.....57378	
2	2050.....52266	1933.....53489	1819.....54751	1709.....56054	1602.....57401	28
	2048.....52286	1931.....53510	1817.....54773	1707.....56076	1600.....57424	
3	2046.....52306	1929.....53531	1815.....54794	1705.....56099	1598.....57447	27
	2044.....52326	1927.....53551	1813.....54815	1703.....56121	1597.....57470	
4	2042.....52346	1925.....53572	1811.....54837	1701.....56143	1595.....57493	26
	2040.....52366	1923.....53593	1809.....54858	1700.....56165	1593.....57516	
5	2038.....52387	1921.....53614	1808.....54880	1698.....56187	1591.....57538	25
	2036.....52407	1919.....53634	1806.....54901	1696.....56209	1590.....57561	
6	2034.....52427	1917.....53655	1804.....54922	1694.....56231	1588.....57584	24
	2032.....52447	1915.....53676	1802.....54944	1692.....56254	1586.....57607	
7	2030.....52467	1913.....53697	1800.....54965	1691.....56276	1584.....57630	23
	2028.....52487	1911.....53718	1798.....54987	1689.....56298	1583.....57653	
8	2026.....52508	1910.....53738	1796.....55008	1687.....56320	1581.....57676	22
	2024.....52528	1908.....53759	1795.....55030	1685.....56342	1579.....57699	
9	2022.....52548	1906.....53780	1793.....55051	1683.....56365	1578.....57722	21
	2020.....52568	1904.....53801	1791.....55073	1682.....56387	1576.....57745	
10	2018.....52588	1902.....53822	1789.....55095	1680.....56409	1574.....57768	20
	2016.....52609	1900.....53843	1787.....55116	1678.....56431	1572.....57791	
11	2014.....52629	1898.....53864	1785.....55138	1676.....56454	1571.....57814	19
	2012.....52649	1896.....53884	1783.....55159	1674.....56476	1569.....57837	
12	2010.....52670	1894.....53905	1782.....55181	1673.....56498	1567.....57860	18
	2009.....52690	1892.....53926	1780.....55202	1671.....56521	1565.....57884	
13	2007.....52710	1890.....53947	1778.....55224	1669.....56543	1564.....57907	17
	2005.....52730	1889.....53968	1776.....55246	1667.....56565	1562.....57930	
14	2003.....52751	1887.....53989	1774.....55267	1665.....56588	1560.....57953	16
	2001.....52771	1885.....54010	1772.....55289	1664.....56610	1559.....57976	
15	1999.....52791	1883.....54031	1771.....55311	1662.....56632	1557.....57999	15
	1997.....52812	1881.....54052	1769.....55332	1660.....56655	1555.....58022	
16	1995.....52832	1879.....54073	1767.....55354	1658.....56677	1553.....58046	14
	1993.....52852	1877.....54094	1765.....55376	1657.....56700	1552.....58069	
17	1991.....52873	1875.....54115	1763.....55397	1655.....56722	1550.....58092	13
	1989.....52893	1873.....54136	1761.....55419	1653.....56745	1548.....58115	
18	1987.....52914	1871.....54157	1760.....55441	1651.....56767	1546.....58138	12
	1985.....52934	1870.....54178	1758.....55463	1650.....56790	1545.....58162	
19	1983.....52954	1868.....54199	1756.....55484	1648.....56812	1543.....58185	11
	1981.....52975	1866.....54220	1754.....55506	1646.....56835	1541.....58208	
20	1979.....52995	1864.....54242	1752.....55528	1644.....56857	1540.....58232	10
	1977.....53016	1862.....54263	1750.....55550	1642.....56880	1538.....58255	
21	1975.....53036	1860.....54284	1749.....55572	1641.....56902	1536.....58278	9
	1973.....53057	1858.....54305	1747.....55593	1639.....56925	1534.....58302	
22	1971.....53077	1856.....54326	1745.....55615	1637.....56947	1533.....58325	8
	1969.....53098	1854.....54347	1743.....55637	1635.....56970	1531.....58348	
23	1967.....53118	1853.....54368	1741.....55659	1634.....56992	1529.....58372	7
	1966.....53139	1851.....54390	1739.....55681	1632.....57015	1528.....58395	
24	1964.....53159	1849.....54411	1738.....55703	1630.....57038	1526.....58418	6
	1962.....53180	1847.....54432	1736.....55725	1628.....57060	1524.....58442	
25	1960.....53200	1845.....54453	1734.....55746	1627.....57083	1523.....58465	5
	1958.....53221	1843.....54474	1732.....55768	1625.....57106	1521.....58489	
26	1956.....53241	1841.....54496	1730.....55790	1623.....57128	1519.....58512	4
	1954.....53262	1839.....54517	1728.....55812	1621.....57151	1517.....58536	
27	1952.....53283	1837.....54538	1727.....55834	1619.....57174	1516.....58559	3
	1950.....53303	1836.....54559	1725.....55856	1618.....57196	1514.....58583	
28	1948.....53324	1834.....54581	1723.....55878	1616.....57219	1512.....58606	2
	1946.....53344	1832.....54602	1721.....55900	1614.....57242	1511.....58630	
29	1944.....53365	1830.....54623	1719.....55922	1612.....57265	1509.....58653	1
	1942.....53386	1828.....54644	1718.....55944	1611.....57287	1507.....58677	
30	1940.....53406	1826.....54666	1716.....55966	1609.....57310	1506.....58700	0
	A B	A B	A B	A B	A B	
	107°00'	106°30'	106°00'	105°30'	105°00'	

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	75°00'	75°30'	76°00'	76°30'	77°00'	
