

Chapter 3

Reconnaissance

A proper reconnaissance will –

- Gather all existing survey data on the area.
- Test and determine the usability and visibility of existing stations.
- Select sites for the main and supplemental stations.
- Specify any signal heights.
- Determine monumentation requirements.
- Collect terrain and climatic information.
- Arrange for access with private property owners or local government officials.
- Check on the availability of billeting, messing, medical, maintenance, and other required support.

Section I

FUNDAMENTALS

RECONNAISSANCE REQUIREMENTS

The special factors that the reconnaissance party must consider are determined by the objective of the survey and the methods, techniques, and equipment that will be employed. Survey methods and techniques are not within the scope of this chapter; therefore, only the more general considerations are given.

Triangulation and Trilateration

Although seldom used, special conditions may arise that make triangulation or trilateration feasible. These two methods make the greatest demand on the reconnaissance party. The mathematical computations place stringent requirements on the size and shape of the geometric figures. For this reason, the location of the stations will normally be dictated to the field reconnaissance party based on results of the office reconnaissance. The reconnaissance party must ensure that all stations to be observed from a proposed station are intervisible. Thorough knowledge of triangulation/trilateration criteria is absolutely necessary.

Transverse

The demands for traverse reconnaissance are less stringent than for triangulation. Care must be taken to ensure that both rear and forward stations are visible from each proposed station. Wherever possible, distances between stations should be uniform. In control surveys that may become part of the national network, the SSGCN must be satisfied. Spacing between stations will be dependent on the EDM available.

Taping. Taping remains a reliable way of determining distance. Terrain between stations must be moderate and uniform. Brush and tree clearing will be necessary in many cases. A tape traverse should follow previously cleared routes such as roads, railroads, power line rights-of-way, or pipelines.

Electronic distance measuring equipment. The EDM traverse reconnaissance requires intervisibility between stations, minimum and maximum allowable distances based on the EDM characteristics, and clearance above possible obstructions. Electro-optical and infrared EDM will be dependent on weather (clouds, fog, and haze). Microwave EDM will be affected by nearby power lines and radio frequency interference (RFI).

Leveling

Leveling reconnaissance will depend on the type of leveling performed.

Differential. Differential leveling should follow routes containing the least amount of change in elevation; between bench marks, and for individual setups. Preferred routes for differential leveling are the same as for taping.

Trigonometric. Trigonometric leveling reconnaissance is accomplished when reconnaissance for traverse is performed. When given a choice between a

relatively level observation or a greatly elevated or depressed elevation, select the relatively level observation. Failure to accurately level the instrument will cause greater error in an elevated/depressed observation.

Other Control Methods

Reconnaissance for other methods of extending control will vary according to the physical characteristics and limitations of the equipment or system used. No matter what system or equipment is being used, the proposed station must be accessible and the proposed station must be able to be included in the local survey control scheme. Stations occupied by satellite receivers (MX-1502, GPS receivers) must be free of surrounding (vertical) obstructions, RFI, and surfaces that will reflect the satellite signal onto the back side of the antenna. The distance between the receivers must meet the minimum distance as computed using the project specifications. Stations occupied by PADS must not exceed the maximum distance and time from the initialing station.

COMPOSITION OF RECONNAISSANCE PARTY

The reconnaissance party will vary in disposition and number according to the method of survey, type of terrain, transportation, extent of the survey, and density of control required. The chief of the reconnaissance party is normally the section chief or the survey technical sergeant. The reconnaissance party usually varies from three to five personnel. The reconnaissance party will include the survey party chief and personnel who will be instrument operator, recorder, computer, and rodman (some duties can be combined). The most qualified members of the unit should be assigned to reconnaissance, because a properly designed reconnaissance will result in a survey project that is accurate, complete, and performed expeditiously. Reconnaissance party personnel should be thoroughly briefed on the project instructions and the specifications of the survey mission.

Reconnaissance is accomplished in three phases: office, field, and reporting the gathered information.

Section II OFFICE RECONNAISSANCE

EXISTING DATA

During the office reconnaissance phase, the first step is to gather all existing data on the area to be surveyed. Depending on the area, there maybe a number of sources which maintain some type of reliable survey data. The existing data will usually consist of trig lists, station description cards, and aerial photographs or maps. Trig lists come in many forms, depending upon the publishing agency. They may be compiled *DA Form 1959 (Description or Recovery of Horizontal Control Station)* cards, horizontal control data booklets from the National Geodetic Survey (NGS), or a computer printout of coordinates. The sources of information are –

- Local Army units, including: map depots, field artillery target acquisition units, SIC, survey units.
- National Geodetic Survey and US Geologic Survey.
- US Army Corps of Engineers District Offices.
- US Department of the Interior, Bureau of Land Management (BLM).
- State and local surveyors.
- When working in other nations, the existing data are sometimes received from the national agency charged with the mapping of that nation. However, approval must be received from the appropriate higher headquarters before direct contact is established with a foreign government.

Regardless of the source of information, all trig lists, officially classified or not, must be safeguarded. Once secured, this information should be maintained as a data base for that area. At some later date it may be necessary to conduct additional surveys in the same area or an adjacent area.

MAP AND PROFILE STUDY

While the existing material is being assembled, it should not be evaluated. The evaluation cannot take place until all material has been assembled and annotated on the available maps or aerial photographs. The required survey control points (SCP) from the project directive are also plotted and an evaluation of the usability of existing controls can be conducted. The required control is compared with the existing control to determine whether the existing control meets requirements or additional basic control is needed. It is possible that many stations that are required may be eliminated because adequate control exists. For those required stations that must be established, a tentative route of survey is anoted on the maps and profiles of the lines of survey are made. These profiles can normally be drawn by two methods:

Hand and Eye Interpretation

Hand and eye interpretation is laborious and should only be undertaken when time permits. Each proposed line is followed, picking out distances and elevations on the line. The result is a **cross-section** of the line that is plotted and drawn. Refer to *FM 21-26*, Paragraph 10-8 (Profiles), for the procedure.

Analytical Photogrammetric Position System (APPS)

The APPS also has the capability to determine profiles, using data base and aerial photographs of the area in question.

No matter which method is used, the tentative results for intervisibility between proposed stations must be confirmed by field reconnaissance.

Section III FIELD RECONNAISSANCE

Each survey project will be different. The party chief must be able to use knowledge of previous projects and apply the lessons learned. The methods and procedures can be changed to suit the conditions of the current project. A successful party chief will also use the knowledge and ingenuity of his personnel.

INSPECTION

When time permits, a preliminary field inspection of the area is conducted by the party chief and one other person (survey technical sergeant, if available). When gathering information concerning the area to be surveyed, include types of terrain, heights of trees, road width, road surface type, spacing between roads, microclimate (fog, haze, and heat waves), and any other factors that will affect distance measuring and intervisibility between proposed stations. The inspection may be conducted using vehicles, helicopters, or airplanes, depending on what may be available. The results of the inspection will affect the scheme and route for the survey.

