Field Manual
No. 5-232

***FM 5-232**
HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, DC, 27 September 1989

TOPOGRAPHIC SURVEYING

This field manual is a guide to MOS 82D, Topographic Surveyor. It provides techniques not located in any commercial text concerning the precise determination of position, azimuth, or elevation of a point. Additionally, this publication describes and standardizes procedures for performance of reconnaissance, station description, and reporting and briefing of survey projects to managers and supervisors.

The material in this manual is applicable without modification to all geodetic survey projects in all environments: prebattle, conventional war (nuclear and nonnuclear), low intensity conflicts, and postbattle. The contents comply with AirLand Battle doctrine and international precision surveying practices.

This manual does not provide previously published surveying doctrine or theory and must be supplemented using commercially available texts or previous editions of technical literature.

Users of this publication are encouraged to submit changes for improving the publication on DA

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This publication was prepared by the US Army Engineer School; the proponent is the United States Army Training and Doctrine Command (TRADOC). It reflects the current thought of this agency and augments existing doctrinal and training literature.

DISTRIBUTION RESTRICTION: Approved for public release; distribution is unlimited.

Unless otherwise stated, whenever the masculine gender is used in this publication, both men and women are included.

*This publication supersedes C1 ~~*TM 5-232, 1 June 1971; TM 5-235, 18 September 1964;*~~ *and* TM 5-441, 4 February 1970.

Posted 3 JUN 96

FM 5-232
*C1

Change

NO. 1

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, DC, 29 May 1990

FIELD MANUAL
TOPOGRAPHIC SURVEYING

FM 5-232, 27 September 1989, is changed as follows:

1. Line through the supersession notice and references as indicated below:

Page

i . . . .Supersession notice, line through: TM 5-232, 1 June 1971; TM 5-235, 18 September 1964.

2-References . . . . under Technical Manuals (TM) line through: TM 5-441 Geodetic and Topographic Surveying.

2. File this change sheet in front of the publication for reference purposes.

By Order of the Secretary of the Army:

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General, United States Army
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DISTRIBUTION:

Active Army, ARNG, and USAR: To be distributed in accordance with DA Form 12-11E, requirements for FM 5-232, Topographic Surveying (Qty rqr block no. 4387), and TM 5-232, Elements of Surveying (Qty rqr block no. 652) and TM 5-441, Geodetic and Topographic Surveying (Qty rqr block no. 678).

*U.S. Government Printing Office: 1990-727-027/00171

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CHAPTER 1
Overview of Surveying

Surveyors determine horizontal and vertical distances between objects, measure angles between lines, determine the direction of lines, and establish points of predetermined angular and linear measurements. Once the field measurements are complete, surveyors use these to compute the data into a final report used for positioning by field artillery, air defense artillery, aviation, intelligence, communications, or construction control points.

Section I
MISSIONS, CLASSIFICATIONS, AND NETWORKS

MISSIONS

The missions of the military topographic surveyor are —

- Support deployable weapons systems (nuclear and nonnuclear) with position and azimuth.
- Support aviation with position, azimuth, and elevation.
- Support intelligence with precise position and azimuth.
- Support communications with line-of-sight profiles, position, and 360-degree visibility studies,
- Establish and extend basic control with field surveys.
- Forward survey data and station description cards to Defense Mapping Agency, the organization's survey information center (SIC), and colocated terrain analysis teams upon request,

These missions are defined in *AR 115-11,* in *FM 5-105,* unit table(s) of organization and equipment (TOE), and by directives from higher headquarters.

GEODETIC AND PLANE SURVEYS

The actual shape of the solid mass of the earth is referred to as the topography. The geoid is defined as the surface of the earth's gravity (attraction and rotation) which, on the average, coincides with mean sea level in the open undisturbed ocean. The spheroid (an ellipsoid of revolution), appears as a figure flattened at the poles and bulging at the equator. It can be described using a mathematical formula that approximately defines a part of the surface of the geoid, However, because of the great variations in topography, many different spheroids exist. Because the earth's surface is irregular and pieces of mathematical computations are unreliable, the surveys conducted depend on the purpose or level of accuracy required. In plane surveys all points are referenced to a flat plane, with curvature wholly or mostly ignored. In geodetic surveys, all established points are referenced to the curved surface of a spheroid and in all computations the effect of curvature is computed,

CLASSIFICATIONS

Technical Classifications

Geodetic surveys take into account the size and shape of the earth. Since the stations in geodetic surveys are routinely spaced over extended distances, more precise instruments and procedures are required than for plane surveys. All observations are made on the actual curved surface of the earth and this curvature is corrected through computations. The computational methods used in geodetic survey are discussed in *TM 5-237.*

Plane surveys ignore the actual shape of the earth and apply the principles of plane geometry and trigonometry. When the survey is less than 250 square kilometers in area and less accuracy is needed, curvature can be ignored. These surveys are treated as if the measurements were made on a flat plane, with all lines being straight. Most localized construction projects and boundary projects are plane surveys. The more extensive highway/railroad construction projects are generally plane surveys. The computational methods used in plane surveys are described in appropriate chapters of *FM 5-233* and *TM 5-237.*

Functional Classifications

Construction surveys. These surveys provide data, planning, and cost estimating essential to locate or lay out engineering works and are recorded on engineer maps. These surveys normally use plane surveying techniques. The methods, techniques, and procedures used by the military construction surveyor are detailed in *FM 5-233.*

Artillery surveys.
Field artillery fire-control surveys are conducted to determine the relative positions of weapons systems to targets, but do not require the accuracy of geodetic surveying procedures despite the relatively large areas and long distances. The requirements, methods, and procedures used by the military field artillery surveyor are detailed in *FM 6-2.*

Air defense artillery weapons systems require the accuracy obtainable only with geodetic survey techniques.

Basic control (geodetic) surveys. These are surveys which provide horizontal and/or vertical positions of points which supplementary surveys may originate from and can be adjusted to. The basic control survey of the United States provides geographic positions and plane coordinates of triangulation/traverse stations and the elevations or bench marks, This information is used as the basis for the control of the topographic survey of the United States; for the control of many state, city, and private surveys; and for hydrographic surveys of the coastal waters. Techniques and procedures used by the military geodetic surveyor are discussed in this manual.

Astronomic surveys. The celestial determination of latitude and longitude separations are calculated by computing distances corresponding to measured angular displacements along the reference spheroids.

Satellite surveys. These surveys are conducted using artificial earth satellites for long-line surveys. Since distances between stations may vary from 100 to 1,500 miles, doppler transit satellites and the global positioning system (GPS) geocentric satellites are typical.

Special surveys.
Hydrographic surveys. These are surveys made on large bodies of water to determine channel depths for navigation and locations of rocks, sandbars, lights, and buoys. In the case of rivers, these surveys are made to support flood control projects, power development, navigation, water supply, and water storage.

Field classification and inspection surveys. These surveys help identify features not normally revealed using a compiler. Examples include political boundary lines, place names, road classifications, and buildings obscured by trees. They also help clarify aerial photographs using comparisons with actual ground conditions.

Gravity surveys. These surveys result in the intensity of the gravitational forces at or near the earth's surface. Gravity observations may be either absolute or relative, Absolute gravity is the gravity at a specific point, while relative gravity reflects gravitational variations from point to point.

Land surveys. This is the process of locating the boundaries and areas of tracts of land.

Inertial surveys. These surveys determine relative positions and azimuths. The position and azimuth determination system (PADS) is now being used extensively to support artillery survey requirements.

Airfield surveys. These surveys are made to determine any combination of the following:
- Location of obstacles within 10 nautical miles of the airfield center.
- Dimensions of runways and taxiways, heights of flight towers, and navigational aids.
- Safe approach angles to runways and minimum safe glide angle.
- Elevation of barometer on the airfield.
- Positions and azimuths of points designated for inertial navigational systems (INS) checkpoints.
- Requirements of the Federal Aviation Administration (FAA), United States Army Aeronautical Services Office (USAASO), or equivalent military activity.
- Incidents of a military aircraft crash or disaster.

SURVEY NETWORKS

Horizontal and vertical survey control within a country is usually established by a network of control areas. These areas are all referenced to a single datum and are related in position or elevation to each other. The networks are called basic, supplementary, and auxiliary. Currently, all horizontal networks in the United States are referenced to the *North American 1927 Datum (NAD 1927)* and *North American 1984 Datum (NAD 84* and *WGS 83* are the same) with coordinates currently being published in both data.

Mean Sea Level 1929 is being used for vertical control points. Within the continental United States, the following definitions are used.

Basic

Basic horizontal control networks. These networks are usually established by first-order geodetic triangulation, precise electronic traverse, or satellite translocation. The lines of the basic network are typically spaced approximately 96 kilometers apart throughout a country.

Basic vertical control networks. These networks are established by first-order differential leveling in areas spaced from 90 to 160 kilometers apart throughout the country. Permanent bench marks are spaced approximately 3 kilometers apart on these lines.

Supplementary

Supplementary horizontal control network. This network is usually established by second-order survey procedures. The supplementary nets are used to fill in the areas between the basic control lines. Ultimately, a station of either the basic or supplementary networks will be spaced at intervals of between 6 to 16 kilometers across the country.

Supplementary vertical control network. This network is established by second-order differential leveling. These lines are run within the basic control arcs to provide a planned control line spacing of about 10 kilometers. Permanent bench marks are emplaced about 2 kilometers apart on these lines.

Auxiliary

Horizontal auxiliary (or additional) control networks. These networks are usually established by second- or third-order survey procedures. The networks are established to provide localized control to be used by surveyors for artillery control, construction engineering surveys, mapping projects, or other positioning requirements. Additionally, as more states require geodetic accuracies, these networks will be used by states and other agencies for boundary and property surveys.

Vertical auxiliary control networks. These networks are established by third-order differential leveling and are used to provide localized vertical control. This control is also used to support artillery construction and engineering projects.

Section II
FIELD WORK

Survey field work consists of making observations and measurements and recording the data. The surveyors must also overcome many factors that combine to affect working conditions.

OBSERVATION AND MEASUREMENT FUNCTIONS

Observations and measurements are generally made for the following reasons:

Observing Distances and/or Directions (Angles)

- To establish triangulation and traverse stations for basic, supplementary, and auxiliary control networks.
- To establish gun and target positions for artillery batteries.
- To establish horizontal control to support PADS.
- To establish point and lines of reference for locating detail such as boundary lines, roads, buildings, fences, rivers, bridges, and other existing features.
- To stake out or locate roads, buildings, landing strips, pipelines, and other construction projects,.
- To establish lines parallel to or at right angles to other lines; or to determine the area of tracts of land, measure inaccessible distances, or extend straight lines beyond obstacles.
- To establish picture points for data bases.
- To do any other work which may require use of geometric or trigonometric principles.

Observing Differences in Elevations

- To establish bench marks for basic, supplementary, or auxiliary vertical control networks.
- To determine differences in elevation of terrain along a selected line for plotting projects and computing grade lines.
- To stake out grades, cuts, and fills for earthmoving and other construction projects.
- For trigonometric elevations of triangulation and traverse stations for control nets and mapping projects.
- For gun and target position for field artillery batteries.

Recording Field Notes

Field notes are made to provide a permanent record of the field work. These notes take the form of-

- Field recording booklets.
- Single sheet recording forms.
- Magnetic tapes for automatic data recording.
- Plane table sheets.
- Land survey plans.
- Property plans.
- Recovery and station description cards.

- Control diagrams showing relative location, methods, and type of control established and/or recovered.

FACTORS AFFECTING FIELD WORK

The field surveyor must be constantly alert to the various conditions. Weather, terrain, personnel, equipment, purpose, required accuracy, systematic procedures, rates of progress (speed), and the enemy situation all influence the work.

Weather and Terrain

Weather and terrain can adversely affect field surveys. The effectiveness of optical and electro-optical instruments can be severely reduced by fog, mist, smog, or ground haze. Swamps and flood plains under high water can impede taping or leveling operations. Distances measured over open water and fields of flat unbroken terrain or near high-power transmission lines can create ambiguities when using microwave equipment. Maximum length measurements obtained by electro-optical distance measuring equipment (DME) can be reduced in bright sunlight. Good reconnaissance and proper planning can alert the field parties of the best times and methods to use.

Personnel

The level of training and experience of the personnel also affect field work. The rate of progress often varies in proportion to the personnel experience level.

Equipment

Modern, well-maintained equipment can often increase the rate of progress. Even older equipment, if properly maintained or adjusted, will yield accurate results. Repairing or replacing broken instruments or parts is sometimes responsible for slowing down or stopping a field survey. Therefore, equipment reliability must be considered when setting completion dates.

Purpose and Type of Survey

The purpose and type of survey determine the accuracy requirements. First-order triangulation, traverse, or leveling for the control networks must have high accuracy standards. At the other extreme, cuts and fills for a highway have much lower standards. In some surveys, distances to inaccessible points must be determined. Highly accurate distance and angle measurements are required so that these values, when used in trigonometric formulas, will yield acceptable results.

Required Accuracy

Accuracy requirements will dictate the equipment and procedures selected. For instance, comparatively rough procedures can be used in plane table operations, but control network leveling requires much more precise and expensive equipment as well as extensive, time-consuming procedures.

Errors

All measurements contain some error. The errors classified as systematic and accidental are the most common uncontrollable errors. Besides errors. measurements are susceptible to mistakes or blunders. These arise from misunderstanding the problem, poor judgment, confusion, or carelessness. The overall effect of mistakes and blunders can be greatly reduced by establishing a systematic procedure. The system will be an advantage in all phases of the survey and can result in great time savings.

Rates of Progress (Speed)

Rates of progress vary depending on experience and repetition. As skill and confidence increase, so will speed. Proper preparation and planning will reduce duplication of effort and increase efficiency.

Enemy Situation

A hostile environment often forces a schedule adjustment. Night work will require greater speed, fewer lights, and increased security. Adding security forces increases the number of vehicles and personnel which, in turn, involves reduced efficiency, thus retarding even the most ambitious time schedule.

FIELD NOTES

Even the best field survey is of little value if the notes are not complete and clear. The field notes are the only record that is left after the survey party leaves the field site. The surveyor’s notes must contain a complete record of all measurements or observations made during the survey. When necessary, sketches, diagrams, and narrations should be made to clarify notes. Write overs, erasing, use of ink eraser, correcting tape, and whiteout are strictly forbidden. These actions, when prohibited by the unit survey standing operating procedures (SOP), are cause for punishment under the Uniform Code of Military Justice. Recording errors are to be lined out, initialed by the recorder and the correct new reading entered on the recording form.

Recording Qualities

Good field notes share these qualities:

Neatness. The lettering conforms to the gothic style portrayed in *FM 5-553.* All entries are formatted according to local SOPs.

Legibility. Only one interpretation should be possible. Decimal points and commas must be clear and distinct.

Completeness. All entries are completed and all resolved data are finished according to local SOPs.

Done in field. All recording is done on the correct specified forms entirely in the field. Notes are never recorded on scrap paper and transcribed to a field recording form. If performing an underground survey, obtain and use a covered clipboard to protect the notes.

No erasures. All field work will be done in black or blue-black ink suitable for photocopying. The only exception is the field sheet of a plane table survey.

No write overs. Field notes show what happened in the field. If a number is changed, the correct procedure is to make a single slanted line through the incorrect number. The individual making the corrections inserts the correct number directly above or next to the corrected value, creating the new entry and initialing the change. A note will be entered in the Remarks column stating why the number was changed.

True picture. The field notes accurately describe the field experience. Sketches, diagrams, and notes reduce or eliminate questions.

Organizing Survey Notes

Survey notes are usually kept in a field notebook, or on individual recording forms, or on tape if an automatic data collector is used. Regardless of the type used, the following information must appear:

1 Instruction for return of the book or notes, if they should be lost. Usually, it will be returned to the commander of the particular unit.
2 Index of field notes contained in the book and cross--referenced to additional books or binders.
3 List of party personnel, their duties, and the dates on the project (from - to).
4 List of instruments used, to include types, serial numbers, calibration date, constant values, and dates used.
5 A generalized sketch and description of the project.
6 The actual survey notes on each page containing data. The heading must be filled out, to include –

- Station names, including establishing agency and date.
- Date of the survey.
- Personnel names and survey duty (instrument operator, notekeeper).
- Instruments used and serial numbers.
- Weather data.
- The actual observed data, to include all required reductions.
- Pertinent notes, as required.
- The observer's initials, indicating that the observer has checked all entries and ensured they are correct. The observer's initials will be at the bottom right corner of the recording form.