	A B	A B	A B	A B	A B	
0	1506.....58700	1406.....60140	1310.....61632	1217.....63181	1128.....64791	30
	1504.....58724	1404.....60164	1308.....61658	1215.....63208	1126.....64819	
1	1502.....58748	1403.....60189	1306.....61683	1214.....63234	1125.....64846	29
	1500.....58771	1401.....60213	1305.....61709	1212.....63260	1123.....64873	
2	1499.....58795	1399.....60238	1303.....61734	1211.....63287	1122.....64901	28
	1497.....58818	1398.....60262	1301.....61759	1209.....63313	1120.....64928	
3	1495.....58842	1396.....60287	1300.....61785	1208.....63340	1119.....64956	27
	1494.....58866	1394.....60311	1299.....61810	1206.....63366	1117.....64983	
4	1492.....58889	1393.....60336	1297.....61836	1205.....63392	1116.....65011	26
	1490.....58913	1391.....60360	1295.....61861	1203.....63419	1114.....65038	
5	1489.....58937	1390.....60385	1294.....61887	1202.....63445	1113.....65066	25
	1487.....58960	1388.....60410	1292.....61912	1200.....63472	1112.....65093	
6	1485.....58984	1386.....60434	1291.....61938	1199.....63498	1110.....65121	24
	1484.....59008	1385.....60459	1289.....61963	1197.....63525	1109.....65148	
7	1482.....59032	1383.....60483	1288.....61989	1196.....63551	1107.....65176	23
	1480.....59055	1381.....60508	1286.....62014	1194.....63578	1106.....65204	
8	1479.....59079	1380.....60533	1284.....62040	1193.....63605	1104.....65231	22
	1477.....59103	1378.....60557	1283.....62065	1191.....63631	1103.....65259	
9	1475.....59127	1377.....60582	1281.....62091	1190.....63658	1101.....65287	21
	1474.....59151	1375.....60607	1280.....62117	1188.....63684	1100.....65314	
10	1472.....59175	1373.....60631	1278.....62142	1187.....63711	1099.....65342	20
	1470.....59198	1372.....60656	1277.....62168	1185.....63738	1097.....65370	
11	1469.....59222	1370.....60681	1275.....62194	1184.....63764	1096.....65398	19
	1467.....59246	1368.....60706	1274.....62219	1182.....63791	1094.....65425	
12	1465.....59270	1367.....60730	1272.....62245	1181.....63818	1093.....65453	18
	1464.....59294	1365.....60755	1270.....62271	1179.....63845	1091.....65481	
13	1462.....59318	1364.....60780	1269.....62296	1178.....63871	1090.....65509	17
	1460.....59342	1362.....60805	1267.....62322	1176.....63898	1089.....65537	
14	1459.....59366	1360.....60830	1266.....62348	1175.....63925	1087.....65564	16
	1457.....59390	1359.....60855	1264.....62374	1173.....63952	1086.....65592	
15	1455.....59414	1357.....60879	1263.....62400	1172.....63978	1084.....65620	15
	1454.....59438	1356.....60904	1261.....62425	1170.....64005	1083.....65648	
16	1452.....59462	1354.....60929	1260.....62451	1169.....64032	1081.....65676	14
	1450.....59486	1352.....60954	1258.....62477	1167.....64059	1080.....65704	
17	1449.....59510	1351.....60979	1257.....62503	1166.....64086	1079.....65732	13
	1447.....59534	1349.....61004	1255.....62529	1164.....64113	1077.....65760	
18	1445.....59558	1348.....61029	1253.....62555	1163.....64140	1076.....65788	12
	1444.....59582	1346.....61054	1252.....62581	1161.....64167	1074.....65816	
19	1442.....59606	1344.....61079	1250.....62607	1160.....64194	1073.....65844	11
	1440.....59630	1343.....61104	1249.....62633	1158.....64221	1071.....65872	
20	1439.....59654	1341.....61129	1247.....62659	1157.....64248	1070.....65900	10
	1437.....59679	1340.....61154	1246.....62685	1155.....64275	1069.....65928	
21	1435.....59703	1338.....61179	1244.....62711	1154.....64302	1067.....65957	9
	1434.....59727	1336.....61204	1243.....62737	1152.....64329	1066.....65985	
22	1432.....59751	1335.....61229	1241.....62763	1151.....64356	1064.....66013	8
	1430.....59775	1333.....61254	1240.....62789	1150.....64383	1063.....66041	
23	1429.....59800	1332.....61279	1238.....62815	1148.....64410	1061.....66069	7
	1427.....59824	1330.....61304	1237.....62841	1147.....64437	1060.....66098	
24	1425.....59848	1329.....61330	1235.....62867	1145.....64464	1059.....66126	6
	1424.....59872	1327.....61355	1234.....62893	1144.....64491	1057.....66154	
25	1422.....59896	1325.....61380	1232.....62919	1142.....64518	1056.....66182	5
	1421.....59921	1324.....61405	1230.....62945	1141.....64546	1054.....66211	
26	1419.....59945	1322.....61430	1229.....62971	1139.....64573	1053.....66239	4
	1417.....59969	1321.....61456	1227.....62998	1138.....64600	1052.....66267	
27	1416.....59994	1319.....61481	1226.....63024	1136.....64627	1050.....66296	3
	1414.....60018	1317.....61506	1224.....63050	1135.....64655	1049.....66324	
28	1412.....60042	1316.....61531	1223.....63076	1133.....64682	1047.....66352	2
	1411.....60067	1314.....61556	1221.....63103	1132.....64709	1046.....66381	
29	1409.....60091	1313.....61582	1220.....63129	1130.....64736	1045.....66409	1