RECOVERY AND VERIFICATION OF EXISTING CONTROL STATIONS

In areas where control is to be extended or established, there frequently are control stations (from earlier surveys) that must be recovered and verified. These stations will serve as the starting points for proposed triangulation nets, traverse lines, or level lines, and should have been identified and annotated on overlays during the office reconnaissance phase. The existing stations will be located on the ground, described, and verified for accuracy, prior to using them for extending control.

Locating Existing Control Stations

Existing control stations (and their establishing surveys) follow patterns that will vary very little from one area to another. Recognizing the patterns and associating the patterns with the terrain types will assist the surveyor in locating the existing stations.

Triangulation stations are usually found on the highest point of a hill or mountain. In areas of little relief, the stations may be located at prominent points or sites where a tower could be easily erected.

Bench marks and traverse stations are typically located along roads, railroads, pipelines, or other transportation routes which permit intervisibility and accessibility. Bench marks and traverse stations will also be found along waterways, rivers, canals, and coastlines.

Sources and Use of Available Information

In some areas, urbanization has changed road or drainage patterns. In rural areas, new land may be cleared and cultivated, while older fields become overgrown or reforested. When searching for a station, gather and consider all available information.

Trig lists, control cards, and control bulletins contain brief descriptions and sketches of stations. The information may be outdated or insufficient for a final product, but will permit the surveyor to locate the general vicinity and search for the station. The final location of the station will involve the use of distances and azimuths from the reference marks to the station.

Previous survey data will include survey schemes, overlays, or plots depicting the relative position of the stations in the general area. After one or more stations have been recovered, the other stations may be roughly plotted and located using magnetic compass and either intersection or resection methods.

Aerial photographs may be used if the station to be recovered can be identified on the photographs. Using features that are permanent and prominent on both the photograph and the ground will permit the surveyor to reach the station site. Aerial photographs can be used with the APPS and data base of the area in question.

Maps with the plotted coordinates of the station will permit the surveyor to identify the route of travel to the

station. The map will also assist the surveyor in determining the accessibility of the station.

Local sources of information include local surveyors, police or public service officials, construction companies, and landowners. Local sources may be the only means of locating a station if the area has dramatically changed since the other sources of information have been published.

Station Verification

Verification of a station must be performed before using the station. Where only one other station is intervisible, a check distance measurement will be performed. Where two or more stations are intervisible, check angle observations will be performed. After the measurements and observations have been performed and reduced, they will be compared to the published computed information. If the results agree within the overall specifications for the survey project, the stations may be used.

SELECTING STATION SITES

New Stations

New station sites will be selected after all existing stations have been recovered, described, and verified. The new stations will be placed where required to complete the scheme of the survey.

Factors to Consider

Correct selection of a site for a new station will result in time and expense saved and will prolong the life of the new station. The following factors must be considered when selecting a site for a station:

Permanency. If the proposed site may experience disturbance or land development, another site should be considered. If the proposed site must be used, the station should have guard or witness posts placed around the station.

Intervisibility. Intervisibility of stations is mandatory. The reconnaissance party must consider lines of sight and possible obstructions to those lines. Growth of trees and brush must be considered when determining intervisibility between stations. The adjoining stations must be positively identifiable, and surrounding features cannot be mistaken for the adjoining stations. Vertical clearance of the line of sight will also be included during the intervisibility determination.

Marking of Stations

Marking of stations will assist in the positive identification of stations. This may be accomplished using a beacon target, a tripod wrapped with high visibility

cloth, a rock cairn built adjacent to the station, or any other marking device that is visible and identifiable from long distances. Just prior to starting observations, the location and identity of a station may be verified through the use of colored smoke grenades, or in conjunction with radios, by the survey teams at that station and the adjoining stations.

CAUTION

Smoke grenades are HOT and when incorrectly used will obscure the survey target. Make sure the smoke grenade is downwind of the station and on bare ground to prevent fires.

Naming the Stations

Names for the new stations will normally be controlled by the customer (project name or number followed by the sequence number of that station in the scheme of control extension). In the absence of guidance from the customer, the following rules will be adhered to:

- 1** Use the name of a nearby geographical feature. If that is not possible, use the name of a local political subdivision.
- 2** Use short names, as opposed to long names.
- 3** Do not duplicate names or designations.
- 4** Make sure the station name is correctly spelled on all documents.
- 5 DO NOT USE ANY OF THE FOLLOWING:**
 - Names of party personnel.
 - Nicknames.
 - Names without meaning.
 - Names arising from incidents during the project.

Old stations that are reestablished will be given the same name with a numerical suffix such as Boulder #2.

Landowners

Permission must be obtained prior to conducting a survey on any private land. The survey technical sergeant or the party chief, working through the local military legal office, will contact and negotiate with landowners for access to prospective station sites before entering the land. Written permission is highly preferred to oral permission, because the permission to enter the land is documented. The local Staff Judge Advocate will assist you in this matter, and will help keep you out of potential trouble.

United States. The reconnaissance party and all survey parties should have a **right-of-entry** letter to the overall area from their headquarters. The right-of-entry letter should be prepared in accordance with AR 405-10, Paragraph 13. This letter does not entitle the survey team to have access to private property or

into restricted areas without further permission. When the landowner is contacted, a full explanation of the work to be done is given. Do not attempt to conceal any inconveniences or damage that may arise. Government regulations concerning damage claims should be explained when necessary. A letter explaining the work and asking consent should be mailed to the property owner in the case of an absentee owner who cannot be reached in person or who is not at home when contact is attempted.

Other nations. When working in other nations, the right-of-entry letters for overall areas within a country are generally negotiated by the appropriate officer of the US Embassy within that country. However, a right-of-entry letter or approval from the host nation is not always sufficient for access to all public lands within the national boundaries. It sometimes becomes necessary to contact the local officials where the work is to be performed. Agreements will be conducted in accordance with local customs. Some countries consider an oral agreement, or any statement that could be construed to be an oral agreement, to be contractual and binding. If assets, material or otherwise, are transferred, close coordination with the Staff Judge Advocate is required.

CURVATURE AND VERTICAL REFRACTION

A factor entering into many field calculations is the correction introduced by the earth's curvature and the atmospheric refraction. Due to the earth's curvature, distant points will appear to fall below a level line of sight from the point of observation. Vertical refraction, on the other hand, causes the line of sight to curve downward and makes the distant point appear higher than its true elevation.

Vertical Refraction

The vertical refraction is about one-eighth of the curvature and opposite in sign. In survey work, the two are generally combined and the approximate resultant correction is given by the formula –

$h \text{ (meters)} = K \text{ (horizontal distance in kilometers)}^2 \text{ times } 0.0676.$

Where:

h = height in meters that a line horizontal at the point of observation will be above a level surface at K .

K = distance between points in kilometers.

Where h is known:

K = square root of h times 3.8478.

Table 3-1 gives the corresponding values of K and h .