Loose-leaf sheets should be serially numbered to ensure that all sheets are kept and turned in. The cassette tapes must be clearly marked for return to the unit, and require special handling.

Types of Recording

Field note recording takes three general forms: tabulation, sketches, and descriptions.

Tabulation. Numerical data is recorded in columns following a prescribed format, depending on the type of operation, instrument used, and specifications for the type of survey.

Sketches. Sketches add much to the clarity of field notes and should be used liberally. They maybe drawn to scale, as in plane table surveys, or they can be drawn to an approximate scale, as in control cards. If an exaggerated scale is needed to show detail, the use of such a scale is recommended. Measurements should be added directly on the sketch or keyed in some way to avoid confusion. Sketches require the same qualities as all other field notes.

Descriptions. Tabulations with or without sketches can also be supplemented with narrative descriptions. The description may only consist of one or two words or it maybe very detailed. It must be remembered that survey notes become a part of historic records. A brief description entered at the time of the survey maybe important and helpful at some time in the future.

Abbreviations and Symbols

It is strongly recommended that standard abbreviations, signs, and symbols be used in all survey notes. These abbreviations, signs, and symbols must be in accordance with current guidelines in such publications as *AR 310-50, FM 21-31,* and *FM 101-5-1.* If there is any doubt as to the meaning or interpretation of a symbol or abbreviation, the words must be spelled out.

Corrections

Field notes are considered legal documents, since they can and have been used in court proceedings. As such. NO ERASURES OR WRITE OVERS ARE PERMITTED. Individual numbers are corrected as stated in Recording Qualities, page 1-5. No position will be voided or rejected in the field except in the case of disturbing the instrument or target or observing the wrong target. In either case, the position should be **reobserved,** stating in the Remarks section the location of the reobserved data.

Waterproofing

Every effort must be made to protect field notes. Even in high humidity or rain, field notes can be waterproofed by spraying a thin coat of clear acrylic plastic on the field record. If applied before the recording, the paper will be waterproof but still allow recording with ordinary writing instruments. The field notes can be sprayed again after use, and the plastic fixes the writing and prevents water damage to the records. One such spray is *Krycor, workable FIXA T-IF #1306;* however, many other sprays are available and any of them may be used.

SURVEY COMMUNICATIONS

Survey party members may find themselves separated. The ability to communicate with each other may mean the difference between successfully completing a section of work or not. Even at relatively short distances (as in taping, plane table, or leveling operations), background noises can obscure direct voice contact. At longer distances such as in electronic distance measuring equipment (EDME) or direction measurement operations, effective direct voice contact is impossible. Therefore, some other types of communications are required.

Hand Signals

Communication over short distances can effectively be accomplished using hand and arm signals such as are shown in Figure 1-1. All party members must know the signals and their exact meaning. Each signal is given while facing the person being signaled.

Voice Communications

On long lines where hand signals are impossible, the radio must be used. Each theater of operations or Army command has published communications-electronics operation instructions (CEOI), with which the user units must comply. Only frequencies obtained through the local signal officer may be used. All personnel using radios must be familiar with the CEOI and the unit's communications SOP before using a radio. All radio communications must be kept as short and secure as possible.

Mirrors and Lights

Mirrors and lights can also be used for communication. The emergency signal mirror can use the sun as a light source and is a fairly accurate sighting device. Morse code or other prearranged signals can be used to effectively communicate during the day. At night, the same signals can be used with a 5-inch or other light.

Section III
OFFICE WORK

Surveying also consists of converting the field measurements into a more usable form. The conversions or computations maybe required immediately to continue the field work. At other times, they must be held until a series of field measurements is completed. This is called office work, even though some of the operations may be performed in the field during lapses between measurements.

OPERATIONS

Some office functions use special equipment (slide rules, conversion tables, calculators, computers, or drafting equipment) or require extensive references and working areas.

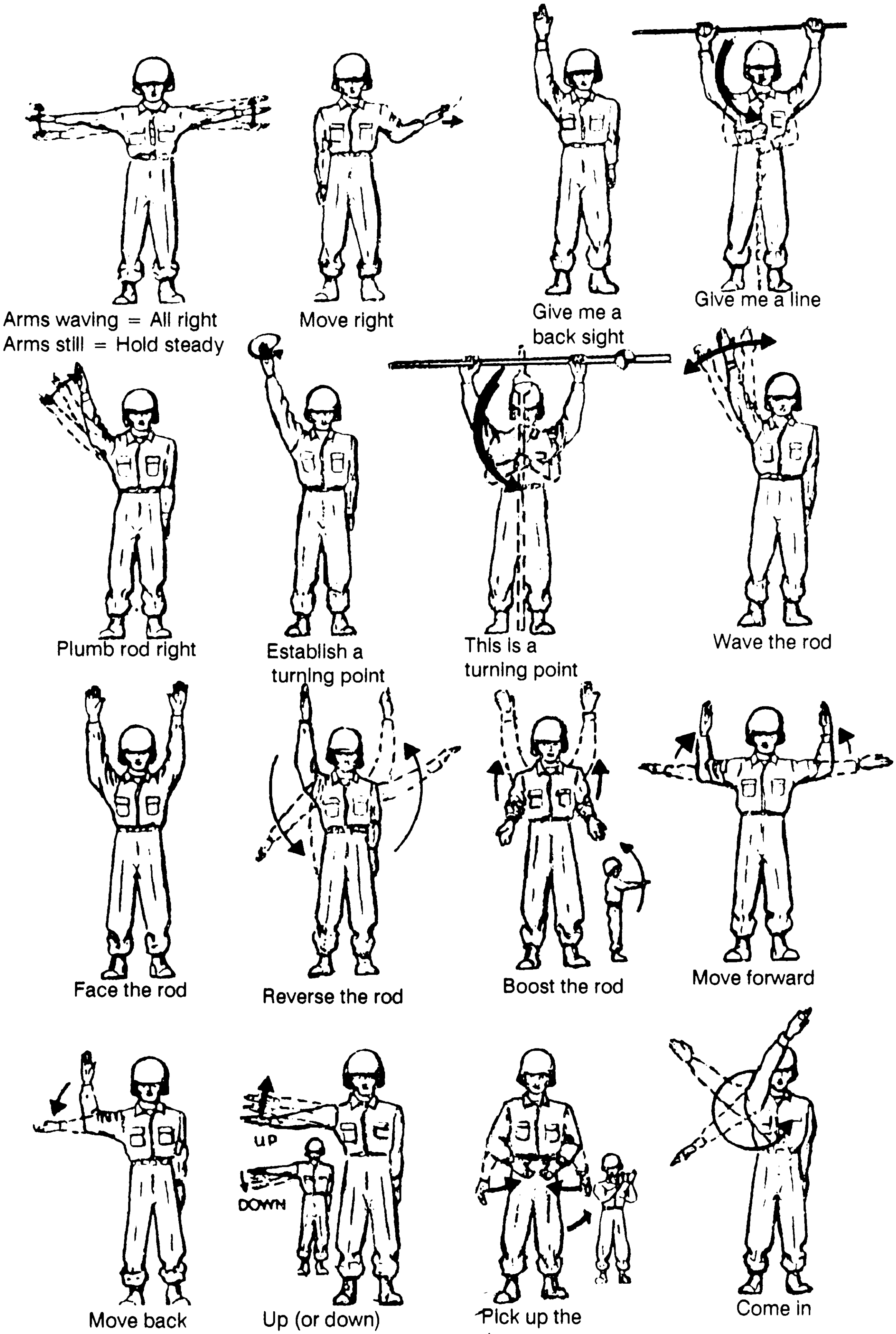
Working Up Field Notes

During survey operations, many field measurements require some form of arithmetical computation. It may be a simple addition of several full (tape) lengths and a partial tape length to record a total distance between two points. It maybe adding or subtracting differences in elevation to determine height of instrument or elevation during leveling, or it maybe checking angles to see that the allowable error is not exceeded.

Computing

Office computing converts distances, angles, and rod readings into a more usable form. The measurements may end up as a computed volume of dirt to be moved for a highway cut or fill, an area of land needed

Figure 1-1. **Hand and arm signals**



for a construction project, or an adjusted position of some point or mark from which other measurements can be made.

Distances. Distances measured by tape are measured in short horizontal distances. For higher accuracy, corrections to taped distances must be applied for temperature, tension, or sag of the tape. The desired result is the horizontal distance between two points, In electronic distance measuring (infrared and microwave), the distance is almost always on a slope and has to be corrected for temperature and barometric pressure, then reduced to corrected horizontal distance.

Azimuths and bearings. In many operations, the observed angles are converted into directions of a line from north (azimuths) or a north-south line (bearings).

Relative positions. The distance and direction of a line between two points determines the position of one point relative to the other point. If the direction is given as a bearing or azimuth, a trigonometric formula using the sine or cosine of the angle, multiplied by the distance, will result in a coordinate difference between the two points.

Adjusting

Some survey techniques are not complete until one more procedure is performed.

Definition. Adjusting is the determination and application of corrections to data. Adjustment causes the data to be consistent within themselves and to a given set of references. Small errors which are not apparent during individual measurements can accumulate to a sizable amount. For example, assume that 100 measurements were made to the nearest unit and required determining which unit mark is closer to the actual measurement. At the end of the course, an error of + 4 units resulted. Adjusting the result means reducing each measurement by 0.04 unit, Since the measurements were only read to the nearest unit, a single adjustment would not be measurable at any point and the adjusted result would be correct. Some of the more precise surveys require least square adjustments.

Traverse. Traverse is the measurement of lengths and determination of directions of a series of lines between known points and establishes the coordinates of the intermediate points. When computed, the accumulated closing error shows up as a position displacement of a known point. The displacement is corrected and distributed among the intermediate (traverse) points.

Triangulation. Adjusting triangulation consists of adjusting the three angles of each triangle to equal 180 degrees, then computing the lengths of the unknown sides of the triangle, using a measured or computed side (baseline). The newly computed sides become the known distance values of adjoining triangles. Computing continues through the triangulation net until a second baseline is reached. The closure (difference between the measured baseline distance and the distance as computed through the triangles) must be within prescribed limits. The amount of closure is then adjusted back through the net, affecting the positions of the stations.

Elevations. Depending on the purpose, the elevations on some level lines are computed as the measurements are taken. When the line is closed, the difference in elevation between the measured and the known elevation is adjusted over all the stations in the line. In higher order leveling, only the differences in elevation are recorded during the measuring, with all adjusting done at the completion of the line. The error is then distributed among the various sections of the line.

PROCEDURES

Establishing Records

Office computations reduce the field notes to a tabular or graphic form. This becomes a permanent record and is stored for further use or subsequent operations. Many standardized forms are available and cover most procedures. These forms are recommended when available, but the surveyor is not limited to these. As long as the sheets are clearly identified and bound as a set, they may be acceptable. Normally, all field notes will be abstracted and the field notes filed separately. The abstracts will be bound along with all computing forms into a single binder or folder, and maintained on file for further reference. All pages, either abstracts or computing forms, will bear the name and date of the person performing the work. The pages will also bear the name and date of at least one person who has checked that page. At no time will any of these records be disposed of or destroyed.

Checking

Surveying is a series of checks. The field notes should be checked by the observer, the recorder, and the party chief before the notes are turned in for office work. Prior to computing, the assigned person should check the notes again. Most mathematical problems can be solved by more than one acceptable method. In checking a set of computations, a method which differs from the original computation may be desirable. An inverse solution, starting with the computed values and solving for the field data is one possibility. A graphic solution may be used. Each step that cannot be checked by any other means must be checked by a totally independent recomputation by another individual. Any errors or mistakes found must be resolved and rechecked before the computation is accepted.

Chapter 2
Project Planning

Survey operations, whether under combat conditions or not, are like any other military operation. They must be carefully planned. Enthusiasm, technical proficiency, and dedication will not by themselves make up for poor planning. All plans must be dynamic in nature. They must be constantly evaluated and updated to remain current. This chapter will address project planning primarily from a logistics and administrative standpoint. Most of the information contained in this chapter is concerned with prebattle operations. Some general technical planning will be addressed but only as it impacts on administrative and logistics support. Project planning can be broken down into the following phases:

1. **Receipt of Project Directive.** This includes the initial project evaluation, determining the project requirements, assessing the unit's ability to accomplish the project, drafting the preliminary plan and milestone schedule, and coordinating the needed administrative and logistical support.
2. **Trips.** Trips are used to gather information to be used in the conduct of the project and to evaluate project progress. The information gathered will be logistical, administrative, or technical depending on the type of trip. Information obtained during these trips is used to refine the project plans and milestone schedules.
3. **Project Execution.** This is the actual conduct of the project – putting the project plans into effect. Unexpected or unusual circumstances will make additional plan modification necessary.

Section I
EVALUATING AND SCHEDULING

After receipt of a project directive, planning the project begins. This preliminary planning will involve evaluating the directive, assessing unit capability, and determining a preliminary schedule of events. It is important that all estimates, including time and funds, be labeled **preliminary** for all reports or briefings, If this is not done, the customer, supported units, or higher headquarters may not get an accurate picture of the true extent of the project.

PROJECT REQUIREMENTS

The first step in project planning involves evaluating the requirements as stated in the project directive. In many instances, requests will come from offices or units that have no real knowledge of survey requirements. When this happens, the support request must be carefully evaluated to ensure that what the customer has ordered is, in fact, what the customer needs. This evaluation is based on past experience and is usually done by the survey technician. Generally, there are three cases of requirement versus need:

1 The customer has-requested more accurate work than is really needed.
2 The customer has requested work that is less accurate than is needed.
3 The customer has requested work that matches the need.

In the first case, the customer is typically not survey-oriented and only sees the **orders and classes of accuracy** as words and numbers on a page. The customer simply does not understand the differences and the cost implications of each. Generally, telephonic explanation of the differences in orders of accuracies will resolve most potential conflicts. In those cases where the customer cannot be swayed from an erroneous perception of orders of accuracy, demonstrating the cost differences will generally change the customer's mind. If the customer remains adamant in the request, then planning to accomplish the request should begin. In those cases where the request is for less accuracy than is needed, the customer must also be contacted. The differences in orders of accuracy must be explained. Since funding costs usually go up in more or less direct proportion to the order or class of accuracy, it maybe even more difficult to change the customer's attitude about the request. Again, if the customer cannot be swayed, then planning to accomplish the request as is must begin. In both these instances, careful documentation of all contacts and conversations with the customer should be kept. At some future date, the customer may realize that the survey unit gave good advice and wish to change the initial request. If the recommendations for change are not accurately documented, the unit may be liable to correct the project.

In the third case, where it is determined that the customer has requested work that matches the need, planning can begin. Fortunately, this is usually the case, particularly in dealing with other military units that are routine survey users.

CAPABILITIES

Assessing the ability of the unit to conduct any type of survey is perhaps one of the most difficult tasks to be undertaken. Fortunately, many mechanisms exist to assist in this evaluation. The single best indicator is the commander's and survey technician's personal familiarity with their soldiers. Since this is not always accurate, a number of systems have been established to help in this evaluation.

Among these are the Army Training and Evaluation Program (ARTEP) and the skill qualification test (SQT). The ARTEP contains the mission training plan, battle drills, and evaluation guides for assessing the unit's ability to conduct various team tasks. The SQT is used to evaluate the technical abilities of individual soldiers. This annual evaluation of each soldier's technical ability can be used as an indicator of both weak and strong areas. Another tool that can be used is the unit's files. These records contain information on the unit's past performance on similar projects. They contain the names of personnel who conducted the project and the duration time. Also, any problems that arose are listed and explained in great detail. This information can prove to be very valuable not only for assessing the unit's ability to conduct the project, but in planning the project as a whole. The result of this assessment is a listing of the unit's training deficiencies. The survey technician will then develop a training program to address these shortcomings. Obviously, this program will be designed around the time constraint of the projected project start date. The tendency to always assign the most qualified personnel should be avoided. Usually, a mix of highly qualified and entry-level soldiers should be assigned to any project to ensure new people get the experience they need.