	1407.....60116	1311.....61607	1218.....63155	1129.....64764	1043.....66438	
30	1406.....60140	1310.....61632	1217.....63181	1128.....64791	1042.....66466	0
	A B	A B	A B	A B	A B	
	104°30'	104°00'	103°30'	103°00'	102°30'	

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	77°30'		78°00'		78°30'		79°00'		79°30'		
	A	B	A	B	A	B	A	B	A	B	
0	1042	66466	960	68212	881	70034	805	71940	733	73937	30
	1040	66495	958	68242	879	70065	804	71973	732	73971	
1	1039	66523	957	68272	878	70097	803	72005	731	74005	29
	1038	66552	955	68301	877	70128	802	72038	730	74039	
2	1036	65580	954	68331	876	70159	800	72070	729	74073	28
	1035	66609	953	68361	874	70190	799	72103	728	74107	
3	1033	66638	951	68391	873	70221	798	72136	726	74142	27
	1032	66666	950	68421	872	70252	797	72168	725	74176	
4	1031	66695	949	68450	870	70284	796	72201	724	74210	26
	1029	66724	947	68480	869	70315	794	72234	723	74245	
5	1028	66752	946	68510	868	70346	793	72266	722	74279	25
	1026	66781	945	68540	867	70377	792	72299	721	74313	
6	1025	66810	943	68570	865	70409	791	72332	719	74348	24
	1024	66838	942	68600	864	70440	790	72365	718	74382	
7	1022	66867	941	68630	863	70471	788	72397	717	74417	23
	1021	66896	939	68660	862	70503	787	72430	716	74451	
8	1020	66925	938	68690	860	70534	786	72463	715	74486	22
	1018	66953	937	68720	859	70566	785	72496	714	74520	
9	1017	66982	935	68750	858	70597	783	72529	712	74555	21
	1015	67011	934	68781	856	70629	782	72562	711	74589	
10	1014	67040	933	68811	855	70660	781	72595	710	74624	20
	1013	67069	932	68841	854	70692	780	72628	709	74659	
11	1011	67098	930	68871	853	70723	779	72661	708	74693	19
	1010	67127	929	68901	851	70755	777	72694	707	74728	
12	1008	67156	928	68931	850	70786	776	72727	706	74763	18
	1007	67185	926	68962	849	70818	775	72760	704	74797	
13	1006	67214	925	68992	848	70850	774	72794	703	74832	17
	1004	67243	924	69022	846	70881	772	72827	702	74867	
14	1003	67272	922	69053	845	70913	771	72860	701	74902	16
	1002	67301	921	69083	844	70945	770	72893	700	74937	
15	1000	67330	920	69113	843	70976	769	72926	699	74972	15
	999	67359	918	69144	841	71008	768	72960	698	75007	
16	997	67388	917	69174	840	71040	767	72993	696	75042	14
	996	67417	916	69204	839	71072	765	73026	695	75077	
17	995	67447	914	69235	838	71104	764	73060	694	75112	13
	993	67476	913	69265	836	71135	763	73093	693	75147	
18	992	67505	912	69296	835	71167	762	73127	692	75182	12
	991	67534	910	69326	834	71199	761	73160	691	75217	
19	989	67563	909	69357	833	71231	759	73193	690	75252	11
	988	67593	908	69387	831	71263	758	73227	688	75287	
20	987	67622	907	69418	830	71295	757	73260	687	75322	10
	985	67651	905	69449	829	71327	756	73294	686	75358	
21	984	67681	904	69479	828	71359	755	73328	685	75393	9
	982	67710	903	69510	826	71391	753	73361	684	75428	
22	981	67739	901	69541	825	71423	752	73395	683	75464	8
	980	67769	900	69571	824	71455	751	73429	682	75499	
23	978	67798	899	69602	823	71488	750	73462	680	75534	7
	977	67828	897	69633	821	71520	749	73496	679	75570	
24	976	67857	896	69664	820	71552	747	73530	678	75605	6
	974	67886	895	69694	819	71584	746	73563	677	75641	
25	973	67916	894	69725	818	71616	745	73597	676	75676	5
	972	67945	892	69756	816	71649	744	73631	675	75712	
26	970	67975	891	69787	815	71681	743	73665	674	75747	4
	969	68005	890	69815	814	71713	742	73699	673	75783	
27	968	68034	888	69849	813	71746	740	73733	672	75819	3
	966	68064	887	69879	811	71778	739	73767	670	75854	
28	965	68093	886	69910	810	71810	738	73801	669	75890	2
	964	68123	885	69941	809	71843	737	73835	668	75926	
29	962	68153	883	69972	808	71875	736	73869	667	75961	1
	961	68182	882	70003	807	71908	735	73903	666	75997	
30	960	68212	881	70034	805	71940	733	73937	665	76033	0
	A	B	A	B	A	B	A	B	A	B	
	102°00'		101°30'		101°00'		100°30'		100°00'		

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	80°00'	80°30'	81°00'	81°30'	82°00'	
	A B	A B	A B	A B	A B	
0	665.....76033	600......78239	538......80567	480......83030	425......85644	30
	664.....76069	599......78277	537......80607	479......83072	424......85689	
1	663.....76105	598......78315	536......80647	478......83114	423......85734	29
	661.....76141	597......78352	535......80687	477......83157	422......85779	
2	660.....76176	595......78390	534......80727	476......83199	421......85825	28
	659.....76212	594......78428	533......80767	475......83242	420......85870	
3	658.....76248	593......78466	532......80807	474......83284	419......85915	27
	657.....76284	592......78504	531......80847	473......83327	418......85960	
4	656.....76320	591......78542	530......80887	472......83369	418......86006	26
	655.....76357	590......78580	529......80927	471......83412	417......86051	