Table 3-1. Correction for earth's curvature and refraction

Distance km	Correction m	Distance km	Correction m	Distance km	Correction m
1	0.1	21	29.8	41	113.5
2	0.3	22	32.7	42	119.1
3	0.6	23	35.7	43	124.8
4	1.1	24	38.9	44	130.7
5	1.7	25	42.2	45	136.7
6	2.4	26	45.6	46	142.8
7	3.3	27	49.2	47	149.1
8	4.3	28	52.9	48	155.5
9	5.5	29	56.8	49	162.1
10	6.8	30	60.8	50	168.8
11	8.2	31	64.9	51	175.6
12	9.7	32	69.1	52	182.5
13	11.4	33	73.5	53	189.6
14	13.2	34	78.0	54	196.8
15	15.2	35	82.7	55	204.2
16	17.3	36	87.5	56	211.7
17	19.5	37	92.4	57	219.3
18	21.9	38	97.5	58	227.1
19	24.4	39	102.7	59	235.0
20	27.0	40	108.0	60	243.0

Intervisibility

The general problem for intervisibility is determining how much a line of sight between two stations will clear or fail to clear an intervening obstruction. The formula is –

$$h = h_1 + (h_2 - h_1) \frac{d_1}{d_1 + d_2} - 0.0676 \frac{d_1 d_2}{d_1 + d_2}$$

Where

h = elevation of line at obstruction, in meters.

h_1 = elevation of lower station, in meters.

h_2 = elevation of higher station, in meters.

d_1 = distance from lower station to obstruction, in kilometers.

d_2 = distance from higher station to obstruction, in kilometers.

The first two terms of the above formula are a solution of similar triangles. The last term is the curvature and refraction correction. If the two stations are at the same elevation, the obstruction can be cleared using signals of equal height and the above formula becomes simply –

$$h = h_{1,2} - 0.0676 \frac{d_1 d_2}{d_1 + d_2}$$

and the height of signal at each end is –

$$h_{1,2} = h + 0.0676 \frac{d_1 d_2}{d_1 + d_2}$$

For a given length (K) between stations, the elevation required at one station to see the other across a level surface such as water is K squared $\times 0.0676$. If both stations are raised to the same elevation, the

height (h_1, h_2) required at each station is $(K/2)$ squared $\times 0.0676$, or one-fourth that at one end only.

In the field, the method generally amounts to a determination of an equal signal height for both stations so that the line of sight will clear the obstruction. Signal heights are nearly always computed in this way. Sometimes, a higher signal is specified at one station for some other line than the one under consideration. This permits a lower signal at the opposite end of the line. The amount one signal may be reduced in height for a given increase of the other is proportional to the distance of the two stations from the obstruction. The station nearer to an obstruction will require the least height to clear the line (Figure 3-1). To see station A, a high tower would be needed at station B, whereas a lower tower at station A would see station B. The amount that one instrument elevation may be reduced in height for a given increase in the height of the other is proportional to the distances of the two stations from the obstruction. If the distances A to H and B to H were 1.3 kilometers and 8.7 kilometers respectively, the ratio would be about 1:7.

Obstructions

Sometimes a series of obstructions occurs along a line of sight. It may not be possible to pick out by inspection the one that the line must clear. A lower obstruction near the middle of the line may require higher signals to clear than a higher obstruction near

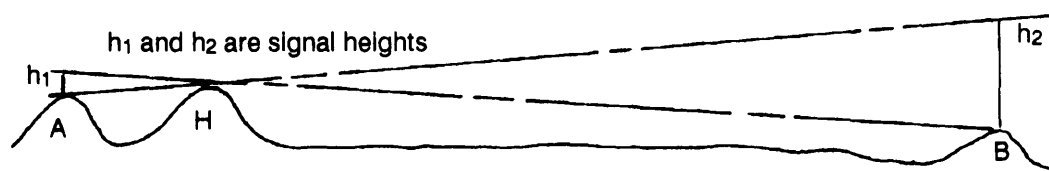


Figure 3-1. Clearance of obstruction

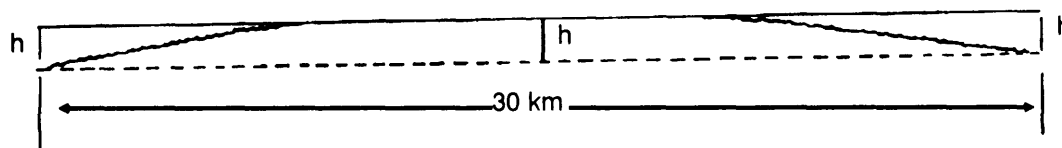


Figure 3-2. Signal heights for line over water

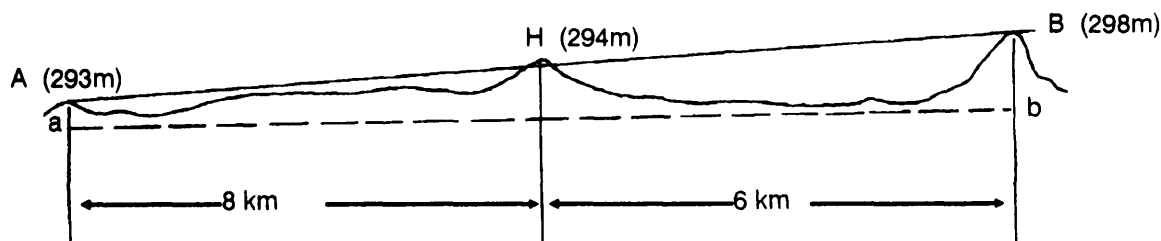


Figure 3-3. General formula solution

either end. The simplest way to determine the critical obstruction is to compute the signal heights for each one in turn. The following example of corrections illustrates a typical problem. Two stations are at water level on opposite shores of a bay 30 kilometers wide. What is the required height (h) of equal signals to make the line of sight clear the surface? According to the formula on page 3-6 –

$$h = (K/2)^2 \times 0.0676 = (30/2)^2 \times 0.0676 = 15.2 \text{ meters}$$

Figure 3-2 shows has the distance that a line joining the stations passes below the earth's surface. Because the obstruction is equidistant from the two stations, h will also be the required height of equal signals at the two ends needed to clear the line of sight.

Elevation of the Line of Sight

The problem when two end stations are not at the same elevation and/or the obstruction is not at the point midway between them (Figure 3-3) can be solved by the use of the **general formula** or the **computation of similar triangles** as discussed below. Either method is acceptable.

Applying the **general formula** in the Intervisibility paragraph, page 3-6 –

$$h = h_1 + (h_2 - h_1) \frac{d_1}{d_1 + d_2} - 0.0676 \frac{d_1 d_2}{d_1 + d_2}$$

$$h = 293.0 + (298.0 - 293.0) \frac{8}{8 + 6} - 0.0676 (8) (6)$$

$$h = 293.0 + (5) 0.57 - 3.25$$

$$h = 293.0 + 2.85 - 3.25 = 292.60$$

Therefore, the amount of the obstruction at H = 294.0 - 292.6 = 1.4 meters.