CONSTRAINTS ON ACCURACY

The Standards and Specifications for Geodetic Control Networks (SSGCN) were established by the Federal Geodetic Control Committee. These standards define the orders of accuracy for all geodetic quality work conducted in the United States. These SSGCN are used to ensure uniformity of all work conducted to support and extend the National Network. The United States Army, through the Corps of Engineers, is a member of the Federal Geodetic Control Committee and has signed the basic document agreeing to comply with the SSGCN. All Army survey activities conducted within the United States should be in compliance with these standards.

When possible, surveys in other nations should also be in compliance. Due to military necessity. there will be occasions when compliance is not possible due to mission requirements. Some of these situations are –

- Projects conducted in time of war.
- Projects conducted as training exercises designed as realistic war training exercises.
- Projects not intended for inclusion in the National Network.
- Projects conducted to support consumer requests that specifically exempt compliance.
- At the discretion of the survey technician in charge.

When feasible, all field activities should conform to the SSGCN. At some later date, it maybe determined that any given project should have been included in the National Network. If the field work was in total compliance, only the computations will need to be refined.

MILESTONES

Milestone schedules are developed to allow for estimating project duration and costs and managing personnel and resources. A milestone schedule generally takes the form of a time line, with events noted as they should occur. This time line allows a commander or customer to see at a glance how a project is proceeding. It is impossible for this manual to give specific guidance on the development of time lines for all types of survey activities. Therefore, general tips will be discussed. Under combat conditions, it may not be feasible to develop precise time lines. The flow of battle will dictate dramatic changes to any milestone schedule and most work will have to be accomplished on very short suspenses. In these situations, developing a time line will be time-consuming and in many cases counterproductive. Under normal prebattle operations, it is feasible and advisable to develop milestone schedules. Care should be taken to ensure that the resulting time line is not overly ambitious. There are a number of variables associated with anytime line. These include but are not limited to –

- Availability and type of equipment.
- Experience of party personnel.
- Terrain, vegetation, and weather.
- Extent or area of project.
- Priority of other projects.
- Enemy or adversary intervention.

Table 2-1 shows typical rates of progress for various types of survey operations. These are **rule-of-thumb** estimates. Each unit must develop its own rate of

Table 2-1. **Typical rates of progress for third-order surveys using the survey section**

Method of survey	Basic figure	Average distance per setup or figure			Daily progress (10-hour day)			Monthly progress			% Rerun		
		Terrain			Terrain			Terrain			Terrain		
		A	B	C*	A	B	C*	A	B	C*	A	B	C*
(1) Triangulation		Kilometers			Figures			Figures					
	Quad	9	9	15	3	3	2	40	40	20	5	5	5
	Triangle	6	6	10	7	7	4	100	100	40	5	5	5
(7) Traverse (2) Microwave (1) (EDME)	Linear	Kilometers			Kilometers			Kilometers					
		2	2	0.5 to 2	24	24	6 to 12	480	480	160	5	5	5
(6) (3) Leveling, differential (3-wire, looped)	Linear	Meters			Kilometers			Kilometers					
		250	150	100	6	4.5	3	120	90	60	10	10	15
(4) Astronomic azimuth	Station	1 per traverse every 30 to 50 stations, 1 per 12- to 15-figure triangulation			2-hour per observation								
(4) Baseline measurement microwave	Base	Every 10 figures of triangulation			1-hour per base								
(5) (8) Modular tower erection	Tower				6-hour erection per tower								

* In dense jungle areas, clearing parties of large size are required.

(1) Includes movement between stations–vehicle or helicopter.

(2) In planning microwave traversing, it must be realized that much depends on the transportation provided for moving equipment. Helicopter-supported, and with 10,000 meter observations, a rate of progress in excess of 100 kilometers per day is possible.

(3) Requires 1/2 survey section, foot travel.

(4) Requires 1/3 survey section, travel time not included.

(5) Requires 1/2 survey section, travel time not included.

(6) For single run levels, double the daily progress.

(7) Three EDMEs available per section.

(8) Number of towers required by triangulation or traverse is unpredictable without prior reconnaissance.

progress table based on the equipment and level of expertise of assigned personnel.

Project schedules can be established by several different approaches. The two most common are establishment based on a firm start date or on a firm end date. The techniques are similar in both cases, with some rather obvious differences. If the start date has been firmly established, then the project is laid out from beginning to end with each event occurring as it will happen. If the end date has been established, then the project must be reverse planned. That is, events that occur last must be programmed from the end of the project backward until the start time is established. In all cases, schedules must be realistic but not overly ambitious. Delays due to weather, equipment and personnel shortcomings, or any other problems must be built into the schedule. In most cases, it is better to estimate a longer duration time and finish early than to underestimate and miss a scheduled end date.

ADMINISTRATIVE SUPPORT

Administrative support is normally concerned with documentation, both technical and nontechnical. The technical support is usually the typing of reports, tabulating and preparing technical data, or preparing briefing materials. Technical administrative actions are often accomplished by the survey team itself with limited help from clerical personnel. Nontechnical support usually involves personnel actions. These actions are normally handled by specialists in administrative actions such as Personnel and Administration Center (PAC) or Adjutant General (AG) clerks. It is not the intent of this manual to outline specific methods of accomplishing these tasks. Rather, this section will deal with general guidance as to what should be accomplished and when. It deals primarily with peacetime operations conducted elsewhere than at the unit's installation. Wartime requirements are addressed in the various SOPs of the unit, parent unit, and major Army commands (MACOM),

Prior to Deployment

Before a survey unit deploys to another installation or area, a number of administrative actions should be accomplished. Basically, all routine personnel actions of all survey party members should be accomplished before departing. This ensures that there will be minimal actions to be accomplished while deployed. All soldiers should make sure that their pay portions, allotments, insurance statements, and other financial requirements are correct and up to date. Other actions that may be required are powers of attorney and routine medical checks such as physicals and dental checks. If a long duration time is anticipated, it is advisable that all personnel be scheduled for and complete a records review, to include promotion packets, personnel and finance records, and emergency data cards.

After all these actions have been completed, there will theoretically be no need for nontechnical administrative support. In reality, however, new actions will be required from time to time. Therefore, the party chief should make arrangements for handling any actions that may be required during the project. The local installation PAC or AG should provide this information. Depending on the nature of the required action, the party chief may be able to simply submit the paperwork through the mail. If these actions cannot be done through the mail or through telephonic contact, a visit to the AG at the project installation or the nearest military facility may be required.

During a Project

From the preceding paragraph, it is obvious that there will be times when the party chief or the individual is not able to complete some required action. The home installation should provide guidance to the party chief on how to overcome these problems. If the project is being conducted on a military installation, the party chief should check in with the local AG. This visit should be made before any problems are encountered. It is recommended that the project installation AG be contacted during the reconnaissance phase and a point of contact (POC) established. When this is done, this AG will know the survey unit is in the area and will usually give any assistance they can. As is often the case, the project may be in an area other than on a military reservation. In the United States, there will usually be a military representative of some type who can assist. It maybe possible to arrange for limited support from the local office of the Army Recruiting Command. In other instances, Army Reserve or National Guard units maybe able to offer assistance.

Regardless of the source of assistance, it must be established before it is needed. Nothing is more frustrating to a soldier than to have a personal problem and not have a ready solution. This hurts the soldier's performance and ultimately degrades the survey team's capability. Technical administrative support will usually be nonexistent and will be the responsibility of the survey team. Such actions will normally be restricted to typing technical reports and compiling/consolidating technical data.

After a Project

Nontechnical administrative support after the project is identical to prior support. The home installation PAC, AG, and finance and accounting office (FAO) will handle these actions. Among these actions are filing travel vouchers, initiating new personnel actions, and reviewing personnel and finance records. The parent unit will be able to assist in technical administrative support. This normally involves no more than a clerk typist to finalize the technical reports and information.

LOGISTICS

This section will give general guidance on the types of logistics arrangements and planning that should be accomplished. Many of these topics will be covered in very general terms. Because of the requirements of the various MACOMS and general support units, it is not possible for this section to be all-encompassing.

Preparation for Movement

Much of the specific information concerning preparation for moving a survey section or unit will be contained in the unit's or parent organization's SOP. It goes without saying that moving a unit of any size takes careful and thorough planning. When a unit moves, it is imperative that all equipment and personnel that will be required move as cohesively as possible, These movement plans should be developed to cover all contingencies and developed well in advance of any anticipated moves. They should address moving any size element of the unit or the entire unit. Most of the requirements for movement are described in *FM55-10.* This concise reference manual should be on hand when preparing any movement plans. The information contained is applicable to most situations, wartime or peacetime. In some cases, it maybe necessary to supplement the basic manual. The supplement will normally be drafted by the MACOM.

Communications

One of the most important and often overlooked aspect of any successful operation is communications. During movement, regardless of the mode of transportation, the unit will normally be dispersed in serials. During survey field procedures, the field teams will be located throughout the corps area. In all situations, it is imperative that the elements of the unit have the ability to communicate with the command and control section.

Planning communications support requires the same careful attention to detail as any other aspect. Depending upon the nature of the operation. it must first be determined how much and what type of communications equipment will be required. Normally, there will be some type of mix of hard-wire, land-line, and portable radios. After the number of devices is established for optimum use, the unit must determine how much of its own equipment is available to handle the load. If the unit does not have adequate equipment. there are two courses of action that can be taken. The first is to arrange for support from the customer or other organization. This is often a very satisfactory solution to the problem when it is possible. However, the unit will often have to operate within its own equipment limitations. In this case, it will be necessary to reevaluate the planned communications network and eliminate some nice-to-have communications elements. Another solution is the local purchase of handheld portable radios. The devices will normally be added to the unit's table of distribution and allowances (TDA) account. If this solution is used, it will probably be necessary to check with the communications center to ensure that there are no frequency conflicts as a result of nonstandard communications equipment. One of the best means of communication is the standard military radios available in all units. These devices give instant, usually reliable access to all users. However, there are a number of problems associated with these radios. Some major problem areas are –

- The lack of adherence to approved radio procedures.
- The potential of enemy exploitation of nonsecure communications. This exploitation can take the form of obtaining intelligence information, deception, radio direction finding, or jamming.
- Power supply or poor maintenance of the radios.
- Atmospheric conditions that render the radios inoperative.
- The range of single receivers without radio relay equipment.

The first two areas are directly related and the solutions are similar. All units have CEOIs that provide frequency and call sign allocations as well as security measures. Strict adherence to these procedures is mandatory. Training all personnel and radio telephone operators (RTO) in the proper procedures will ensure the denial of intelligence information to the enemy. It will also help prevent the other exploitation techniques any adversary may employ.

Power supply and maintenance problems must be addressed before the equipment is to be used. Proper maintenance procedures on all equipment can eliminate most problems. The entire communications system should be checked occasionally to ensure that it is functioning as designed. Batteries for battery-operated systems should be stored in an approved fashion and checked/replaced as needed.

Atmospheric conditions are a major problem for which there are only limited solutions. It maybe necessary to establish land-line communications to overcome atmospheric problems. If this is the best solution, a series of communications checkpoints will have to be developed along routes of travel and throughout the area of operation. This system is often cumbersome, particularly if a move is over great distances or into undeveloped areas. The establishment of radio relays will in some cases overcome these difficulties. When required, the same techniques described in Chapter 3 for line of sight determination maybe used to establish radio relay positions. This method will require additional radio equipment and personnel. In a combat environment, it may be possible to contact the communications officer in the corps and arrange for radio repeater access. Once all problems have been resolved, the only aspect remaining is the use of the equipment that has been selected. The importance of proper radio procedures as specified in the CEOIs cannot be overemphasized. Communications security procedures must be strictly adhered to.

Material Support

It is not the intent of this manual to provide specific details on how to procure required materials or material support. This information is generally spelled out in the various SOPs of the units involved. Rather, the intention is to emphasize the importance of prior arrangements for these resources. As part of the planning process, an estimate of the time and materials will be developed. This estimate is based on previous experience with similar projects and the known requirements of the present project. These requirements should be originally developed with no regard to costs or difficulty of procurement. Determine what is needed, then figure out how to get it. Normally, most of the material support will be the responsibility of the customer. However, this cannot be assumed to be true. It should be clearly documented in the reports from the various trips mentioned above. In particular, the initial site visitation trip (ISVT) and reconnaissance trips should result in clear POCs for acquiring necessary materials. Technical supplies should be supplied by the unit through normal supply channels.

Section II
INFORMATION-GATHERING TRIPS

This section will describe trips as they apply to normal prebattle operations. In some instances, some of these trips can be consolidated or eliminated. The overall need for the various described trips will depend on a number of variables, including –

- The unit's familiarity with the area concerned.
- The amount of information already on hand concerning the project or supported unit.
- The anticipated duration of the project.
- The amount of problems encountered by the unit.

INITIAL SITE VISITATION TRIP

The ISVT is basically a fact-finding mission. This trip is normally conducted by the survey technician, the project noncommissioned officer in charge (NCOIC), and sometimes the unit commander or representative. The primary function of this trip is to gather information that will be used to plan the project and to establish POCSsfor the various support functions that will be required.

All project directives will identify an overall POC. This individual or office is normally concerned with the results of the project and may not be able to provide the types of assistance that will be required to work on and complete the project. Often, the overall POC will be able to assist in establishing POCs for all administrative and logistics requirements.

The types of support that must be arranged prior to any field activities include maintenance, medical and dental, personnel actions, supplies, billeting, messing and mail, and additional personnel. These arrangements must be geared specifically to meet the needs of the reconnaissance party and generally to support the project execution party.

For successful completion of the reconnaissance phase, all arrangements must be made with respect to care of personnel and equipment during the ISVT. Careful records should be maintained. with Memorandums of Agreement (MOA) being drafted as required. The types of documentation that must be prepared as a result of the ISVT are listed in Chapter 8, Section I.

RECONNAISSANCE TRIP

The purpose of the reconnaissance (recon) trip is to finalize arrangements for the project and specifically to lay out the field work. The conduct of the reconnaissance is discussed in Chapter 3. During the recon, it is imperative that all arrangements made during the ISVT be checked to ensure that they are correct and viable. There may be a delay between the recon and project execution that causes some previously established POCs to be lost or changed. If this occurs, a replacement POC must be established. Any events which occur that have not been anticipated should be carefully documented. The documentation required as a result of the reconnaissance is discussed in Chapter 8.

PROJECT VISITATION

Project visitation trips are generally conducted by the survey technician or command representative. Their primary purpose is twofold. The first is to check on the progress of the project. This is the responsibility of the survey technician. Any recurring technical problems will be discussed at length and resolved in such a manner as to preclude recurrences. Obviously, if problems have been occurring prior to a visitation trip, contact with the parent unit should have been made previously. Technical difficulties that need resolution should not be left unresolved until a scheduled project visitation trip. The second function of the project visitation is to check on the health. welfare, and morale of the troops. This cannot be ignored. It is imperative that the commander knows how the troops are doing with respect to the job and as individuals. If numerous technical problems have been occurring, it is possible that some personal problems might be overlooked. The project visitation can often resolve these problems before they become major limiting factors on the project execution. The documentation for this trip is normally in the form of a trip report and should be included in the final project folder for historical purposes.

Section III
PROJECT EXECUTION

Project execution is merely executing the plans that have been laid. If all planning has been correctly done, the survey team should arrive and go straight to work with no delays. As problems occur, the POCs that have been previously established should be contacted and the problems resolved as expeditiously as possible.

Specific details on project execution are covered in the chapters concerning specific survey activities. The documentation required for all phases of project planning and execution is contained in Chapter 8.