5	654.....76393	589......78618	528......80967	470......83455	416......86096	25
	653.....76429	588......78656	527......81008	469......83497	415......86142	
6	652.....76465	587......78694	526......81048	468......83540	414......86187	24
	650.....76501	586......78733	525......81088	467......83583	413......86233	
7	649.....76537	585......78771	524......81129	467......83626	412......86278	23
	648.....76574	584......78809	523......81169	466......83668	411......86324	
8	647.....76610	583......78847	522......81210	465......83711	411......86370	22
	646.....76646	582......78886	521......81250	464......83754	410......86415	
9	645.....76683	581......78924	520......81291	463......83797	409......86461	21
	644.....76719	580......78962	519......81331	462......83840	408......86507	
10	643.....76756	579......79001	518......81372	461......83884	407......86553	20
	642.....76792	578......79039	517......81413	460......83927	406......86599	
11	641.....76828	577......79078	516......81453	459......83970	405......86645	19
	639.....76865	576......79116	515......81494	458......84013	405......86691	
12	638.....76902	575......79155	514......81535	457......84056	404......86737	18
	637.....76938	574......79193	513......81576	456......84100	403......86783	
13	636.....76975	573......79232	512......81617	455......84143	402......86829	17
	635.....77011	571......79271	511......81657	454......84186	401......86876	
14	634.....77048	570......79309	510......81698	454......84230	400......86922	16
	633.....77085	569......79348	509......81739	453......84273	399......86968	
15	632.....77122	568......79387	508......81780	452......84317	399......87015	15
	631.....77158	567......79426	507......81821	451......84361	398......87061	
16	630.....77195	566......79465	506......81863	450......84404	397......87107	14
	629.....77232	565......79503	505......81904	449......84448	396......87154	
17	627.....77269	564......79542	504......81945	448......84492	395......87201	13
	626.....77306	563......79581	504......81986	447......84535	394......87247	
18	625.....77343	562......79620	503......82027	446......84579	393......87294	12
	624.....77380	561......79659	502......82069	445......84623	392......87341	
19	623.....77417	560......79698	501......82110	444......84667	392......87387	11
	622.....77454	559......79737	500......82151	444......84711	391......87434	
20	621.....77491	558......79777	499......82193	443......84755	390......87481	10
	620.....77528	557......79816	498......82234	442......84799	389......87528	
21	619.....77565	556......79855	497......82276	441......84843	388......87575	9
	618.....77602	555......79894	496......82317	440......84887	387......87622	
22	617.....77639	554......79933	495......82359	439......84931	387......87669	8
	616.....77677	553......79973	494......82400	438......84976	386......87716	
23	615.....77714	552......80012	493......82442	437......85020	385......87764	7
	614.....77751	551......80051	492......82484	436......85064	384......87811	
24	612.....77788	550......80091	491......82526	435......85109	383......87858	6
	611.....77826	549......80130	490......82567	434......85153	382......87906	
25	610.....77863	548......80170	489......82609	434......85197	381......87953	5
	609.....77901	547......80209	488......82651	433......85242	381......88001	
26	608.....77938	546......80249	487......82693	432......85286	380......88048	4
	607.....77976	545......80288	486......82735	431......85331	379......88096	
27	606.....78013	544......80328	485......82777	430......85376	378......88143	3
	605.....78051	543......80368	484......82819	429......85420	377......88191	
28	604.....78088	542......80407	483......82861	428......85465	376......88239	2
	603.....78126	541......80447	482......82903	427......85510	376......88286	
29	602.....78164	540......80487	482......82945	426......85555	375......88334	1
	601.....78201	539......80527	481......82987	426......85599	374......88382	
30	600.....78239	538......80567	480......83030	425......85644	373......88430	0
	A B	A B	A B	A B	A B	
	99°30'	99°00'	98°30'	98°00'	97°30'	

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	82°30'	83°00'	83°30'	84°00'	84°30'	
	A B	A B	A B	A B	A B	
0	373.....88430	325.....91411	280.....94614	238.6....98076	200.4...101843	30
	372.....88478	324.....91462	279.....94670	237.9....98137	199.8...101908	
1	371.....88526	323.....91514	279.....94725	237.2....98197	199.2...101974	29
	371.....88574	323.....91565	278.....94781	236.6....98257	198.6...102040	
2	370.....88623	322.....91617	277.....94836	235.9....98318	198.0...102106	28
	369.....88671	321.....91668	276.....94892	235.3....98378	197.4...102172	
3	368.....88719	320.....91720	276.....94948	234.6....98439	196.8...102238	27