The computation of obstruction is the solution of **similar triangles**. In Figure 3-4, the elevations of the points are: A = 293 meters, B = 298 meters, and obstruction H = 294 meters. The distance from A to H = 8 kilometers and from B to H = 6 kilometers. Use Table 3-1, page 3-5, to first determine the effective elevation of points H and B. The effective elevation of H = 294.0 - 4.3 = 289.7 meters and of B = 298.0 - 13.2 = 284.8 meters. The effective elevation of the line at the observation H is now computed. In b, Figure 3-4, we form the similar triangles using the effective elevation of B and H. Then, solving for x –

$$x : 6 = 8.2 : 14, \frac{x}{6} = \frac{8.2}{14} \text{ or } x = \frac{(6)(8.2)}{14} = 3.5 \text{ m}$$

Therefore, the effective elevation of the line at the obstruction H = 284.8 + 3.5 = 288.3 meters. Then, the effective elevation of the line at H = 288.3; hence 288.3 - 289.7 = - 1.4 meters. Therefore, the line fails to clear the obstruction at H by 1.4 meters.

HORIZONTAL REFRACTION

Some lines are affected by abnormal horizontal refraction. Therefore, the reconnaissance party should try to avoid lines likely to give refraction trouble. Horizontal refraction is caused by layers of air or air currents of unequal temperature and density along the lines of sight. Lines passing near the base of a mountain range or bluff will be affected by the air currents flowing down side canyons and ravines

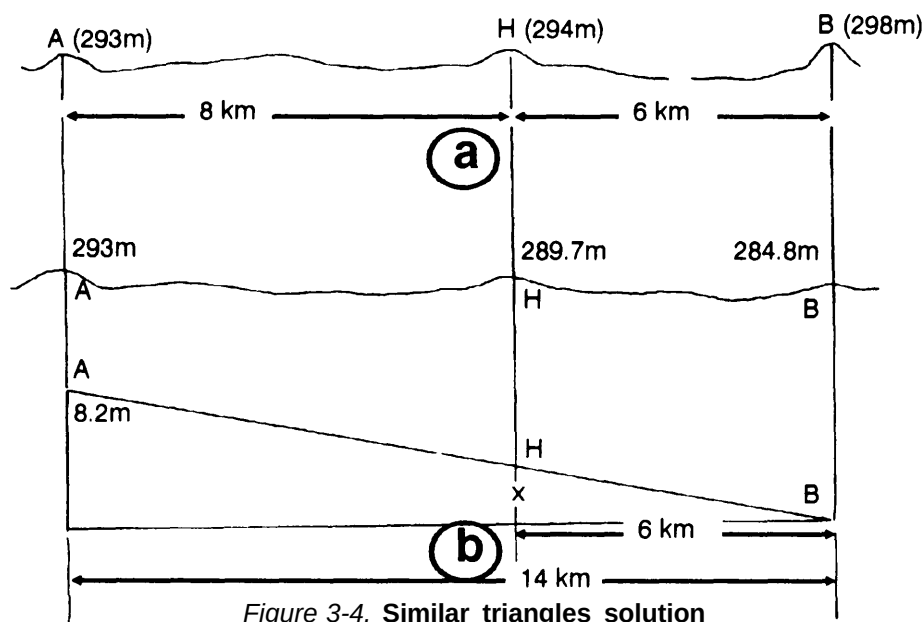


Figure 3-4. Similar triangles solution

(Figure 3-5). These varying air densities produce a condition similar to that of a beam of light passing through a series of very flat prisms. The kind of cover or vegetation, the range in temperatures between day and night, the direction and velocity of the wind, and the humidity are important factors. Another example of serious refraction trouble is a valley through an open plain and bordered by bluffs on either side. When it is impossible to avoid such a condition, the stations should be placed back on the tablelands as far as possible (Figure 3-6). Lines between the headlands and parallel to the valley will give the least accurate results and should be avoided. Horizontal refraction is much greater in barren or open country than in built-up areas. Over heavy timber the effects of air currents are small. The party chief may generally ignore the refraction effects in such areas.

On calm nights the atmosphere tends to stratify into layers of different temperatures and densities. The coefficient of vertical refraction then becomes larger than normal, lifting distant objects above the horizon. This abnormal nighttime refraction may vary between three and five minutes of arc. A **refraction line** is one that is normally obstructed but becomes visible at night. Directions observed over refraction lines are not unduly affected horizontally and their use is sometimes permissible, although they should be used only as a last resort.

Stormy or windy nights may break up the air strata and the abnormal vertical refraction may disappear entirely. Over sloping ground, the air strata may be inclined, in which case there will be a horizontal component of the refraction. Lines should always be kept well clear of bare ground.

HEIGHT OF OBSTRUCTIONS

Locating Stations to Miss Obstructions

It is often necessary to locate stations so the lines of sight will miss obstructions requiring signals to impractical heights. Blocks of unusually high timber will often be seen in heavily wooded areas. Plot the blocks on the map and ensure that all lines miss them. Intersections from water tanks, section corners, and other established stations will give the positions of the obstructions.

Determining Tree and Building Heights

Heights of trees in wooded areas and the heights of buildings in urban areas must be determined. The most direct method is to physically measure the obstruction, but this is not always easily or conveniently accomplished. There are many and various instrumental and improvised methods that can be used.

Two such methods are the shadow and vertical angle methods.

Shadow method. This method of determining the height of trees employs the similar angle method, where the height of the tree equals a known height times the length of the tree's shadow, divided by the length of the known height's shadow (Figure 3-7).

Vertical angle method. This method employs a theodolite and a tape. Measure the distance from the base of the tree to a point where the top of the tree is visible; then, with the theodolite observe the vertical angle or zenith distance to the top of the tree. The height of the tree above the telescope axis will be $d \tan a = h$, where d is the distance measured and a is the vertical angle. The height of the telescope above the base of the tree is added to the computed height to obtain the height of the tree (Figure 3-8, page 10). The angle need only be observed to the nearest degree and the distance measured to the 0.5 foot or 0.1 meter. It is usually desirable to use only full tape lengths when using this method.

CLEARING LINES OF SIGHT

The required clearance of lines of sight to avoid excessive refraction and dispersion of light will vary with the type of vegetation cover and with other physical conditions along the line. Regions combining a bare ground surface with a wide daytime temperature range require the greatest clearance and heavily timbered areas in a humid climate require the least. The following are average minimum values of the amount of clearance required for lines of sight:

Over water – 3 meters,

Over open plains where the sun is hot during the day and the atmosphere dry – 9 to 12 meters.

Over cultivated land interspersed with wooded areas – 4.5 to 6 meters.

Over treetops – 3 meters.

Special conditions may modify the clearance required. Extremes of heat and drought create special problems. Furthermore, the greatest vertical refraction is likely to occur in the regions requiring greatest clearance. In computing signal heights, reconnaissance parties often ignore the effect of the superstructure and this gives an added factor of safety. Microwave measuring instruments are susceptible to reflections from ground or water between stations. However, they can give acceptable measurements despite low obstructions directly within the line of sight. The optical electronic devices require the same line of sight clearance as theodolites.