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 EDME 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 EDME traverse reconnaissance requires intervisibility between stations, minimum and maximum allowable distances based on the EDME characteristics, and clearance above possible obstructions. Electro-optical and infrared EDME will be dependent on weather (clouds, fog, and haze). Microwave EDME 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 anotated 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 bc 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 maybe 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 (meters) = K (horizontal distance in kilometers) squared 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 –

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

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 frost 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 –

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

and the height of signal at each end is –

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

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 x 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 x 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

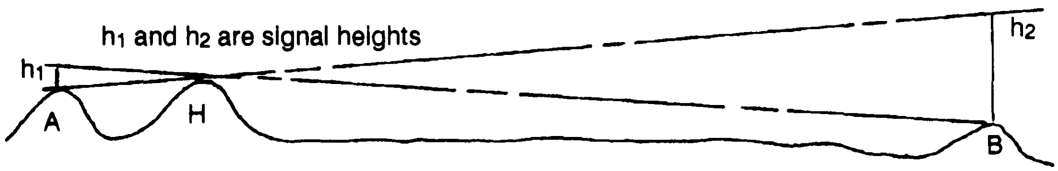


Figure 3-1. **Clearance of obstruction**

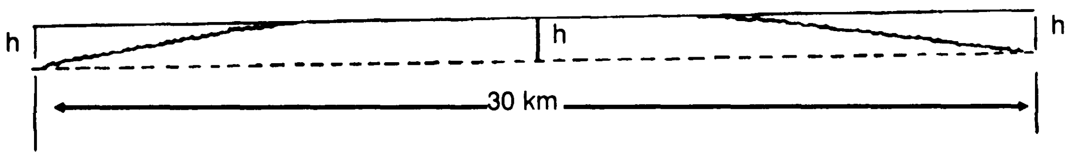


Figure 3-2. **Signal heights for line over water**

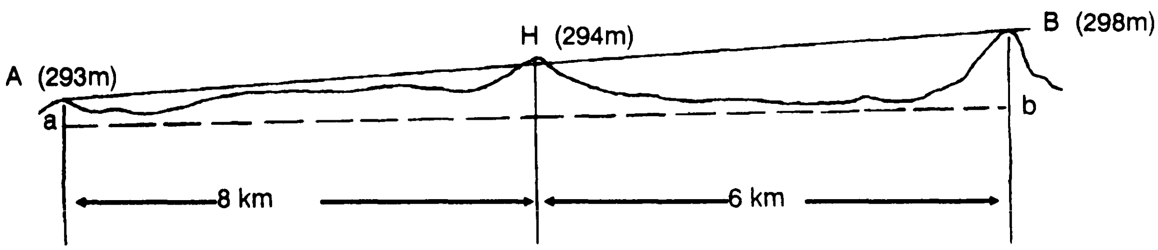


Figure 3-3. **General formula solution**

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 –

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

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 –

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

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

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

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

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

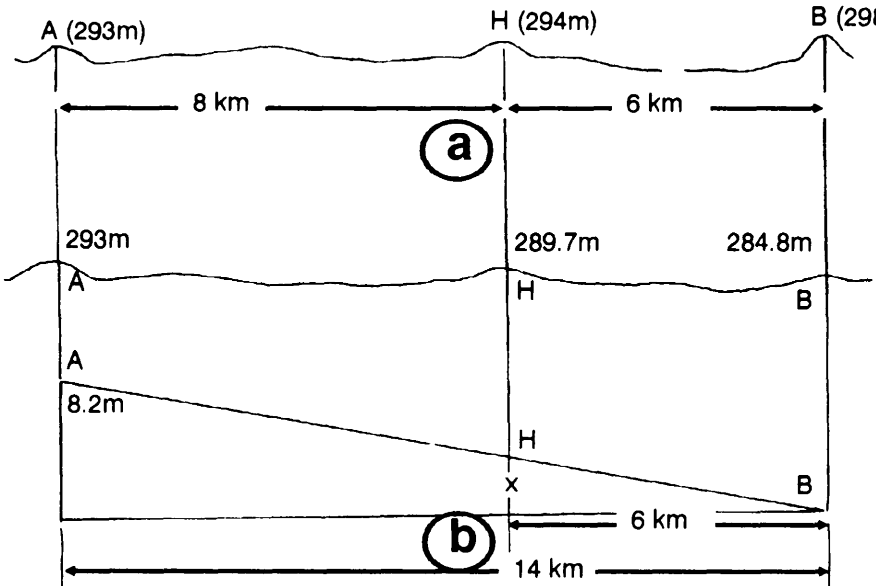


Figure 3-4. **Similar triangles solution**

(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.

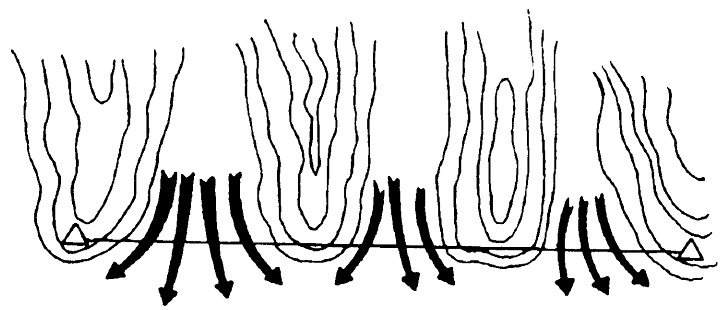


Figure ***3-5.*** **Horizontal refraction due to air currents (ravines)**

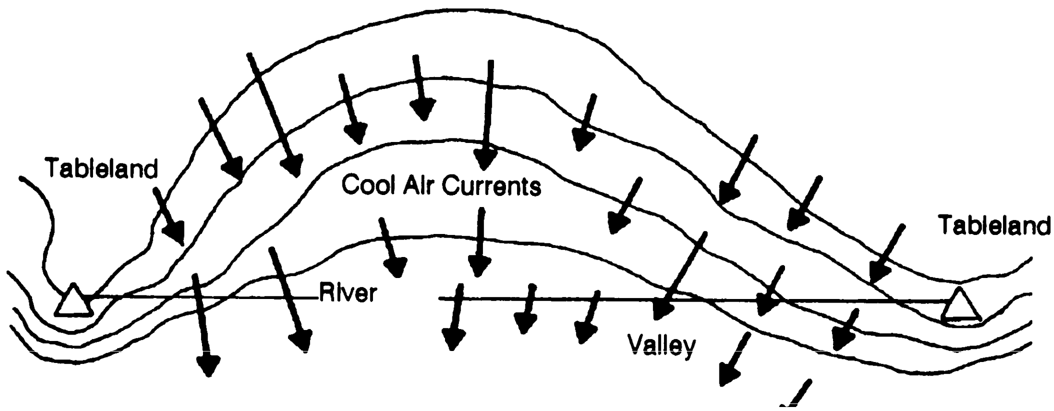


Figure 3-6. **Horizontal refraction due to air currents (hills)**

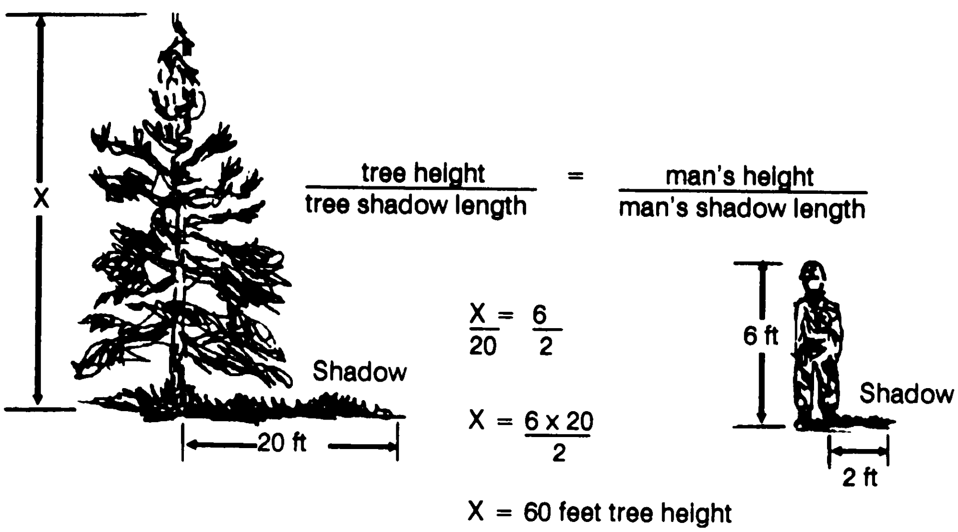


Figure ***3-7.*** **Tree height by shadow method**

MONUMENTING

The monumenting of stations is accomplished during the reconaissance 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 maybe 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

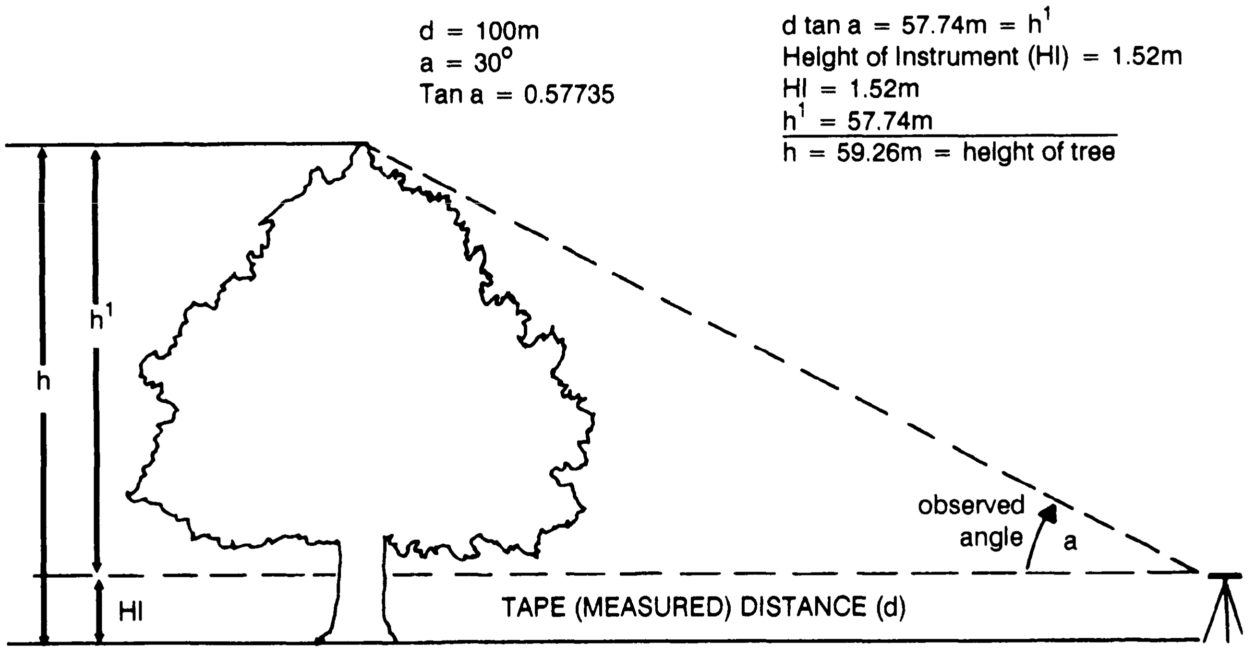


Figure 3-8. **Tree height by vertical angle method**

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.

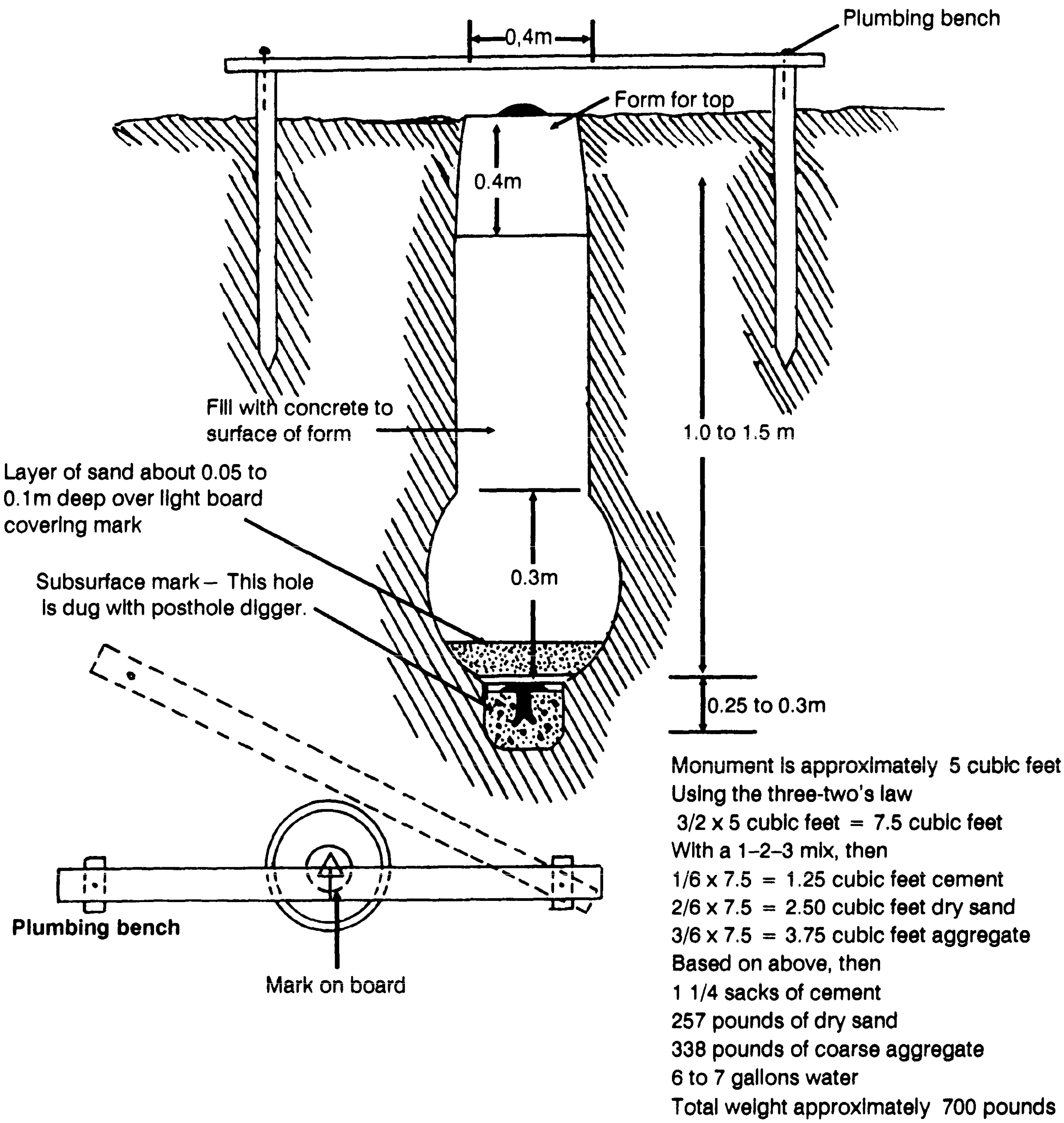


Figure 3-9. **Monument construction**

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 strutures 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	TYPE OF MARK	STATION	
UNITED STATES	Bronze disk	Cotton, 1962, AMS	
LOCALITY	STAMPING ON MARK	AGENCY (CAST IN MARKS)	ELEVATION
Maricopa, Arizona-	1962, Army Map Service	Corps of Engineers	1179.2 (FT) 359.42 (M)
LATITUDE	LONGITUDE	DATUM	DATUM
33 03 15.771 N	112 01 32.659 W	1927 NAD	Sea Level Datum of 1929
(NORTHING)(EASTING) (FT) (M)	(EASTING)(NORTHING) (FT) (M)	GRID AND ZONE	ESTABLISHED BY (AGENCY)
3 657 591.90	404 234.41	UTM 12	AMS
(NORTHING)(EASTING) (FT) (M)	(EASTING)(NORTHING) (FT) (M)	GRID AND ZONE	DATE / ORDER
			1962 / Third

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	GEOD. DISTANCE (METERS) (FEET)	GRID DISTANCE (METERS) (FEET)
R.M. # 2	90° 46' 50."0	° ' "	11.412	
TT N-31 (AZ MK)	138 48 25.1		553.1705	
R.M. # 1	180 58 25.0		6.828	
Base Station "A"	263 54 08.51	83 59 53.69	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-Pheonix 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 "⊢" intersection to the right; turn right and proceed in a southerly direction for approximately 0.25 miles (0.4 km) to a "⊢" intersection of a road to the right and the site of the station.

The station is located 4.2 meters south of the centerline (℄) of a paved road to the west; 7.6 meters west of the centerline (℄) 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.