	367.....88767	319.....91772	275.....95004	233.9....98499	196.2...102304	
4	366.....88816	319.....91824	274.....95060	233.3....98560	195.6...102371	26
	366.....88864	318.....91876	274.....95116	232.6....98621	195.0...102437	
5	365.....88913	317.....91928	273.....95172	232.0....98682	194.4...102504	25
	364.....88961	316.....91980	272.....95228	231.3....98743	193.8...102570	
6	363.....89010	316.....92032	271.....95285	230.7....98804	193.2...102637	24
	362.....89059	315.....92085	271.....95341	230.0....98865	192.6...102704	
7	362.....89107	314.....92137	270.....95397	229.4....98926	192.0...102771	23
	361.....89156	313.....92189	269.....95454	228.7....98988	191.4...102838	
8	360.....89205	313.....92242	269.....95510	228.1....99049	190.8...102905	22
	359.....89254	312.....92294	268.....95567	227.4....99111	190.2...102973	
9	358.....89303	311.....92347	267.....95624	226.8....99172	189.6...103040	21
	357.....89352	310.....92399	267.....95681	226.1....99234	189.0...103107	
10	357.....89401	310.....92452	266.....95737	225.5....99296	188.4...103175	20
	356.....89450	309.....92505	265.....95795	224.8....99357	187.8...103243	
11	355.....89499	308.....92558	264.....95851	224.2....99419	187.2...103311	19
	354.....89548	307.....92610	264.....95909	223.5....99482	186.7...103379	
12	353.....89597	307.....92663	263.....95966	222.9....99544	186.1...103447	18
	353.....89647	306.....92716	262.....96023	222.3....99606	185.5...103515	
13	352.....89696	305.....92769	262.....96080	221.6....99668	184.9...103583	17
	351.....89746	304.....92823	261.....96138	221.0....99731	184.3...103651	
14	350.....89795	304.....92876	260.....96195	220.3....99793	183.7...103720	16
	349.....89845	303.....92929	260.....96253	219.7....99856	183.2...103788	
15	349.....89894	302.....92982	259.....96310	219.1....99918	182.6...103857	15
	348.....89944	301.....93036	258.....96368	218.4....99981	182.0...103926	
16	347.....89994	301.....93089	257.....96426	217.8...100044	181.4...103995	14
	346.....90044	300.....93143	257.....96484	217.2...100107	180.8...104064	
17	345.....90093	299.....93196	256.....96542	216.5...100170	180.3...104133	13
	345.....90143	298.....93250	255.....96600	215.9...100233	179.7...104202	
18	344.....90193	298.....93304	255.....96658	215.3...100296	179.1...104272	12
	343.....90243	297.....93358	254.....96716	214.6...100360	178.5...104341	
19	342.....90293	296.....93411	253.....96774	214.0...100423	178.0...104411	11
	341.....90344	295.....93465	253.....96833	213.4...100487	177.4...104480	
20	341.....90394	295.....93519	252.....96891	212.8...100550	176.8...104550	10
	340.....90444	294.....93573	251.....96950	212.1...100614	176.2...104620	
21	339.....90494	293.....93628	251.....97008	211.5...100678	175.7...104690	9
	338.....90545	292.....93682	250.....97067	210.9...100742	175.1...104760	
22	337.....90595	292.....93736	249.....97126	210.3...100806	174.5...104830	8
	337.....90646	291.....93790	249.....97184	209.6...100870	174.0...104901	
23	336.....90696	290.....93845	248.....97243	209.0...100943	173.4...104971	7
	335.....90747	289.....93899	247.....97302	208.4...100998	172.8...105042	
24	334.....90798	289.....93954	247.....97361	207.8...101063	172.3...105113	6
	333.....90848	288.....94009	246.....97420	207.1...101127	171.7...105183	
25	333.....90899	287.....94063	245.....97480	206.5...101192	171.1...105254	5
	332.....90950	287.....94118	245.....97539	205.9...101256	170.6...105325	
26	331.....91001	286.....94173	244.....97598	205.3...101321	170.0...105397	4
	330.....91052	285.....94228	243.....97658	204.7...101386	169.5...105468	
27	330.....91103	284.....94283	243.....97717	204.1...101451	168.9...105539	3
	329.....91154	284.....94338	242.....97777	203.5...101516	168.4...105611	
28	328.....91205	283.....94393	241.....97837	202.8...101581	167.8...105683	2
	327.....91257	282.....94448	241.....97897	202.2...101646	167.2...105754	
29	326.....91308	281.....94503	240.....97957	201.6...101712	166.7...105826	1
	326.....91359	281.....94559	239.....98017	201.0...101777	166.0...105898	
30	325.....91411	280.....94614	239.....98076	200.4...101843	165.6...105970	0
	A B	A B	A B	A B	A B	
	97°00'	96°30'	96°00'	95°30'	95°00'	

WHEN LHA (E OR W) IS GREATER THAN 90°, TAKE "K" FROM BOTTOM OF TABLE

	85°00'	85°30'	86°00'	86°30'	87°00'	
	A B	A B	A B	A B	A B	
0	165.6...105970	134.1...110536	105.9...115641	81.1...121432	59.6...128120	30
	165.0...106043	133.6...110616	105.5...115732	80.7...121538	59.2...128241	
1	164.5...106115	133.1...110696	105.0...115823	80.3...121639	58.9...128362	29
	163.9...106187	132.6...110777	104.6...115913	79.9...121743	58.6...128483	
2	163.4...106260	132.1...110858	104.2...116004	79.5...121848	58.2...128605	28