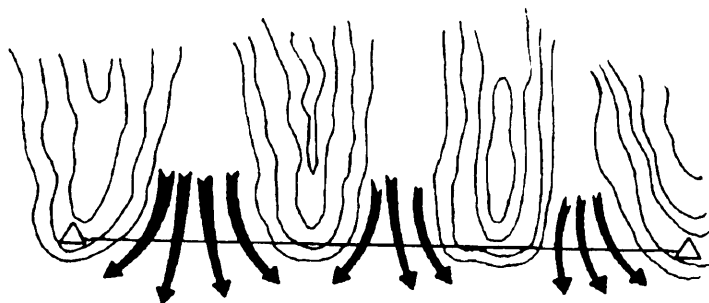


Figure 3-5. Horizontal refraction due to air currents (ravines)

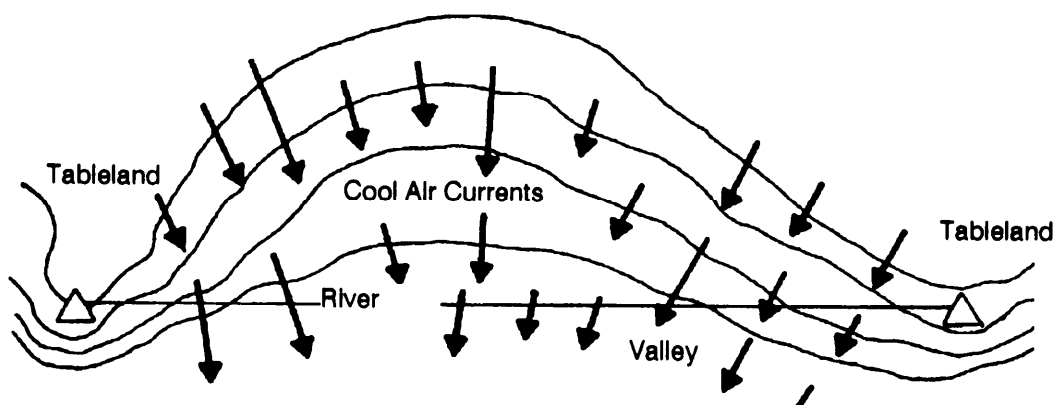


Figure 3-6. Horizontal refraction due to air currents (hills)

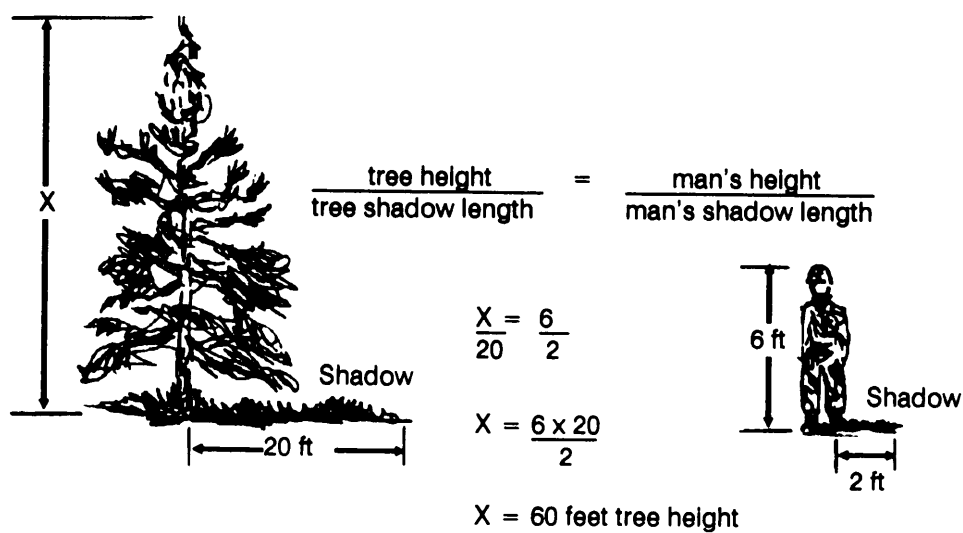


Figure 3-7. Tree height by shadow method

MONUMENTING

The monumenting of stations is accomplished during the reconnaissance phase of a survey operation.

Surface Station Marks

A variety of standard monuments are currently available for use as station marks. On projects conducted for the Defense Mapping Agency (DMA), standard DMA disks should be used. The disks are set in the top of a concrete post or other appropriate monument. Each method of survey has an individually designated disk. These station marks must be as permanent as possible and be intelligently placed for present and future use and safety from damage. In cultivated fields or in pastures which may later be cultivated, the owner's permission should be obtained to build rock cairns or to set guard or witness posts around monuments.

Subsurface Station Marks

Subsurface marks are mandatory for first-, second-, and third-order stations. They are used for lower-order stations when located in an area where they are likely to be disturbed, such as sandy or marshy ground or in urban areas.

Types of Monuments

The type of monument used depends on the terrain, climate, and soil composition. Monuments can be generally subdivided into two general categories: standard and nonstandard.

Standard monuments. These are monuments that use some form of the standard survey disk. These disks may be either brass, bronze, aluminum, or other alloys.

Poured concrete. The classic standard monument is one that must be completely poured concrete with the disk set in the top of the concrete (Figure 3-9). The procedures and dimensions described here are for a second-order or higher monument. For third-order or lower surveys, the dimensions can be reduced. To emplace a standard poured monument, a hole is excavated 1.0 to 1.5 meters deep and 0.4 meter across the top. The depth variance is to ensure the monument is well below the active frost zone. The lower 0.3 meter is belled. This helps ensure the permanence of the finished station. If a subsurface mark is required, an additional 0.25 to 0.3 meter is dug directly in the bottom center of the hole. This chamber is filled with concrete mixed at a ratio of one part cement, two parts sand, and three parts aggregate. The subsurface mark – either a proper stamped disk, a nail, or bolt – is placed in the center of the concrete. After this concrete has set for 24 hours, a plumbing bench is erected. This will ensure the subsurface mark and the surface