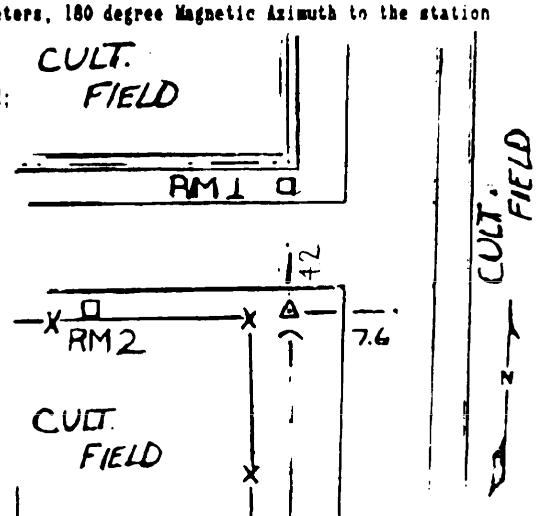
Reference Mark (RM) #1 is a Corps of Engineer's bronze disk stamped; "COTTON, R.M. #1, 1962, ARMY MAP SERVICE", in a 10 inch (23 cm) round concrete post flush with the ground at 6.8 meters, 180 degree Magnetic Azimuth to the station mark.

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 Engneer'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

DA FORM 1959, 1 OCT 64 — REPLACES DA FORMS 1959 AND 1960, 1 FEB 57, WHICH ARE OBSOLETE

DESCRIPTION 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 orginial 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 orginally 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 part y 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 (S0I), 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.

Chapter 4
Targets and Signals

A target is generally considered to be a nonilluminating signal. Target requirements can be met by three general types: tripods, bipeds, and poles, all of which may incorporate variations. The targets are constructed of wood or metal frameworks with cloth covers.

Section I
TARGETS

SIZE, SHAPE, AND COLOR OF TARGETS

For ready bisection, the target should be as narrow as possible without sacrificing distinctness. The easiest of targets to bisect are triangular in shape, with square- and rectangular-shaped targets being next. Targets that are round are the poorest of targets due to problems in pointing during repeated observations. These targets should be avoided whenever possible, A target which subtends an angle of four to six seconds of arc will be easy to bisect. Since one second of arc equals 0.5 centimeters at a l-kilometer distance, an angle of six seconds requires a target 3 centimeters wide at that distance or 30 centimeters at 10 kilometers. Under adverse lighting conditions, the target width will have to be increased. To make a target readily visible against both light and dark backgrounds, it should be constructed of alternating bands of red and white or orange and yellow. Flags of an appropriate size may be added to aid in finding the target or by filling the background with blaze orange cloth to contrast the target. All cloth used on the targets should be slashed after construction to minimize wind resistance and to avoid pilfering in areas where cloth may be valuable.

LOCATION OF TARGETS

The location of targets by observers is sometimes a difficult and tedious task, depending upon the type of terrain and foliage in the area. In jungle-type areas where the targets are not profiled or silhouetted, they are very difficult to locate without direct sunlight shining on them. To expedite the location of targets, it sometimes becomes necessary to use some method of illuminating the target area. Five of the generally accepted methods are –

- The lighting of highway-type flares
- The use of a handheld flashing mirror
- The use of a strobe light unit, if available
- The use of colored smoke grenades during daylight hours
- Vehicle headlights

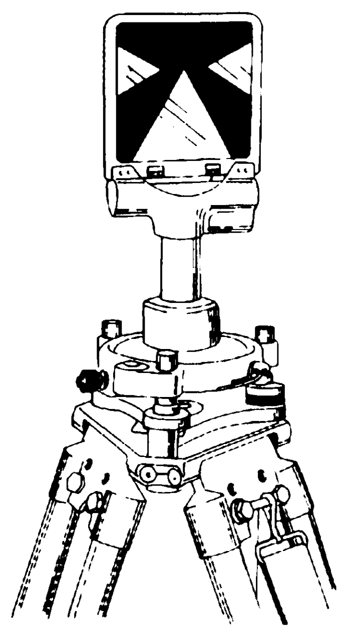
Once the area of the target is located, it becomes a simple task to find the exact location of the target. The use of iridescent cloth on the target in place of regular signal cloth is recommended if the cloth can be interchanged, especially in jungle areas.

TYPES OF TARGETS

Target Set

The target set is a precise survey target device generally used for short traverse lines (approximately 4 kilometers). The target set assembly (Figure 4-1) consists of a lower and upper group *(TM5-6675-244-15).* The lower group is a tribrach with a three-screw leveling head, circular bubble, and optical plumbing device. The upper group contains a plate with three triangles, a long level vial, and a lighting attachment. The upper group is removable and interchangeable with the theodolite.

Figure 4-1. **Target set assembly**



Use. In traverse operations where continual backlights and foresights are needed and where distances are not excessive, the target sets can be used in a leapfrog technique. The actual distance the target can be seen depends on background, lighting, and weather conditions,

Pointing. Care must be taken in pointing the target at the observer in order to eliminate the appearance of distortion of the target when viewed through the telescope. A disadvantage of the target set is that only one at a time maybe set at a station.

Tripod Target

The tripod-type target is the most satisfactory from the standpoint of stability, simplicity of construction, durability, and accuracy. It ranges from a simple hood of cloth, cut and sewn into a pyramid shape and slipped over the instrument tripod, to the permanent tripod with the legs embedded in concrete, sides braced, vertical pole placed at the top, and the upper part boarded up and painted. Temporary tripod targets may be constructed of 2-inch by 2-inch lumber, pipe, poles, or bamboo joined at one end by wire, or bolts threaded through drilled holes. The tripod must be guyed and plumbed (Figure 4-2) and the legs should be set in depressions to prevent lateral movement. On uneven ground, one leg may have to be shortened or dug in to maintain a symmetrical appearance from all directions. Signal cloth wrapped around the tripod should be used only on lower-order (fourth-order) work, as it is almost impossible to make it symmetrical around the station.

Biped Target

Biped targets are more simply constructed than tripods, but are less stable and must be strongly guyed. Figure 4-3 shows an issued surveying beacon. It is a biped target and is carried disassembled in a canvas case about 53 inches long. It can be assembled, erected, and plumbed by two people in 15 minutes or less and can be dismantled and packed in 5 minutes, If this target must be left standing in the weather for any extended period, the rope guys should be replaced with wire and two more guys added at each end of the crossbar. In soft ground, the pointed legs will sink unevenly because of wind and rain, and should be set in holes bored in the end of wooden stakes driven flush

Figure 4-2. **Tripod targets**

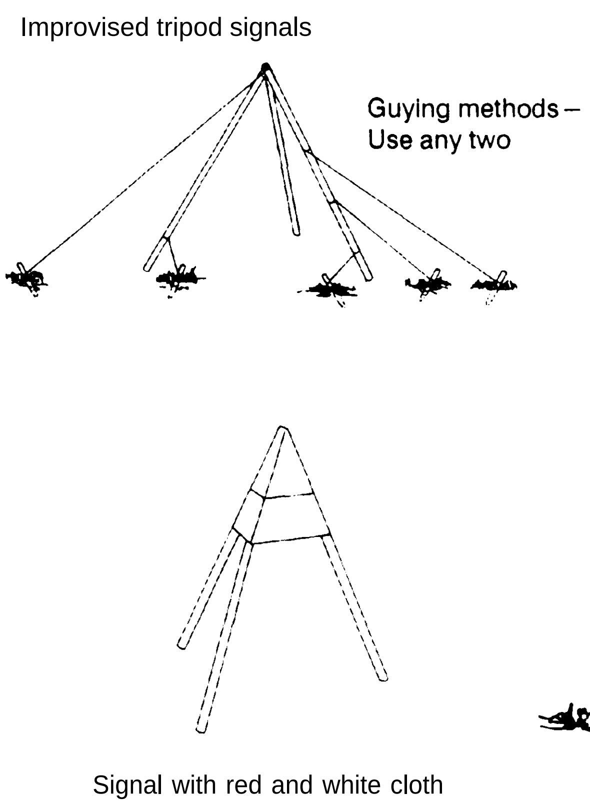
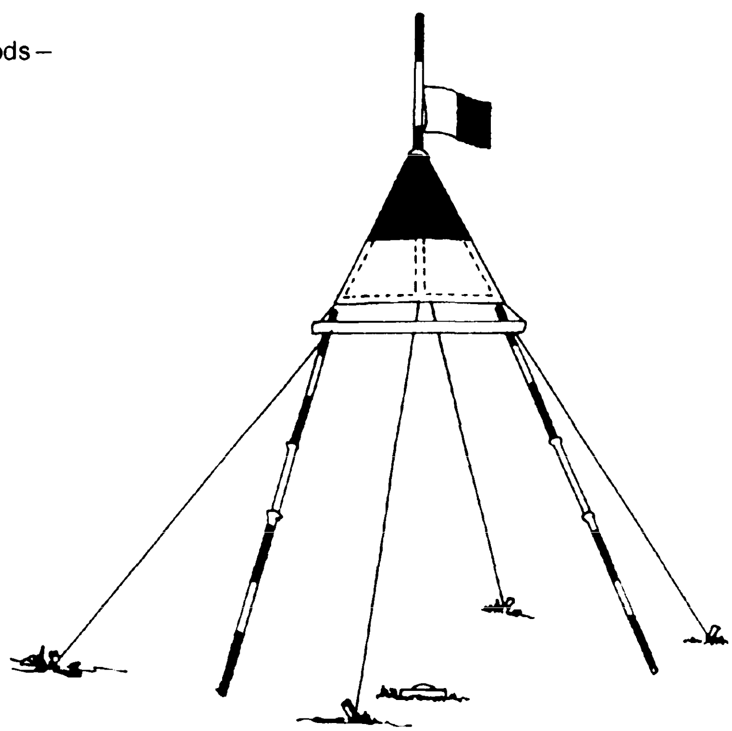


Figure 4-3. **Biped target**



with the ground or in a short piece of 2-inch by 4-inch lumber laid flat in a shallow hole.

Pole Targets

Pole targets (Figure 4-4) are seldom used because the station cannot be occupied while the target is in place. In certain cases. as when a picture point is to be intersected or an unoccupied station must be used and the cutting of lines of sight is extremely difficult or impossible, a pole target which can be seen above the medium-sized trees may be erected. The staff may be constructed of 2-inch by 2-inch lumber or cut poles, varying from about 2 inches (5 centimeters) to 6 inches (15 centimeters) in diameter. The method of joining sections of 2-inch by 2-inch lumber and the construction of a panel target are shown in Figure 4-4. The target must be plumbed by manipulating the guy wires or ropes. Special care must be taken when warped or crooked boards are used to construct pole targets, and they must be checked for eccentricity.

CENTERING AND PLUMBING TARGETS

When setting a target, it must be plumbed exactly over a station. A target is said to be eccentric when the vertical center is not on the vertical line passing through the station mark. The proper correction can always be made for eccentricity by remembering the approximation **a second is a foot at 40 miles** (actually 39.065 miles) or that an inch represents about 3 1/4 seconds at a distance of 1 mile. Always check a target or signal that has been observed for eccentricity. Any eccentricity found must be recorded so that the computer can be certain of the facts when correcting the observations.

PHASE

When observations are made on targets in the daylight, errors in the horizontal angle measurements due to unequal lighting of a target are referred to as phase (Figure 4-5). When one side is brightly lighted and the other is in the shadows, the observer tends to favor the sunlit side. Sometimes, with a skylined white target, the reverse is true and the dark side is favored. Phase is an eccentricity which could be corrected for, if its exact amount were known. The observer is rarely able to measure its amount accurately, since influencing factors such as the angle of the sun with the line of sight, the opacity of the signal, the shape of the

Figure 4-4. **Pole targets**

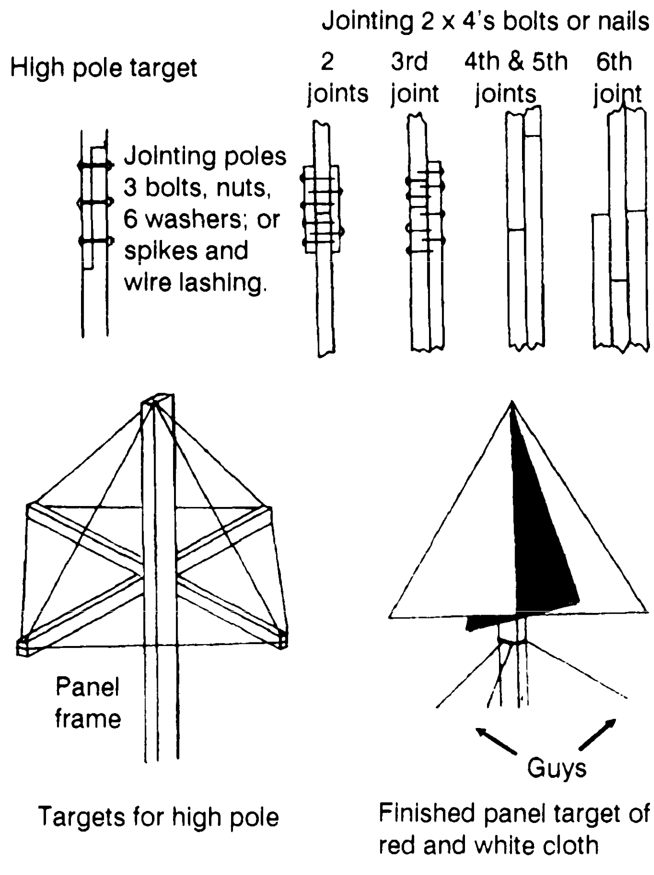
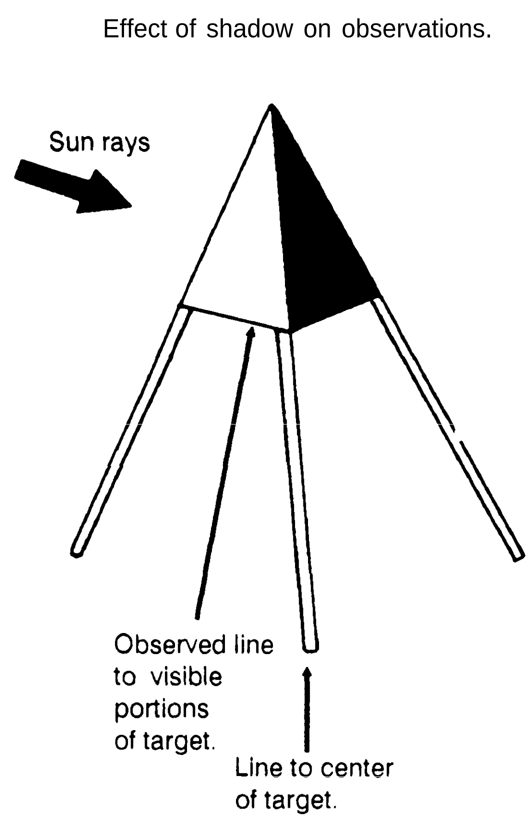


Figure 4-5. **Phase**



object sighted upon, and the intensity of the sunlight change rapidly. Trigonometric formulas for the correction of phase based upon the direction of the sun have appeared in some textbooks, but are rarely practical. It is usually best to delay observations until poor conditions improve or no longer exist.

Section II
SIGNALS

Signals are those survey targets that are either illuminated by natural sunlight (heliotrope) or are electrically lighted by use of wet or dry cell batteries. The observations for all second-order, Class I triangulation and traverse are usually done at night by using signal lights because of more stable atmospheric conditions which allow for better pointings. Observations may be made during daylight hours using lights, but for high accuracy surveys this is done only under extreme conditions.