	162.8...106333	131.6...110939	103.7...116096	79.2...121952	57.9...128727	
3	162.3...106406	131.1...111020	103.3...116187	78.8...122057	57.6...128849	27
	161.7...106479	130.6...111101	102.9...116278	78.4...122161	57.3...128972	
4	161.2...106552	130.1...111183	102.4...116370	78.0...122267	56.9...129095	26
	160.6...106625	129.6...111264	102.0...116462	77.6...122372	56.6...129218	
5	160.1...106698	129.2...111346	101.6...116554	77.3...122478	56.3...129342	25
	159.6...106772	128.7...111428	101.1...116647	76.9...122584	56.0...129466	
6	159.0...106846	128.2...111510	100.7...116739	76.5...122690	55.7...129591	24
	158.5...106919	127.7...111592	100.3...116832	76.1...122796	55.3...129716	
7	157.9...106993	127.2...111674	99.8...116925	75.8...122903	55.0...129841	23
	157.4...107067	126.7...111757	99.4...117018	75.4...123010	54.7...129967	
8	156.9...107141	126.2...111839	99.0...117112	75.0...123117	54.4...130093	22
	156.3...107216	125.8...111922	98.5...117205	74.6...123225	54.1...130219	
9	155.8...107290	125.3...112005	98.1...117299	74.3...123332	53.7...130346	21
	155.2...107364	124.8...112088	97.7...117393	73.9...123441	53.4...130473	
10	154.7...107439	124.3...112171	97.3...117487	73.5...123549	53.1...130600	20
	154.2...107514	123.8...112255	96.8...117581	73.2...123657	52.8...130728	
11	153.6...107589	123.4...112338	96.4...117676	72.8...123766	52.5...130856	19
	153.1...107664	122.9...112422	96.0...117771	72.4...123875	52.2...130985	
12	152.6...107739	122.4...112506	95.6...117866	72.1...123985	51.9...131114	18
	152.1...107814	121.9...112590	95.2...117961	71.7...124095	51.6...131243	
13	151.5...107890	121.5...112674	94.7...118056	71.3...124204	51.3...131373	17
	151.0...107965	121.0...112759	94.3...118152	71.0...124315	51.0...131503	
14	150.5...108041	120.5...112843	93.9...118248	70.6...124425	50.7...131633	16
	149.9...108117	120.1...112928	93.5...118344	70.3...124536	50.3...131764	
15	149.4...108183	119.6...113013	93.1...118440	69.9...124647	50.0...131896	15
	148.9...108269	119.1...113098	92.7...118537	69.5...124759	49.7...132027	
16	148.4...108345	118.7...113183	92.3...118633	69.2...124870	49.4...132159	14
	147.8...108421	118.2...113269	91.8...118730	68.8...124982	49.1...132292	
17	147.3...108498	117.7...113354	91.4...118827	68.5...125094	48.8...132425	13
	146.8...108574	117.3...113440	91.0...118925	68.1...125207	48.5...132558	
18	146.3...108651	116.8...113526	90.6...119022	67.8...125320	48.2...132692	12
	145.8...108728	116.3...113612	90.2...119120	67.4...125433	47.9...132826	
19	145.2...108805	115.9...113699	89.8...119218	67.1...125546	47.6...132961	11
	144.7...108882	115.4...113785	89.4...119316	66.7...125660	47.3...133096	
20	144.2...108960	114.9...113872	89.0...119415	66.4...125774	47.1...133231	10
	143.7...109037	114.5...113958	88.6...119513	66.0...125888	46.8...133367	
21	143.2...109115	114.0...114045	88.2...119612	65.7...126003	46.5...133503	9
	142.7...109192	113.6...114133	87.8...119711	65.3...126118	46.2...133640	
22	142.2...109270	113.1...114220	87.4...119811	65.0...126233	45.9...133777	8
	141.6...109348	112.7...114307	87.0...119910	64.6...126349	45.6...133914	
23	141.1...109426	112.2...114395	86.6...120010	64.3...126465	45.3...134052	7
	140.6...109505	111.7...114483	86.2...120110	63.9...126581	45.0...134191	
24	140.1...109583	111.3...114571	85.8...120211	63.6...126697	44.7...134330	6
	139.6...109662	110.8...114659	85.4...120311	63.3...126814	44.4...134469	
25	139.1...109740	110.4...114747	85.0...120412	62.9...126931	44.2...134609	5
	138.6...109819	109.9...114836	84.6...120513	62.6...127049	43.9...134749	
26	138.1...109898	109.5...114925	84.2...120614	62.2...127166	43.6...134890	4
	137.6...109978	109.0...115014	83.8...120715	61.9...127284	43.3...135031	
27	137.1...110057	108.6...115103	83.4...120817	61.6...127403	43.0...135173	3
	136.6...110136	108.1...115192	83.0...120919	61.2...127521	42.7...135315	
28	136.1...110216	107.7...115282	82.6...121021	60.9...127640	42.5...135457	2
	135.6...110296	107.3...115371	82.2...121124	60.6...127760	42.2...135600	
29	135.1...110375	106.8...115461	81.9...121226	60.2...127880	41.9...135744	1
	134.6...110455	106.4...115551	81.5...121329	59.9...128000	41.6...135888	
30	134.1...110536	105.9...115641	81.1...121432	59.6...128120	41.4...136032	0
	A B	A B	A B	A B	A B	
	94°30'	94°00'	93°30'	93°00'	92°30'	

ALWAYS TAKE "Z" FROM BOTTOM OF TABLE, EXCEPT WHEN "K" IS SAME NAME AND GREATER THAN LATITUDE, IN WHICH CASE TAKE "Z" FROM TOP OF TABLE

	87°30'	88°00'	88°30'	89°00'	89°30'	
	A B	A B	A B	A B	A B	
0	41.4...136032	26.5...145718	14.9...158208	6.6...175814	1.7...205916	30
	41.1...136177	26.2...145899	14.7...158450	6.5...176178	1.6...206646	