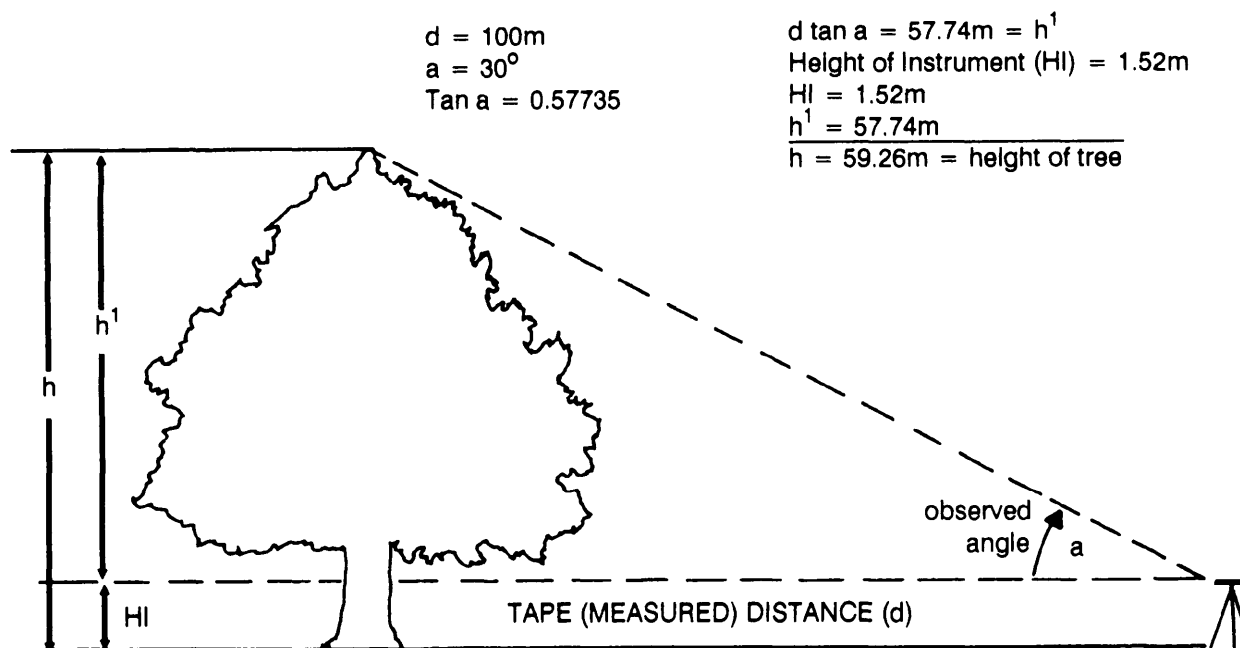


Figure 3-8. Tree height by vertical angle method

mark are in line vertically. The subsurface mark is covered with a thin board and 0.05 to 0.1 meter of sand to prevent disturbance. Unless otherwise directed, stations should be set flush with ground level. The top form may be in the shape of a square or cylinder. After the top form is poured and tamped, the top of the monument is smoothed and the surface disk is plumbed into position and set in the concrete. The

concrete should be mixed in proportions of one part cement, two parts sand, and three parts aggregate, except for the top 0.30 meter of the monument which should be slightly richer. Where only cement and sand are available, the lower part should be proportioned one part cement to three parts sand and the upper part should be one part cement and two parts sand. No reinforcement rods should be used.

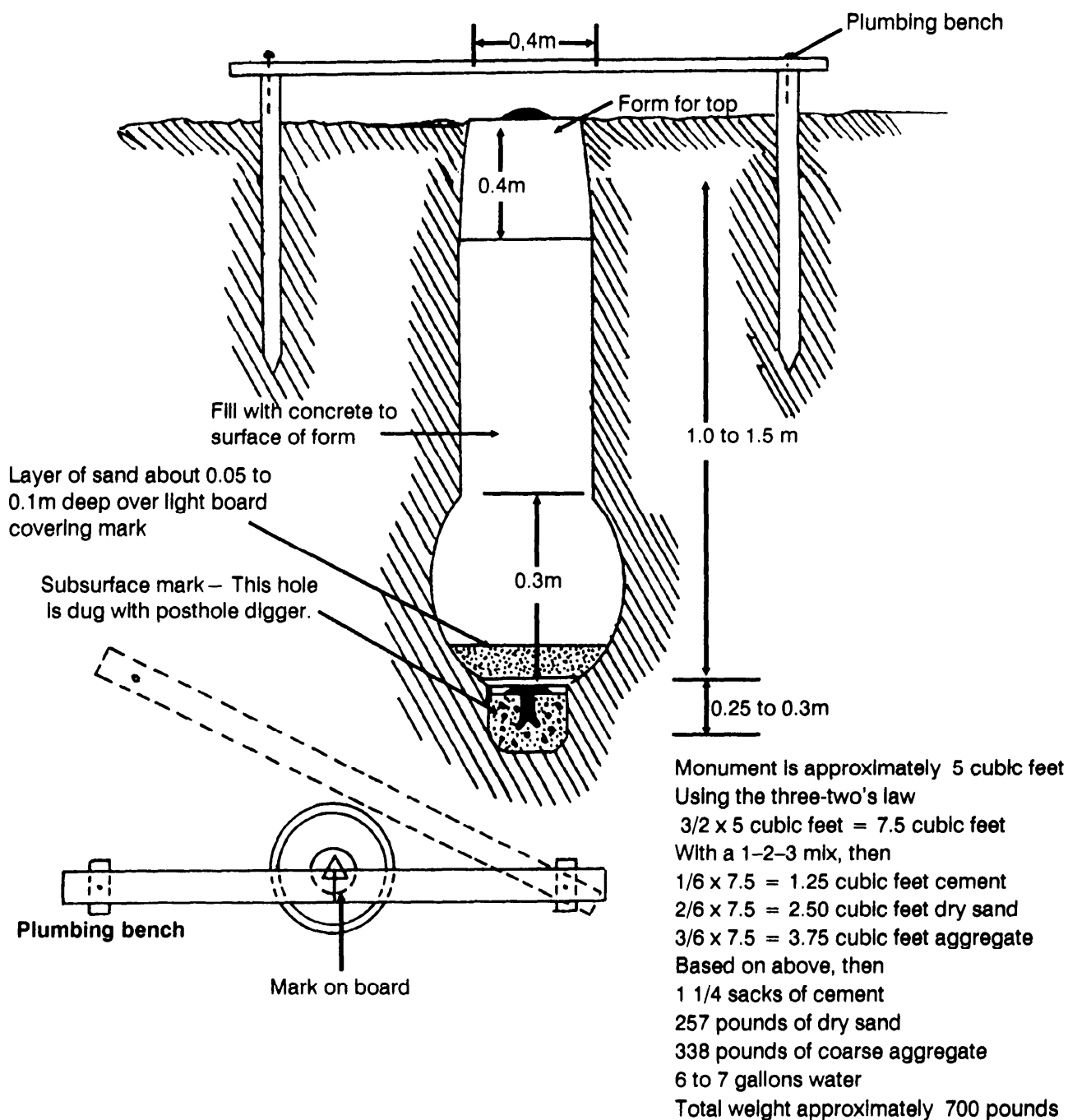


Figure 3-9. Monument construction

Precast. To eliminate the need for mixing and pouring monuments at the station site, precast monuments may be used if the project specifications permit. These precast monuments are fabricated at the base station or camp and are constructed with the equivalent dimensions listed for poured concrete, page 3-10. If a subsurface mark is required, it is emplaced as above with the precast monument being carefully plumbed.

Natural rock or boulders. When solid rock outcropping or very large boulders are the station site, monumenting maybe done by using a star drill to make a hole about 0.06 meter (2.5 inches) deep to receive the shank of the marker. The hole is filled with epoxy resin and the disk is inserted with the resin slightly built up around the edge. When a solid bench or ledge is covered with a few feet of top soil, the subsurface mark should be in the ledge and a concrete monument should be set above it to protrude above the surface.