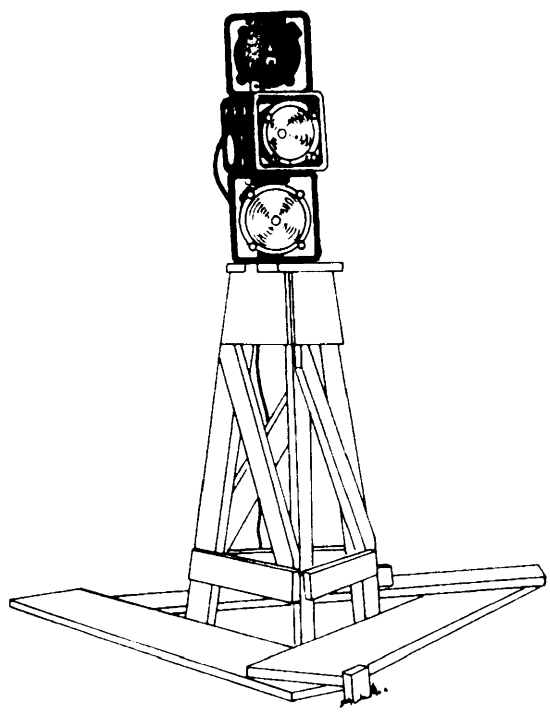
SIGNAL LIGHTS

The most commonly used signal light has a 5-inch reflector. These signal lights (Figure 4-6) are used as illustrated for lines of sight in excess of 8 kilometers, but by masking the face of the light they can be used for shorter lines of sight. A 5-inch light should **not** be used on lines of sight shorter than 5 miles (8 kilometers). This rule of thumb (no more than 1-inch diameter per mile observed) should be applied to other sizes of lights.

Pointing

The exact horizontal and vertical pointing of the light is very important. If the light is not pointed exactly toward the instrument, only a portion of the reflector will be observed and in some cases this portion will not be plumbed over the station mark. The instrument operator must check the pointing prior to starting the observations by viewing the light through the telescope. During hazy weather and especially on long lines of sight, the view through the telescope may appear as a bright spot surrounded by a flare. The instrument operator should request the lightkeeper to swing the light slightly in a horizontal and vertical are while it is being viewed through the telescope until the best pointing can be determined. The best pointing will be when the light is the brightest. The light is then stopped and locked into position. The bottom light, if lights are stacked, must be pointed first as shown in Figure 4-6. It can be adjusted for brightness by adding or removing batteries. The light should never be improperly pointed to reduce its brilliance as this will create an eccentric light.

Figure 4-6. **Stacking of 5-inch lights**



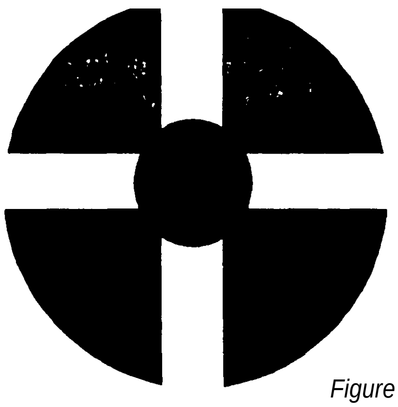
Masking

The light can be masked to reduce the size and brilliance by covering equal portions of the lens both above and below and to the right and left of the center of the glass face. When masking a light, opposite sides of the glass must be masked equally to eliminate eccentricity. One method of masking is shown in Figure 4-7. This type of masking is very good for distances between 6 to 10 kilometers on normal nights. A sheet of orange scribe paper is required but any other color would work almost as well. When using the orange paper as a masking material, the light will present an orange glow with a brilliant white cross for pointing on by the observer. At maximum ranges, the orange glow is practically invisible through the telescope and at minimum ranges the glow will help in identification of the light.

Focusing

The light is focused by means of a screw at the rear of the bulb socket. By turning this screw, the position of the bulb is changed in relationship to the reflector. If the light is not properly focused, it will appear as a fuzzy ball in the telescope. The light maybe focused at night by shining it on a flat surface about 50 meters away and adjusting until the beam is slightly larger than the light. When no distant object is available, afield expedient is to hold one's hand about 6 inches in front of the light and adjust until a dark spot the size of a quarter appears in the center of the beam.

Figure 4-7. **Masking of 5-inch light**



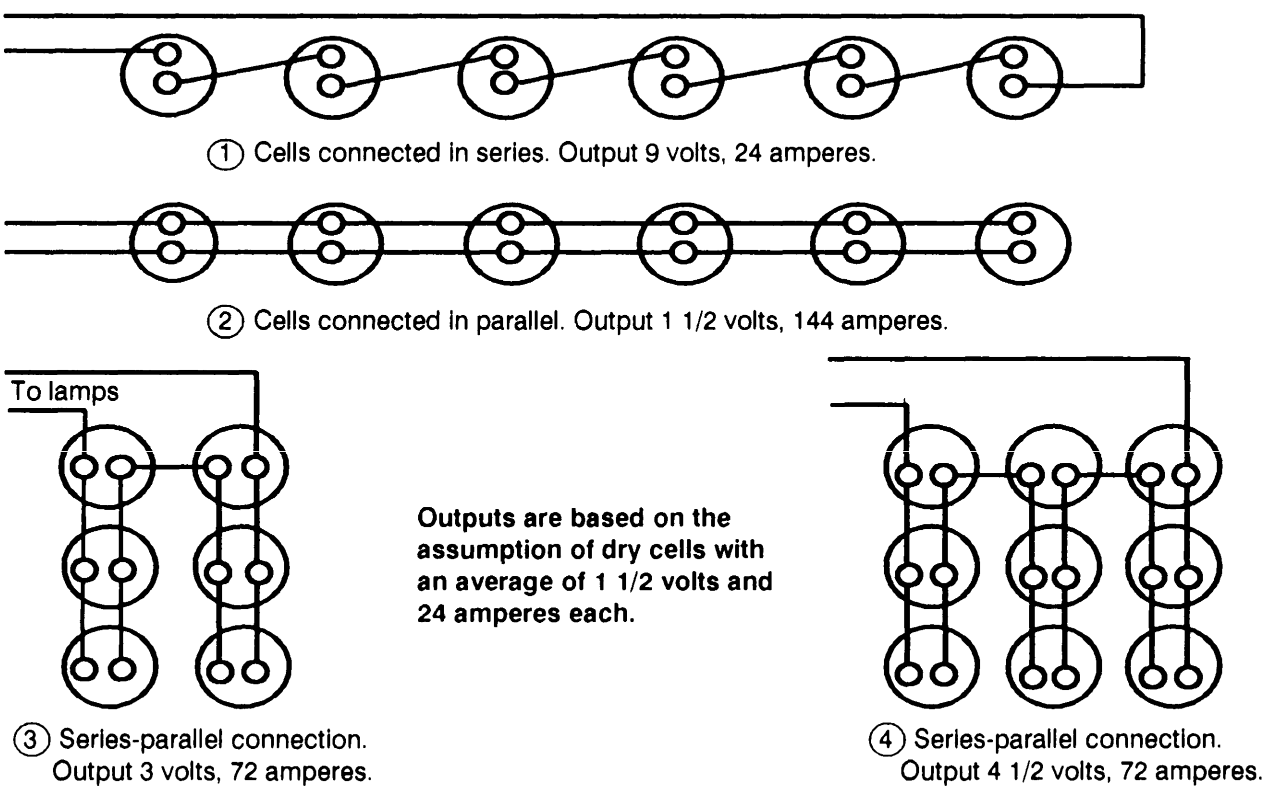
Brilliance

The brilliance of the light is determined by the type of light bulb and the amount of voltage being used. The light is issued with two different bulbs: the standard 3.7-volt bulb and a 6.0-volt bulb. The amount of voltage needed will vary with the lighting requirements. The various battery arrangements are shown in Figure 4-8. If dry cell batteries are not available or are too weak, a field expedient is to connect two lights with 6-volt bulbs in series and then connect them to a 12-volt wet cell battery. Never apply more voltage to the bulbs than their rated value.

Stacking

When lights to several observers from the same station are needed, the lights are stacked, generally on a range pole tripod as shown in Figure 4-6. If lights are stacked over a station, they must be leveled and plumbed over that station mark. The first (lowest) light must be leveled and plumbed, then the other lights are attached and individually checked for level. Care must be taken when attaching additional lights to the pole not to knock the other lights out of plumb.

Figure 4-8. **Battery wiring diagram**



Ranging

When observations are made from a small (low) instrument stand, it is sometimes impossible to plumb the lights directly over the station mark. If this occurs, it is acceptable to use lights on range. The lights must be lined in on range to all stations with a theodolite. The standard theodolite tripod or range pole tripod is used as a stand and should be from 4 to 30 meters from the station. Care must be taken to avoid introduction of eccentricities when using lights on range.

TARGET SET

As previously mentioned, the target set is a precise survey target device. It is also a precise survey lighting device (Figure 4-9) used for short traverse lines (approximately 4 kilometers). When the target set is used for night observations, it requires the attachment of an accessory lighting unit on the back of the target. The lighting unit consists of a metal hood with a light bulb mounted in the center. For the older target sets, the hood hangs on two small metal studs mounted at the top rear of the target. For the newer target sets, the hood slides down over the sides of the target from the rear.

Use

The target set is used as a signal in the same way as when it is used as a target, as discussed in Section I.

Pointing

Extreme care must be taken in the pointing of this device. The lighting attachment must be pointed directly at the observer in order to eliminate the appearance of uneven lighting of the target's triangles.

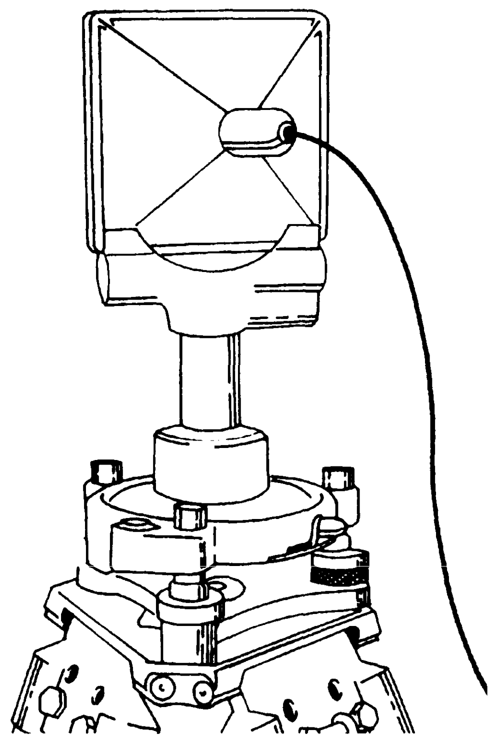
HELIOTROPES

The heliotrope is a device which reflects the sun's light through a pair of mirrors set over a station mark and pointed toward the observer on another station mark.

Characteristics and Procedures

The issued heliotrope consists of a flat base to which are attached two plane mirrors and a pair of sights (Figure 4-10). The base may be mounted on any standard tripod and plumbed directly over a station mark. It can be fitted in the wild-type tribrach and mounted on the tripod. One mirror is fixed to the base; it may be rotated and tilted, and it directs the reflected sunlight through the sights to the observer. If the sun is in the direction of the observer, the fixed mirror is all that is needed. The second mirror is on a movable arm for use when the sun is shining toward the observer. It

Figure 4-9. **Lighting assembly for target**



serves to direct the light into the fixed mirror and from there to the observer. No provision is made for adjusting the pointing in a vertical plane: however, flat wood chips or folded cardboard shims between the bottom of the heliotrope and the tripod head will solve this problem. The main point to remember is that all fittings must be tight, since any play or looseness will cause trouble when the observer sights on the heliotrope. Whichever mirror is receiving the direct sunlight must be attended at all times. Due to the apparent motion of the sun, the sunlight will stop hitting the receiving mirror about every three minutes. Thus, the receiving mirror must be moved with the sun in order to maintain the light source for the observer. The receiving mirror should be just tight enough so that light taps with the fingertip or a pencil will maintain the correct angle. The two sights are seldom aligned perfectly with the light apertures, and tests should be made prior to use so that the proper allowances can be made.

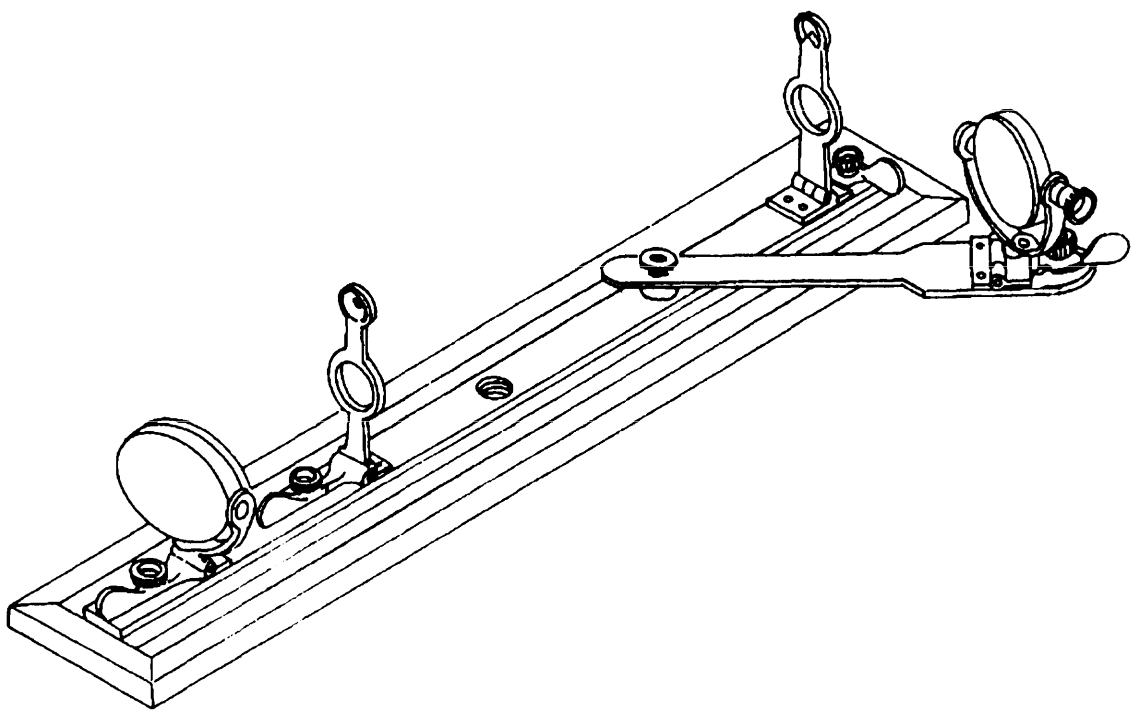
Use

Many surveyors tend to shy away from using the heliotrope because they have not been able to get good results due to faulty pointing techniques. There are times when use of this instrument is the only way to solve a line of sight problem. The intense rays of the reflected sunlight are visible through hazy and smoky atmosphere when no other signals can be detected and the range is essentially unlimited. The heliotrope's use is limited by: first, the necessity for sunlight; second, the difficulty in using it as a target while making simultaneous observations from the same ground station; and third, the difficulty of aligning without radio communications. The second difficulty can be solved by placing the heliotrope to one side of the station and making careful measurements of its eccentricity. It can also be used in this position for simultaneous vertical angle measurements by measuring the difference of elevation from the true station. The third difficulty is not often present, since most survey parties are equipped with radio. The observer, while sighting through the telescope and with the radio in hand, gives a running stream of one-way directions to the heliotrope attendant until the observer has a steady light in the telescope. At this time, the heliotrope attendant needs only to note the position of the sun's image on the sight and periodically adjust the sun mirror. When occupying a station with a heliotrope, the signal tender must continually adjust the mirror to maintain a steady light.

EXPEDIENT LIGHTS

There are many types of expedient lights or signals that can be used when standard equipment is not available or is inoperative. No attempt will be made here to list or illustrate all the different types of expedient lights or signals that can be used. These include the headlight of a vehicle, a masked lantern, a boxed light bulb, or chemical illumination lights. The survey party chief must use experience gained in the field and ingenuity to determine the proper expedient for a particular condition or problem.

Figure 4-10. **Heliotrope**



Chapter 5
Field Procedures

OBSERVATION PRECAUTIONS

Because of the high standards of accuracy required for second-order observation, constant precautions are necessary to counteract as much as possible all sources of error. The party chief should periodically inspect the performance of all observing parties. A good observer achieves the full potential of his instrument at all times. He precisely bisects signals and targets and consistently obtains very little spread (three or fewer of the smallest increments marked on the micrometer) between his direct and reverse pointings. Proficiency can be attained only by a careful study of all factors affecting the accuracy of theodolite observations. Efforts should be made to eliminate all known sources of error. Observation precautions can be summarized as follows:

Instrument Check

Check the instruments and signals for stability. If an instrument is not stable, all other refinements are useless.