1	40.8...136322	26.0...146081	14.6...158693	6.4...176544	1.5...207388	29
	40.5...136468	25.8...146264	14.4...158938	6.3...176914	1.5...208143	
2	40.3...136615	25.6...146448	14.2...159184	6.2...177287	1.4...208912	28
	40.0...136761	25.4...146632	14.1...159431	6.1...177663	1.4...209695	
3	39.7...136909	25.2...146817	13.9...159680	6.0...178042	1.3...210491	27
	39.4...137057	24.9...147003	13.7...159930	5.9...178424	1.3...211303	
4	39.2...137205	24.7...147190	13.6...160182	5.8...178810	1.2...212130	26
	38.9...137354	24.5...147377	13.4...160435	5.7...179200	1.2...212974	
5	38.6...137503	24.3...147566	13.3...160690	5.6...179593	1.1...213834	25
	38.4...137653	24.1...147755	13.1...160946	5.5...179990	1.1...214711	
6	38.1...137804	23.9...147945	13.0...161204	5.4...180390	1.1...215607	24
	37.8...137955	23.7...148135	12.8...161463	5.3...180794	1.0...216521	
7	37.6...138106	23.5...148327	12.7...161724	5.2...181201	1.0...217455	23
	37.3...138258	23.3...148520	12.5...161986	5.1...181613	0.9...218409	
8	37.1...138411	23.1...148713	12.4...162250	5.0...182029	0.9...219385	22
	36.8...138564	22.8...148907	12.2...162516	4.9...182448	0.9...220384	
9	36.5...138718	22.6...149103	12.1...162783	4.8...182872	0.8...221406	21
	36.3...138872	22.4...149299	11.9...163052	4.7...183300	0.8...222452	
10	36.0...139027	22.2...149495	11.8...163322	4.6...183732	0.7...223525	20
	35.8...139182	22.0...149693	11.6...163594	4.5...184168	0.7...224624	
11	35.5...139338	21.8...149892	11.5...163868	4.4...184609	0.7...225752	19
	35.3...139494	21.6...150092	11.3...164144	4.3...185055	0.6...226910	
12	35.0...139651	21.4...150292	11.2...164422	4.2...185505	0.6...228100	18
	34.7...139809	21.2...150494	11.0...164701	4.1...185959	0.6...229324	
13	34.5...139967	21.0...150696	10.9...164982	4.1...186419	0.5...230583	17
	34.2...140125	20.8...150899	10.8...165265	4.0...186883	0.5...231879	
14	34.0...140285	20.6...151104	10.6...165550	3.9...187353	0.5...233215	16
	33.7...140445	20.5...151309	10.5...165836	3.8...187827	0.4...234594	
15	33.5...140605	20.3...151515	10.3...166125	3.7...188307	0.4...236018	15
	33.2...140766	20.1...151722	10.2...166415	3.6...188793	0.4...237491	
16	33.0...140928	19.9...151931	10.1...166708	3.6...189283	0.4...239015	14
	32.8...141090	19.7...152140	9.9...167002	3.5...189780	0.3...240594	
17	32.5...141253	19.5...152350	9.8...167298	3.4...190282	0.3...242233	13
	32.3...141417	19.3...152561	9.7...167597	3.3...190790	0.3...243936	
18	32.0...141581	19.1...152774	9.5...167897	3.2...191303	0.3...245709	12
	31.8...141745	18.9...152987	9.4...168200	3.2...191824	0.2...247558	
19	31.5...141911	18.7...153201	9.3...168505	3.1...192350	0.2...249488	11
	31.3...142077	18.6...153417	9.1...168811	3.0...192883	0.2...251508	
20	31.1...142243	18.4...153633	9.0...169121	2.9...193422	0.2...253627	10
	30.8...142411	18.2...153851	8.9...169432	2.9...193969	0.2...255855	
21	30.6...142579	18.0...154070	8.7...169745	2.8...194522	0.1...258203	9
	30.4...142747	17.8...154290	8.6...170061	2.7...195082	0.1...260685	
22	30.1...142916	17.6...154511	8.5...170379	2.7...195650	0.1...263318	8
	29.9...143086	17.5...154733	8.4...170700	2.6...196225	0.1...266121	
23	29.6...143257	17.3...154956	8.2...171023	2.5...196808	0.1...269118	7
	29.4...143428	17.1...155180	8.1...171348	2.4...197399	0.1...272336	
24	29.2...143600	16.9...155406	8.0...171676	2.4...197998	0.1...275812	6
	28.9...143773	16.8...155633	7.9...172006	2.3...198605	0.1...279591	
25	28.7...143946	16.6...155861	7.8...172339	2.3...199221	0.0...283730	5
	28.5...144120	16.4...156090	7.6...172674	2.2...199846	0.0...288306	
26	28.3...144295	16.2...156320	7.5...173012	2.1...200480	0.0...293421	4
	28.0...144470	16.1...156552	7.4...173352	2.1...201124	0.0...299221	
27	27.8...144646	15.9...156784	7.3...173696	2.0...201777	0.0...305915	3
	27.6...144823	15.7...157019	7.2...174042	1.9...202440	0.0...313833	
28	27.4...145000	15.6...157254	7.1...174391	1.9...203113	0.0...323524	2
	27.1...145179	15.4...157490	6.9...174742	1.8...203797	0.0...336018	
29	26.9...145358	15.2...157728	6.8...175097	1.8...204492	0.0...353627	1
	26.7...145538	15.1...157967	6.7...175454	1.7...205198	0.0...383730	
30	26.5...145718	14.9...158208	6.6...175814	1.7...205916	0.0.........	0
	A B	A B	A B	A B	A B	
	92°00'	91°30'	91°00'	90°30'	90°00'	

GLOSSARY

a'	prime (used to indicate a variable under different situations)
ACR	armored cavalry regiment
AM	amplitude modulated
approx	approximately
ARDF	airborne radio direction finding
b"	double prime (continuation of the variable)
bearing	The angular measurement in degrees from north (true, magnetic, or grid) of an arriving radio wave with relation to the DF site.