Permafrost. In areas of permafrost, a wrought iron water pipe 0.05 to 0.10 meter in diameter and 1.22 meters or more in length is desirable. The pipe should extend through the active (freeze and thaw) layer into a good bond with the permafrost layer. Holes should be drilled in the lower end of the pipe and the lower part should be filled with water for an ice bond with the permafrost. The standard disk is brazed to the upper end of the pipe.

Marsh. Tile forms are used for monuments in marsh areas. After firmly bedding the tile into the marsh, the tile is cleaned out and filled with concrete and a disk is set in the top,

Reference marks (RM). The RMs are usually set in the same type of monument as the main station, but they can be made smaller. The number of RMs set depends upon the method of survey being used. In the triangulation and traverse methods of survey, at least two and normally three RMs will be set for each station. These marks should be located within 30 meters of the station and at intervals of about 120 around the station. No subsurface marks are used with these marks. Marks should be located where they are least liable to be disturbed. It is also necessary that marks be placed where direct measurements can be made to them from the station. It is permissible to use drill holes or chiseled marks in rock outcrops.

Azimuth marks. Azimuth marks are established in connection with SCPs to furnish an azimuth which will be available to local surveyors from an ordinary ground level instrument setup without requiring the building of a tower. This mark is used in the extension of control from the station. Readings to azimuth marks are observed as part of the triangulation procedure. The azimuth mark is a permanent monument, more than 400 meters but less than 3 kilometers from the

triangulation station, and placed in a prominent and safe location. Prominent and permanent man-made structures may also be used as azimuth marks. Some good examples of these would be the light on the top of a water or radio station tower or the cross on a church in a nearby town.

Commercial monuments. A number of commercial monuments are available that can be considered standard monuments. These are generally metal or plastic rods that are driven into the ground with a disk affixed to the top.

Nonstandard monuments. These monuments can take many forms and, if properly installed, provide for a good permanent control station. Some examples are –

- Shell casings, ranging from 7.62-millimeter to 105-millimeter expended shell casings embedded into a concrete post as prepared for standard monuments.
- Sections of rebar or pipe driven into the ground with a concrete collar poured around the upper 0.3 meter.

Witness Posts and Guard Posts

In order to aid in the preservation and to serve as a means of easy recovery of monuments, a witness post and/or guard posts may be established.

Witness posts. A witness post is no more than a sign or stake driven into the ground next to the station or reference mark.

Guard posts. Guard posts are emplaced around stations that are susceptible to damage from ground traffic. They are generally large wood stock 8 by 12 by 8 feet or expended steel such as sections of railroad rails or heavy pipe. Guard posts are usually set 1.0 to 1.5 meters into the ground and secured with concrete. Both guard posts and witness posts are marked in such a fashion as to be readily seen and identified.

DESCRIPTION AND SKETCH OF STATION

The reconnaissance party will prepare a description and sketch of all newly established permanent and temporary stations as well as all stations recovered (Figure 3-10). Stations recovered but not used still must have a description completed. The description and sketch will be on *DA Form 1959*, or in appropriate current field books such as *DA Form 4648, Station Description Book*. The field record will be freehand using vertical gothic lettering. The final *DA Form 1959* should be typed.

COUNTRY UNITED STATES		TYPE OF MARK Bronze disk		STATION Cotton, 1962, AMS	
LOCALITY Maricopa, Arizona		STAMPING ON MARK 1962, Army Map Service		AGENCY (CAST IN MARKS) Corps of Engineers	
LATITUDE 33 03 15.771 N		LONGITUDE 112 01 32.659 W		DATUM 1927 WAD	
(NORTHING)(EASTING) 3 657 591.90		(EASTING)(NORTHING) 404 234.41		GRID AND ZONE UTM 12	
(NORTHING)(EASTING) (M)		(EASTING)(NORTHING) (M)		DATE 1962	
TO OBTAIN		GRID AZIMUTH, ADD		TO THE GEODETIC AZIMUTH	
TO OBTAIN		GRID AZ. (ADD/SUB)		TO THE GEODETIC AZIMUTH	
OBJECT	AZIMUTH OR DIRECTION (GEODETIC)(GRID) (MAGNETIC)	BACK AZIMUTH	GEOL. DISTANCE (METERS)	FEET	GRID DISTANCE (METERS)
R.M. # 2	90° 46' 50.0"		11.412		
TT N-31 (AZ. MK)	136° 46' 25.1"		553.1709		
R.M. # 1	180° 56' 25.0"		8.828		
Base Station "A"	283° 54' 08.51"	83° 59' 53.89"	16505.6605		16500.6268

Recovered as described

The station is located near the town of Maricopa, Arizona.

To reach the station, from the Southern Pacific Rail Road grade crossing in Maricopa, Arizona, proceed in a northerly direction on Maricopa-Phoenix Highway for approximately 0.1 mile (0.16 km) to a '+' intersection; turn right and proceed in a easterly direction for approximately 1.3 miles (2.1 km) to a 'T' intersection to the right; turn right and proceed in a southerly direction for approximately 0.25 miles (0.4 km) to a 'T' intersection of a road to the right and the site of the station.

The station is located 4.2 meters south of the centerline (C) of a paved road to the west; 7.6 meters west of the centerline (C) of a paved road to the north; 1.7 meters north of the north edge of a concrete irrigation headwall; 1.1 meters east of a wooden 4x4 inch white witness post.

The station is marked by a Corps of Engineer's U.S. Army bronze disk stamped: 'COTTON, 1962, ARMY MAP SERVICE', in a 10 inch (23 cm) round concrete post 4 inches (9.2 cm) above the ground.

Reference Mark (RM) #1 is a Corps of Engineer's bronze disk stamped: 'COTTON, R.M. #1, 1962, ARMY MAP SERVICE', in a 10 inch (23 cm) round concrete post flush with the ground at 8.8 meters, 180 degree Magnetic Azimuth to the station mark.

Reference Mark (RM) #2 is a Corps of Engineer's bronze disk stamped: 'COTTON, R.M. #2, 1962, ARMY MAP SERVICE', in a 10 inch (23 cm) round concrete post 4 inches (9.2 cm) above the ground at 13.3 meters, 91 degree Magnetic Azimuth to the station mark, and 13.3 meters, 64 degree Magnetic Azimuth to R.M. #1.

Azimuth Mark (AZ MK) is a Corps of Engineer's bronze disk stamped: 'TT N-31, ARMY MAP SERVICE, 1961', in a 10 inch (23 cm) round concrete post flush with the ground at 3.2 meters north of the north edge of the road bank, 4.3 meters west-northwest of a wooden powerpole, and 1.0 meters northeast of a metal fencepost.

Visibility at tripod height is clear in all directions.

(Miscellaneous Information) to include hazards to survey party and special access requirements.