Instrument Adjustment

Pay careful attention to parallax and inclination of the horizontal circle plate. Errors introduced by these cannot be eliminated. Since the effects of an inclined horizontal circle plate increase with the inclination of the line of sight, the plate level of the T-3, or the striding level of the T-2, is read for second-order observations.

Plumb Signals and Targets

Plumb signals and targets directly over the SCP. Carefully aim targets and signals towards the observing station.

Other Precautions

Other operational precautions for accurate observations are —

- Repainting on the initial after each circle setting.
- Checking the plate level frequently.
- Protecting the instrument from wind, sun, and weather, by using an observing tent.

Do not disturb the instrument during observation of a position by releveling or by lateral thrust on a clamp, tangent screw, or electric switches, or by striking the instrument or its support.

When all other known precautions have been taken, one of the principal causes of reobservation is horizontal refraction. Sometimes elevating the signal will reduce the effects of horizontal refraction, but often the only solution without altering the traverse is to reobserve under different atmospheric conditions.

FIELD CHECK PROCEDURES FOR STARTING AND TERMINATING STATIONS

The starting and terminating stations for a traverse are usually recovered and adjusted stations from a previous triangulation or traverse survey. These stations may be established during the current survey by astronomic observations of the appropriate order of accuracy. These stations must be of the same or a higher order of accuracy as that of the traverse being established. When previously established stations are used, they must be positively identified and a line or angle check must be made. The required limits of these checks (ties) to existing stations will depend upon the order of the survey being accomplished.

Distance Check

When only two intervisible stations of the required order can be recovered, their accuracy can be checked by measuring a check distance between the two. The measured distance is reduced to grid and compared to the computed distance between the stations. Measure the distance between the two stations using the method that is prescribed for the equipment being used. The check distance consists of at least two complete measurements: one concentric, the second eccentric (offset). The amount of offset is carefully measured and will not be greater than 0.5 meters. Reduce the measured distance to grid distance and compare with the computed grid distance. If the measured distance compares to the computed distance within the specifications of the project, then the stations are usable.

Angle Check

When three or more intervisible stations of the required order exist, they can be checked by turning check angles between them. The corrected field angles are then compared to the computed angles.

1. With the theodolite pointed at the target and with the horizontal clamp tightened, the circle is set as follows: Set micrometer scales to read the unit minutes and seconds of the given value. Then, using the horizontal circle drive knob, turn the circle until coincidence (or as near as possible) is obtained at the degree and tens of minutes value of the given reading. After setting the circle in this manner, the actual reading is determined. This setting should normally be accurate to ± 05.0".

2. When measuring a predetermined angle, the instrument is first pointed along the initial line from which the angle is to be measured and the circle is read. The value of the angle is added to the reading to determine the circle reading for the second pointing. Set the micrometer scale to read the unit minutes and seconds of the value to be set on the circle. Then, turn the instrument in azimuth and make coincidence (or as near as possible) at the degrees and tens of minutes value that is to be set. The horizontal slow-motion screw is used to obtain coincidence. After setting the value in this manner, the actual reading is determined. The predetermined value can usually be set on the circle in this way to ± 02.0".

3. It is seldom necessary to set a predetermined value on the vertical circle, except when adjusting the instrument or when locating a preselected star for azimuth. Set the micrometer scale to the unit minutes and seconds of the given zenith distance. Then the telescope is elevated (or depressed) to make coincidence at the predetermined degrees and tens of minutes value. The telescope clamp and vertical slow-motion screw are used to make this coincidence. After setting the value in this manner, the actual reading is determined. The predetermined zenith distance can usually be set on the circle in this way to ± 02.0".

TRAVERSE ROUTE SELECTION PROCEDURES

The party chief usually selects a tentative route from a map and aerial photographs, if available, and plots the proposed station on the reconnaissance map. The lines of sight and all previously established controls (both horizontal and vertical) should also be plotted on the map. The final route is selected during the field reconnaissance. The route that will provide the most rapid means of extending the control with the least effort is usually selected. Often this route will bypass some of the required control points and these points can be connected to the main scheme by separate loop traverses or by side shots if the required order of accuracy is low enough. Full advantage should be taken of previously cleared lines in laying out the traverse. All control stations from previous surveys that exist along the traverse route should be connected whenever possible, to include bench marks.

Reconnaissance Specifications

There are some reconnaissance specifications pertinent to the route selection that are based on the order of accuracy required:

- Minimum distance between stations,
- Maximum number of traverse legs permitted before being required to extend vertical control (direct leveling) from an existing bench mark to the traverse.
- Maximum number of traverse legs permitted before an azimuth check must be made.
- Maximum permitted change in direction of the traverse before an azimuth check must be made, The change in direction is based on the computed deflection angle at the station during the forward run of the traverse.

These specifications are spelled out in the Federal Geodetic Control Committee's publication, *Standards and Specifications for Geodetic Control Networks,* and will be strictly adhered to when supporting National Geodetic Survey or its Control Networks. In all other cases, comply with the project requirements of the using organization while observing correct surveying procedures.

Type of Distance Measuring Equipment

Consideration must be given to the type of distance measuring equipment when planning a traverse route, In most cases, EDME is available and the distances between intervisible stations are limited only by the maximum effective range of the EDME. If taping must be used, limit the distances between the stations to ten lengths of the tape. The ten-length limit will minimize alignment, leveling, and taping errors.

PROCEDURAL SPECIFICATIONS FOR THIRD-ORDER TRAVERSE SURVEY

The following procedures will be performed when extending horizontal control by traverse methods and third-order accuracy is to be obtained:

ALL third-order traverses will have TWO **station angles** observed at each occupied SCP. The sequence for observing station angles is as follows:

1. The observer places the instrument in the direct position (vertical circle on the observer's left) and points the instrument at the rear station. The observer bisects the rear target, sets the initial plate setting (if required), and reads the micrometer.

2. In the direct position, the observer turns the instrument clockwise to the forward station, bisects the target, and reads the micrometer.

3. The observer plunges the telescope, and turns the instrument clockwise to the forward station, with the vertical circle on the observer's right (reverse position). The observer bisects the target, and reads the micrometer.

4. In the reverse position, the observer turns the instrument clockwise until the instrument is pointing at the rear station, bisects the target, and reads the micrometer.

Steps **1** through **4** constitute the **first station angle.**

5. The instrument remains in the reverse position and pointed at the rear station. The observer bisects the target, advances the horizontal plates to the new initial plate setting (if the theodolite so requires), and reads the micrometer.

6. In the reverse position, the observer turns the instrument clockwise until the instrument is pointing at the forward station, bisects the target, and reads the micrometer.

7. The observer plunges the telescope and turns the instrument clockwise until the instrument is pointing at the forward station in the direct position. The observer bisects the target and reads the micrometer.

8. In the direct position, the observer turns the instrument clockwise until the instrument is pointing at the rear station, bisects the target, and reads the micrometer.

Steps **5** through **8** constitute the **second station angle.**

ALL third-order traverses will have TWO **explement angles** observed at each occupied SCP, The sequence for observing explement angles is the same as the sequence for station angles, except that the explement angles are initiated on the forward station.

The **mean of the station angles** will be shown on the recording form.

The **mean of the explement angles** will be shown on the recording form.

The **horizon closure** will be calculated and shown on the recording form. The horizon closure is the sum of the mean station angle and the mean explement angle.

The **error** will be shown on the recording form, The error is the horizon closure minus 360 degrees. The error will not exceed ± 05.0".

The **corrections** will be shown on the recording form. The corrections are the error divided by two, and the algebraic sign reversed. When a 1-second theodolite is used, the corrections will be rounded to 0.1 second, If one correction is rounded up, the other correction will be rounded down. The larger correction will be applied to the larger angle.

The **corrected mean station angle** will be calculated and shown on the recording form (see Figure 6-1, page 6-2).

Traverse lines (legs) will have zenith distances observed **in both directions** within one hour. Reciprocal zenith distances are mandatory for compliance with third-order traverse specifications.

SPECIFICATIONS FOR THIRD-ORDER DIFFERENTIAL LEVELING

The terms differential leveling, direct leveling, geodetic leveling, and spirit leveling describe the same activity: the determination of differences in elevation by direct observation. The terms will be interchangeable in this publication. When performing differential leveling and third-order accuracy is to be obtained, the following procedures will be adhered to:

1. Each day, just before the leveling begins, and immediately following any instance when the level is subjected to unusual shock, the error of the level (C factor) must be determined. The C check will be recorded and kept in the records of the project.

2. The leveling will start from and end on bench marks of third-order accuracy or higher.

3. The method of observation will be three-wire readings.

4. No observation will be made closer to the ground than one-half (0.500) meter. No observation will be made on the rod or precise meter board higher than project specifications require.

5. The rods will be leapfrogged forward.

6. There will be an even number of setups between the starting and ending bench marks.

7. The sequence of observing the rods will be the red rod first sequence: rod # 1 or A of a matched pair of rods will be marked (the foot of the rod is painted or flagging is attached to the rod) to distinguish it from the other rod. The marked rod will be observed and the readings recorded first for each setup.

8. Sections will be double run: from the first bench mark out to the next bench mark and return.

9. The maximum allowable disclosure will be the lesser of the two computed values:
- Twelve millimeters times the square root of the shorter distance run between the bench marks in kilometers, or;
- Twelve millimeters times the square root of the perimeter of the loop (front and back runs combined) in kilometers.

10. Actions not specified above will comply with the specifications set forth by the Federal Geodetic Control Committee.

11. In no instance will proper leveling methodology and procedures be abandoned. Procedures 1 through 10 will be complied with at all times unless the customer sets forth specific methodology, standards, and specifications for performing the differential leveling in his request for survey support.

Chapter 6
Recording and Abstracting Procedures

RECORDING HORIZONTAL DIRECTIONS

Recording horizontal directions will be the same for all orders of accuracy, Horizontal directions will be recorded in *DA Form 4253, Horizontal Direction or Angle Book,* authorized single sheet recording forms, or appropriate media when operating automated integrated survey instruments (AISI). In all cases, complete documentation will be performed in the field, Each time an SCP is occupied, the following will be recorded:

1 **Instrument make, model, and serial number.**
2 **Instrument operator's name.**
3 **Recorder's name.**
4 **Weather description** – three words describing –
- Temperature.
- General atmospheric condition.
- Wind.

5 **Complete designation of the station occupied–**
- Full station name.
- Year the monument was installed.
- Name of agency on the disk.

Each station observed will, when first listed on a page or form, be identified by full station name, year monumented, and name of agency on the disk, If an instrument, signal, or target is set eccentric to a station (not plumbed directly over the station mark), that item will be sketched on the recording form, showing –

1 **Distance of the item from the station.**
2 **Relative directions of the item to** –
- Station is set eccentric from.
- First distant station in a clockwise direction.
- Included angle.

Where intersection stations are observed, the exact part of the object sighted upon must be recorded and shown in a sketch.

Numbers and letters should be approximately half the height between lines, The recording should be centered in the block and on the bottom line of the block. All figures must be neat and legible. There will be no erasures or obscuring of the original figures. Original numbers may be crossed out using a single diagonal line through the numbers. The corrected numbers will be written above the original entry. The person making the correction will place his initials above and to the right of the original entry and within the block. The person making the correction will explain the reason for the correction in the Remarks column when he makes the correction. No position will be voided or rejected on any recording media, except in the case of bumping the instrument or stand, causing the instrument to become unlevel. If the instrument is observed to be unlevel, make a note on the recording media in the Remarks column stating that the instrument was not level, and why. All recordings will be done with a dark reproducible ink, preferably black or blue-black, Directions in degrees, minutes, and seconds will be entered in the Remarks column. A note will be entered in the Remarks column for the first position of each set, describing the general condition: "No eccentricity of instrument or target," "Eccentric target shown to all stations." or other appropriate entry.

Every computation on each page or sheet will be checked by the observer, The observer will verify the computation with a light, visible tick mark to the upper right of the computed numbers, or will correct the numbers (as described above). The observer will confirm that he has checked all computed numbers on the page by placing his initials at the bottom right corner of the page.

On the appropriate page in the front of the recording book, an index will be made of the stations from which observations were made and recorded within the book. An index will also be required for all other recording media, listing where to locate observations from any occupied SCP.

Refer to the appropriate illustration for the following types of observations:

1 **Traverse** (using l-second theodolite) (includes determining horizon closure and corrected station and explement angles for third-order accuracy projects) – Figure 6-1.
2 **Triangulation** (using 0.2-second theodolite) – Figure 6-2.
3 **Zenith distance** (using l-second theodolite) – Figure 6-3.
4 **Vertical angle** (using 0.2-second theodolite) – Figure 6-4,
5 **Side shot** (used for airfield obstruction positioning and reporting) – Figure 6-5.
6 **Astronomic azimuth** – Figures 6-6a and 6-6b.
7 **Two-point intersection** – Figure 6-7.
8 **Plane table** – Figure 6-8.

STATION LEWIS (30TH ENGR BN) 68 DATE 2 JUNE 19 88

INSTRUMENTMAN SFC J. DOE INSTRUMENT WILD T-2 # 1012

RECORDER SFC K. SMOE WEATHER COOL, CLEAR + CALM

POS. / REP.	OBJECT OBSERVED	CHRON TIME H	CHRON TIME M	CHRON TIME S	STOP WATCH	TEL D/R	CIRCLE	CIRCLE	MICRO./VERN. 1ST/A( )	MICRO./VERN. 2D/B( )	MEAN	MEAN D/R	DIR/ANG	REMARKS	LEVELS W	LEVELS E
1	KING 30TH ENGR BN					D	00	00	52							
	68					R	180	00	58		55.0		00.0			
														STA ∠		
	ET-1 USC+GS 68					D	325	10	31							
						R	145	10	35		33.0		38.0	325° 09' 38.0"		
2	KING 30TH ENGR BN					R	210	02	32							
	68					D	30	02	28		30.0		00.0			
														STA ∠		
	ET-1 USC+GS 68					R	175	12	12							
						D	355	12	07		09.5		34.5	325° 09' 34.5"		
													MN STA ∠	325° 09 38.8		
1	ET-1 USC + GS 68					D	00	00	48							
						R	180	00	53		50.5		00.0			
	KING 30TH ENGR BN					D	34	51	15							
	68					R	214	51	19		17.0		26.5	EXP ∠ 34° 50' 26.5"		
2	ET-1 USC+GS 68					R	210	02	27							
						D	30	02	26		26.5		00.0			
	KING 30TH ENGR BN					R	244	52	56							
	68					D	64	52	48		52.0		25.5	EXP ∠ 34° 50' 25.5"		
													MN EXP ∠	34° 50' 26.0"		
													MN STA ∠	325° 09' 38.8		
													HC	360 00 04.8		
													CORR	-04.8 -2.4 + -2.4		
										JCO		CORR	STA ∠	325° 09' 36.4		

DA FORM 1 JUN 74 4253 (Blue)

Figure 6-1. **Recording procedures for horizontal directions using 1-second theodolite**

STATION LEWIS 30TH ENGR BN 68 DATE 2 JUNE 19 88

INSTRUMENTMAN SFC J. DOE INSTRUMENT WILD T-3 1012

RECORDER SFC SMOE WEATHER CALM, COOL, + CLEAR

POS. / REP.	OBJECT OBSERVED	CHRON TIME H	CHRON TIME M	CHRON TIME S	STOP WATCH	TEL D/R	CIRCLE	CIRCLE	MICRO./VERN. 1ST/A(')	MICRO./VERN. 2D/B(")	MEAN	MEAN D/R	DIR. ANG	REMARKS	LEVELS W	LEVELS E
1	Δ JAMES USC+GS	01	18			D	00	00	06.8	06.6	06.7			NO ECC. OF LIGHT		
	68					R	180	00	05.4	05.4	05.4	06.0	00.0	OR INSTR.		
	Δ WILLIS USC+GS					D	67	14	54.9	54.7	54.8					
	68					R	247	14	55.0	54.8	54.9	54.8	48.8	67° 14' 48".8		
	Δ KING 30TH ENGR BN					D	123	39	06.9	06.6	06.8					
	68					R	303	39	06.3	06.2	06.2	06.5	00.5	123° 39' 00".5		
2	JAMES USC+GS					R	191	00	22.9	23.1	23.0					
	68					D	11	00	22.7	22.5	22.6	22.8	00.0			
	WILLIS USC+GS					R	258	15	11.2	11.0	11.1					
	68					D	78	15	10.7	10.6	10.6	10.8	48.0	67° 14' 48".0		
	KING 30TH ENGR BN					R	314	39	23.0	22.8	22.9					
	68					D	134	39	22.5	22.4	22.4	22.6	59.8	123° 38' 59".8		

THE REMAINING POSITIONS ARE SIMILAR TO THESE, EXCEPT THAT THE PLATE IS ADVANCED TO THE PROPER INCREMENT.