BM	bearing mean
BO	bearing observed
BPE	best point estimate
BT	bearing true
c	certain
CADF	commutated-antenna direction finder
CCR	corrected compass rose
CDAA	circularly disposed antenna array
CEP	circular error probability
C&J	collection and jamming
co	company
Col	column
COMSEC	communications security
Cos	cosecants/cosine
cot	cotangent
CRT	cathode ray tube
cut	The point of intersection of two DF lines of bearing.
CW	continuous wave
D	doubtful
DA	Department of the Army
DF	direction finding
diff	difference
div	division
DWDF	direct wave direction finding
E	east
E field	electrical field
EAC	echelons above corps
EEP	elliptical error probability
EF	SSL term
EHF	extremely high frequency
EL	The elevation angle of arriving signal measured from the horizontal plane of the earth.
EM	electromagnetic
EW	electronic warfare

FE	SSL term
FEF	SSL term
fix	The most probable location of a target transmitter's antenna when three or more DF lines of bearing have been plotted on a chart or map.
flash	A high priority message from NCS to the DF sites. The message, usually sent on a restricted radio circuit, provides the basic target information and requested DF support.
FLOT	forward line of own troops
FM	field manual; frequency modulated
FORTRAN	formula translation
freq	frequency
GCAD	great circle azimuth and distance
GHz	gigahertz
GN	grid north
GPS	global positioning system
h	height
h'	Virtual height of the ionospheric layer (where the target signal is reflected) from the surface of the earth. (H prime)
H field	magnetic field
HF	high frequency
Hz	hertz
IEWSE	intelligence and electronic warfare support element
INSCOM	United States Army Intelligence and Security Command
IR	information requirements
kHz	kilohertz
km	kilometer(s)
L or LAT	latitude
LCSS	lightweight camouflage screen system
LF	low frequency
LOB	line of bearing(s)
log	logarithm
long	longitude
LOP	line of position
LOS	line of sight
maint	maintenance
MBG	mean bearing grouping
METT-T	mission, enemy, terrain, troops and time available
MF	medium frequency
MHz	megahertz
MI	military intelligence
minute	A subdivision of angular measure. One degree equals sixty minutes.
MOS	military occupational specialty
MRDFS	man-transportable radio direct ion finding system

N	north seeking; north
NADF	narrow aperture direction finding
NCS	net control station
Nm	nautical miles
NSA	National Security Agency
NSACSS	National Security Agency/Central Security Service
OB	order of battle
OIS	oblique incidence sounder
op	operator
PIR	priority intelligence requirements
plot	The placing of DF bearings on a chart or map so that a target's location can be determined by reference to grid or geographic coordinates. Also called plotting.
POL	petroleum, oils and lubricants
QUMP	quasi uni-modal propagation
RDF	radio direction finding
RF	radio frequency; radiated frequency
s	south
S3	Operations and Training Officer (US Army)
SD	standard deviation
SE	systematic error
SF	Special Forces
SHF	super high frequency
SIGINT	signals intelligence
sin	sine
Sm	statute miles
SOP	standing operating procedures
SSB	single side band
SSL	single station locator
STP	soldier training publication
SWDF	sky wave direction finding
TA	traffic analysis
tan	tangent
TC	training circular
TCAE	technical control and analysis element
TDDF	time-difference direction finders
TEC	Training Extension Course
tip-off	A message, usually initiated by an intercept position, requesting DF action on selected transmitter(s). A tip-off will include, as a minimum, the target activity and frequency and any identifying call signs.
TM	technical manual
TN	true north
TOC	tactical operations center

TO&E	table of organization and equipment
tracking	Real-time identification of the target activity to ensure that the DF sites acquire the correct target. Tracking is usually performed by the NCS on the flash circuit.
TRADOC	United States Army Training and Doctrine Command
UHF	ultra high frequency
us	United States
USA	United States of America
USAISD	United States Army Intelligence School, Fort Devens
USSID	United States Signals Intelligence Directive
UTM	universal transverse mercator
VHF	very high frequency
VIS	vertical incidence sounder
VLF	very low frequency
W	west
WADF	wide aperture direction finding
WFA	wavefront analysis
WFT	wavefront testing
WWII	World War II
$\angle$	angle (geometric symbol)
°	degrees (1 degree equals 60 minutes)
'	minutes (1 minute equals 60 seconds)
"	seconds
Σ	summation operator for calculus
σ	variance

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