SKETCH

The sketch shows a plan view of the station area. A horizontal road runs across the top. To the left of the road is a 'CULT. FIELD'. To the right of the road is another 'CULT. FIELD'. The station mark (RM 1) is located 4.2 meters south of the road centerline. A reference mark (RM 2) is located 13.3 meters west of the station mark. An azimuth mark (AZ MK) is located 3.2 meters north of the road centerline. A wooden powerpole is located 4.3 meters west-northwest of the station mark. A metal fencepost is located 1.0 meters northeast of the station mark. A concrete irrigation headwall is located 1.7 meters north of the station mark. A wooden 4x4 inch white witness post is located 1.1 meters east of the station mark.

DA FORM 1959

REPLACES DA FORMS 1959
AND 1960, 1 FEB 57, WHICH
ARE OBSOLETEDESCRIPTION OR RECOVERY OF HORIZONTAL CONTROL STATION
For use of this form, see TM 5-237, the proponent
agency is TRADOC.

Figure 3-10. Station description card

Description

The description is a narrative report compiled at the station site containing all the information necessary to expeditiously locate the station. It should enable someone totally unfamiliar with the area to go with certainty to the immediate vicinity of the station. In conjunction with the sketch, a positive identification of the station and reference marks should be possible. Repetition must be avoided where possible. A station description should be brief, to the point, and uniform in order of statement. All descriptions will contain —

Recovery note. The two- or three-word phase describes the general condition of the monument. The only recovery notes are —

New station. This is a newly established station for which no description exists.

Recovered as described. When a station is recovered exactly as described, all marks are in good condition, the distances and directions are verified, and the sketch and description are adequate. The statement alone is sufficient for the reconnaissance recovery card. The old sketch and description are transcribed onto the new control card.

Recovered. When a station is recovered but changes have occurred which make the old sketch and description inaccurate or inadequate, a new card should contain a new sketch and/or description of the station. Alterations to the station or reference marks are to be reported, with a description of the altered marks and new measurements of the referenced distances and directions. A definite effort should be made to improve all sketches and descriptions.

Not recovered. This is a station for which no positive evidence of existence can be found after a diligent search has been made.

Destroyed. This is a station at which there is positive evidence that the station did exist, but the station and its reference marks have been so mutilated that it cannot be replaced within 1 centimeter of its original position. The individual making the recovery and writing the description must use judgment in determining the status of a station. It must be remembered that a station may be destroyed for precise purposes but still be valuable for surveys requiring less accurate control; for example, gravity, magnetic, or astronomic surveys.

Reset. This is a station at which the monument and/or station marks have been replaced so that the mark is within 1 centimeter of its original position. A station is reset only from subsurface and/or reference marks that have not been moved from their original positions. The task of resetting monuments maybe assigned to the reconnaissance party.

Disturbed This notation is generally used only with reference to vertical control points. It is a station at which the monument is physically present, but it has been so moved that it has lost its value as a vertical control point within the accuracy to which it was originally established.

General location. This follows the recovery note. It locates the station area on a map, in relation to cities and towns, bridges, and other major landmarks. The political subdivision should also be stated.

Route description or “to reach” statement. This describes the route to follow in order to reach the station site. This should start from an easily located point such as a public building, park, main road intersection, or any other permanent landmark identifiable both on the map and on the ground. Distances between checkpoints on the route are given in miles and tenths or kilometers and tenths. Changes in direction of route are given as both left/right and east/west/north/south.

Station site description. This describes the exact location of the mark in relation to readily identifiable reference marks. The magnetic azimuth and the distance are listed from the reference point to the station mark.

Description of the station mark. This describes the actual mark (drill hole, bronze disk, chiseled mark in stone) and the exact stamping on the mark (agency, year, type of station). It must be noted if the station mark is above or below the ground surface.

Reference marks. These describe the reference marks in the same manner as the station mark, with distances and directions measured from the station mark.

Azimuth mark. This describes the azimuth mark in the same manner as reference marks, except that the distance is usually approximated rather than measured.

View from tripod height. This is a description of field of view from tripod height. For example, “view is unobstructed in all directions except south” and “trees, 60 feet high, 300 feet from the station, obstruct the view between the magnetic azimuths of 170 and 215 degrees.”

Miscellaneous information. Any important information about the station site that is not covered in

any other section can be listed at the bottom of the description. This may include the photo number and mission (if applicable), danger areas, notes concerning access, or any other pertinent information.

Sketch

The sketch should be clear and simple, and should contain only the detail required for positive identification of the station. In general, it should contain –

Features of permanent nature. The features around the station are shown with enough detail so that they will not be confused with similar features. For example, many road intersections and hilltops look alike. It is only when the sketch is extended slightly that the characteristic features become evident. When there is little detail available, a rough contour sketch should be made. All symbols used on the sketches should be standard topographic and military symbols as listed in *FM 21-31* and *FM 101-5-1*.

Scope and scale of sketch. Judgments on what features are actually required to identify the station and the individual's ability to draw usually govern the scope of a sketch. Normally a sketch should include the area within a radius of 200 feet to 1/2 mile. Sketches covering an area of several miles should be avoided. In all cases, the termination point of the **to reach** description must be on the sketch. The sketch need not be drawn to scale.

Orientation. The sketch must be oriented to north; it will be the preprinted arrow on *DA Form 1959*.

TRANSPORTATION

The reconnaissance party will use transportation that is organic to the unit, in accordance with the unit TOE and unit SOP. When available, due to project requirements or customer support, the use of aircraft will enhance the project reconnaissance. Helicopters

will greatly assist and speed reconnaissance by checking routes of travel, lines of sight between stations, selection and identification of stations (existing and proposed), as well as determining the scheme for extending surveying control. If aircraft are used, it is mandatory that the pilots be thoroughly briefed on the survey project and the reason for it. Complete knowledge of the entire project by the pilots will expedite the field reconnaissance and probably accelerate the progress of the project.

COMMUNICATIONS

The reconnaissance party has access to radios, in accordance with the unit TOE and unit SOP. The radios will be used by the surveyors to confirm lines of sight when stations are separated by great distances. Prior to using the radios on a survey project, the party chief will obtain authorized frequencies from the local (customer's) signal officer. The surveyors will use the radios in accordance with the local CEOI and communications-electronics standing instructions (CESI). The surveyors will also adhere to the unit's standing signal instructions (SSI), signal operation instructions (SOI), and radio communications procedures. In the event of a conflict, the procedures of the local (customer's) signal office will take precedence. *FM 24-1* is the authority for signal security.

MISCELLANEOUS INFORMATION

Fuel and Maintenance

The party chief will make arrangements with the customer to ensure that both fuel and maintenance are available for the vehicles he signs for.

Equipment and Office Space

The party chief will ensure that adequate space is available to secure equipment. Adequate space for project administration and field office computing must also be obtained.

Section IV REPORTS

Upon completion of the field reconnaissance of the area to be surveyed, the party chief will submit a reconnaissance report. If the area or the project is large, the project will be divided into phases, with a report

required at the completion of each phase.

The reconnaissance report is discussed in Chapter 8, Section I.