JCB

DA FORM 1 JUN 74 4253 (Blue)

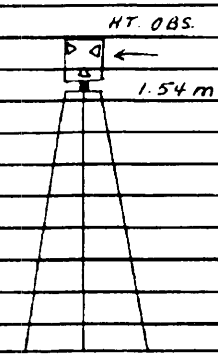
Figure 6-2. **Recording procedures for horizontal directions using 2-second theodolite**

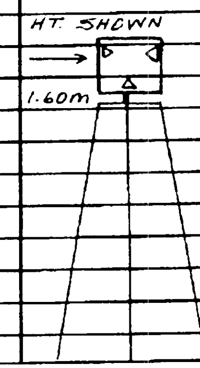
Zenith Distance/Vertical Angle

For use of this form, see FM 5-232, the proponent agency is TRADOC.

STATION LEWIS (USC + GS) 29 DATE PM 14 OCT 19 68 INSTRUMENTMAN SFC J. DOE INSTRUMENT WILD T2 #52119
RECORDER SP4 W. ROE WEATHER BREEZY COOL CALM

OBJECT OBSERVED	CHRON TIME H	CHRON TIME M	CHRON TIME S	STOP WATCH	TEL D/R	CIRCLE	CIRCLE	MICRO. 1ST	MICRO. 2D	MEAN	ZEN DIST	REMARKS	LEVELS W	LEVELS E
1. LEWIS (USC + GS) 29	14	25			D	90	04	51	-03.5	=47.5		HT. = 1.60m		
					R	269	55	16	-03.5	=12.5		HT. = 1.54m		
					Σ	359	59	67	-07.0	=60.0	90° 04' 41".5			
2.	14	30						52	-03.5	=48.5				
								15	-03.5	=11.5				
								67	-07.0	=60.0	90° 04' 48".5			





DA Form 5817-R, AUG 89

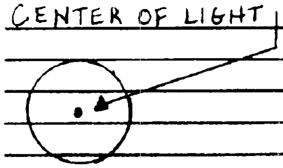
Figure 6-3. **Recording procedures for observing zenith distances using 1-second theodolite**

Zenith Distance/Vertical Angle

For use of this form, see FM 5-232, the proponent agency is TRADOC.

STATION LEWIS (USC + GS) 29 DATE PM 14 OCT 19 68 INSTRUMENTMAN SFC J. DOE INSTRUMENT WILD T-3 # 1852
RECORDER SP4 W. ROE WEATHER CALM, COOL, + CLEAR

OBJECT OBSERVED	CHRON TIME H	CHRON TIME M	CHRON TIME S	STOP WATCH	TEL D/R	CIRCLE		MICRO. 1ST	MICRO. 2D	MEAN	ZEN DIST	REMARKS	LEVELS	
△ WILLIS	23	40			D	93	33	32.0	32.2	32.1		H.I. = 1.85 meters		
(30TH ENGR BN) 68					R	86	26	26.6	26.6	26.6				
				VERT ∡ =	+	07'	07'			05.5	82° 52' 54."5	H.S. = 1.60 meters		
					D	93	33	33.8	34.0	33.9				
OBSERVED:					R	86	26	27.6	27.8	27.7				
					+	07'	07'			06.2	82 52 53.8			
CENTER OF LIGHT														
					D	93	33	33.9	33.9	33.9				
					R	86	26	28.6	28.8	28.7				
					+	07'	07'			05.2	82 52 54.8			
					D	93	33	30.2	30.4	30.3				
	23	55			R	86	26	26.7	26.7	26.7				
					+	07'	07'			03.6	82 52 56.4			
								TOTAL		=	219."5			
								MEAN		=	82° 52' 54."88			
												JEL		



DA Form 5817-R, AUG 89

Figure 6-4 **Recording procedures for vertical angle using 0.2-second theodolite**

STATION LAGUNA-A SIDE SHOT DATE 8 MAR 19 86 INSTRUMENTMAN SPC HOWSIE INSTRUMENT WILD T-2 #51735

RECORDER SPC POTTS WEATHER WARM, BREEZY, CLOUDY

POS. / REP.	OBJECT OBSERVED	CHRON TIME H	CHRON TIME M	CHRON TIME S	STOP WATCH	TEL D/R	CIRCLE		MICRO. : VERN. 1ST / A(")	MICRO. : VERN. 2D / B(")	MEAN	MEAN D/R	DIR / ANG	REMARKS	LEVELS W	LEVELS E
1	COMPASS ROSE					D	00	00	11		12.0					
						R	180	00	13							
	BERM					D	305	10	11							
						R	125	10	21		16.0		STA∠	305 10 04.0		
2	COMPASS ROSE					R	225	00	21							
						D	45	00	19		20.0					
	BERM					R	170	10	23							
						D	350	10	25		24.0		STA∠	305 10 04.0		
												MN	STA∠	305 10 04.0		
1	BERM					D	00	00	23							
						R	180	00	22		22.5					
	COMPASS ROSE					D	54	50	04							
						R	234	50	11		07.5		EXP∠	54 49 45.0		
2	BERM					R	225	00	22							
						D	45	00	18		20.0					
	COMPASS ROSE					R	279	50	15							
						D	99	50	06		10.5		EXP∠	54 49 50.5		
												MN	EXP∠	54 49 47.8		
												MN	STA∠	305 10 04.0		
													HC	359 59 51.8		
													CORR	+08.2 +04.1 +04.1		
										[illegible]		CORR	STA∠	305 10 08.1		

DA FORM 1 JUN 74 4253 (Blue)

Figure 6-5. **Recording procedures for side shot**

STATION LIFT (USAES 79) DATE 24 JULY 19 79

INSTRUMENTMAN SGT HOWARD INSTRUMENT WILD T-2 #50101

RECORDER PFC MAYO WEATHER CLEAR, COOL, CALM

POS. / REP.	OBJECT OBSERVED	CHRON TIME H	CHRON TIME M	CHRON TIME S	STOP WATCH	TEL D/R	CIRCLE		MICRO. / VERN. 1ST / A(")	MICRO. / VERN. 2D / B(")	MEAN	MEAN D / R	DIR / ANG	REMARKS	LEVELS W	LEVELS E
	WWV 15 MHZ UT		LCT													
	03 26	23	25	47												
	03 27	23	26	47												
	03 28	23	27	47												
1	LIFT AZ MK					D	00	00	12							
	(USAES 79)					R	180	00	08			10.0				
	POLARIS	00	46	32		D	212	09	03							
		00	48	09		R	32	08	50			08/56.5		212° 08′ 46.″5		
	Δ		01	37												
	MN	00	47	20.5												
2	LIFT AZ MK					R	225	02	30							
	(USAES 79)					D	45	02	34			30.0				
	POLARIS	00	54	35		R	77	13	43							
		00	55	45		D	257	14	01			13/52.0		212° 11′ 22.″0		
	Δ		01	10												
	MN	00	55	10												
3	LIFT AZ MK					D	90	05	20							
	(USAES 79)					R	270	05	24			22.0				
	POLARIS	01	00	43		D	302	17	17							
		01	02	07		R	122	16	50			17/03.5		212° 11′ 41.″5		
	Δ		01	24												
	MN	01	01	25												

DA FORM 4253, 1 JUN 74 (Blue)

Figure 6-6a. **Recording procedures for astronomic azimuth using 1-second theodolite**

STATION LIFT (USAES 74) DATE 24 JULY 19 79

INSTRUMENTMAN SGT HOWARD INSTRUMENT WILD T-2 # 50101

RECORDER PFC MAYO WEATHER CLEAR, COOL, CALM

POS. / REP.	OBJECT OBSERVED	CHRON TIME H	CHRON TIME M	CHRON TIME S	STOP WATCH	TEL D/R	CIRCLE	CIRCLE	MICRO. / VERN. 1ST / A(')	MICRO. / VERN. 2D / B(')	MEAN	MEAN D : R	DIR / ANG	REMARKS	LEVELS W	LEVELS E
4	LIFT AZ MK					R	310	07	51							
	(USAES 74)					D	130	07	53			52.0				
	POLARIS	01	06	51		R	162	21	20							
		01	08	24		D	342	22	04			21/42.0		212° 13' 50".0		
	Δ		01	38												
	MN	01	07	40												
	WWV 15 MHZ UT															
	05 20	01	19	47												
	05 21	01	20	47												
	05 22	01	21	47												

JEH'

DA FORM 1 JUN 74 4253
(Blue)

Figure 6-6a. **Recording procedures for astronomic azimuth using 1-second theodolite (continued)**

STATION DEC. STA. #1 (USC+GS) DATE 1 JUNE 19 88

INSTRUMENTMAN SGT JACK INSTRUMENT WILD T-3 # 72063

RECORDER PFC DANIELS WEATHER CLEAR, CALM, HOT

POS. / REP.	OBJECT OBSERVED	CHRON TIME H	CHRON TIME M	CHRON TIME S	STOP WATCH	TEL D/R	CIRCLE	CIRCLE
	WWV 15 MHZ		LST					
	23 29	05	07	51.5				
	23 30	05	08	51.5	←			
	23 31	05	09	51.6				
1	DEC. STA. AZ. MK.					D	00	00
	(USC+GS) 75					R	180	00
	POLARIS	11	23	41.8		D	14	15
		11	25	27.0		R	194	15
	Δ		01	45.2				
	MN	11	24	34.4				
2	DEC. STA. AZ. MK.					D	191	00
	(USC+GS) 75					R	11	00
	POLARIS	11	27	57.1		D	205	16
		11	30	11.1		R	25	16
	Δ		02	14.0				
	MN	11	29	04.1				

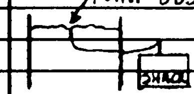
MICRO. / VERN. 1ST / A(")	MICRO. / VERN. 2D / B(")	MEAN	MEAN D · R	DIR / ANG	REMARKS	LEVELS W	LEVELS E
10.0	10.1	10.0					
09.6	09.8	09.7	09.8				
					W E		
14.1	14.2	14.2			03.9 30.9		
36.4	36.6	36.5	25.4		31.4 04.4		
					27.5 26.5		
					+1.0		
25.6	25.8	25.7					
32.4	32.6	32.5	29.1				
					W E		
23.6	23.8	23.7			31.5 04.5		
50.6	50.8	50.7	37.2		04.0 31.0		
					27.5 26.5		
					+1.0		

DA FORM 1 JUN 74 4253 (Blue)

Figure 6-6b. **Recording procedures for astronomic azimuth using 0.2-second theodolite**

STATION HANCHEY (30TH ENGR BN) 81 DATE 6 MAY 1988 INSTRUMENTMAN SP4 FISH INSTRUMENT WILD T-2 #72071

RECORDER WEATHER CLEAR, CALM, COOL

POS. / REP.	OBJECT OBSERVED	CHRON TIME H	CHRON TIME M	CHRON TIME S	STOP WATCH	TEL D/R	CIRCLE	CIRCLE	MICRO. / VERN. 1ST / A(")	MICRO. / VERN. 2D / B(")	MEAN	MEAN D/R	DIR / ANG	REMARKS	LEVELS W	LEVELS E
1	HANCHEY AZ MK					D	00	00	30					POINT OBSERVED 		
	(30TH ENGR BN) 81					R	180	00	31			30.5				
	NDB					D	97	21	03							
						R	277	21	02			02.5				
													STA∡	47° 20' 32".0		
2	HANCHEY AZ MK					R	270	00	31							
	(30TH ENGR BN) 81					D	90	00	29			30.0				
	NDB					R	07	21	04							
						D	187	21	02			03.0	STA∡	47° 20' 33".0		
												MN	STA∡	47° 20' 32".5		
1	NDB					D	00	00	31							
						R	180	00	30			30.5				
	HANCHEY AZ MK					D	262	39	57							
	(30TH ENGR BN) 81					R	82	39	58			57.5	EXPL∡	262° 39' 27".0		
2	NDB					R	270	00	32							
						D	90	00	31			31.5				
	HANCHEY AZ MK					R	172	39	59							
	(30TH ENGR BN) 81					D	352	39	58			58.5	EXPL∡	262° 39' 27".0		
												MN	EXPL∡	262° 39' 27".0		
												MN	STA∡	47° 20' 32".5		
												H°	R.CLOS.	359° 59' 59".5		
												ERROR		-00.5		
												CORR.		+00.2 +00.3		
												CORR.	STA∡	47° 20' 32".7	JEF	

DA FORM 4253, 1 JUN 74 (Blue)

Figure 6-7. **Recording procedures for airfield two-point intersection**

General Survey Notes

For use of this form, see FM 5-232; the proponent agency is TRADOC.

Project		Weather			Wind		Instrument			Date
FAIRFAX COMMON		HAZY			CALM		ALIDADE, K&E #4671			15 SEP 84
Designation		Location			Temp		Organization			Page no. 17 / No. of Pages 41
		FAIRFAX, VA			WARM		99th ENG CO			
Point	**H Dist**	**H Scale**	**RI**	**V Scale**	**Prod ±**	**RC −**	**DE ±**	**HI**	**Elev.**	**Remarks**
		⊼	STATION A				+4.4	170.1	165.7	ELEV STA. A
A1	95	99	0.86	45	−4.3	−2.6	−6.9		163.2	℄ DITCH
A2	135	100	1.35	50	—	−4.3	−4.3		165.8	NE CORNER BLDG
A3	140	100	1.40	48	−2.8	−6.8	−9.6		160.5	TOE OF SLOPE
A4	94	99	0.95	55	[illegible]	−2.0	+2.8		172.9	TOP OF BANK

sample

DA Form 5818-R, AUG 89

Figure 6-8. **Recording procedures for plane table**

ABSTRACTING OF HORIZONTAL DIRECTIONS

Second-order horizontal observation specifications require that an abstract of horizontal directions be compiled for every station at which horizontal directions have been observed. *DA Form 1916, Abstract of Horizontal Directions,* will be completed before leaving the SCP. (Third-order horizontal observations require the determination of horizon closure, corrected station angle, and corrected explement angle on the recording form. This will be accomplished prior to leaving the SCP.) Readings will be entered opposite the proper circle position, as indicated in the field notes, The degrees and minutes for each direction are entered only once, at the top of each column, and the seconds are entered for each circle position (Figure 6-9). The following is a summary of requirements when abstracting and rejecting horizontal directions.

Record all positions observed onto *DA Form 1916.* If two or more observations have been made for the same circle setting (position), list all the observations in the same box and determine the mean for that position.

Examine the list of the form. For all positions which appear to vary greatly from the apparent mean of all the positions, check the computations in the field recording book or recording media. Be alert for a change in the minutes of the computed directions (angles) in the field data. Reject any positions which vary widely from the mean and reobserve the positions, Values that are rejected will be enclosed in parentheses, and followed by "R_o." "R_o" indicates that the value was rejected by observation.

Determine (compute) a mean of the observed positions. The mean value of a direction will be rounded off to the nearest 0.01 second if a T-3 theodolite was used for observations. The mean value of a direction will be rounded off to the nearest 0.1 second if a l-second instrument was used for observations. Reject all observations which differ from the mean by more than the rejection limit (from *Standards and Specifications for Geodetic Control Networks).* Enclose any rejected observations with parentheses, and annotate with "R1." "R1" indicates that the value was rejected using the first mean value. The rejection limit will be applied to each observation with the same amount of accuracy as when the mean was determined (0.01 second for 1/10-second instruments, 0.1 second for 1-second instruments).

Reobserve any rejected positions and redetermine anew mean. Reapply the rejection limit. Any positions still exceeding the rejection limit will be enclosed in parentheses and annotated with "R2." "R2" indicates that the value was rejected using the second mean value. Ensure that sufficient positions remain acceptable (from *Standards and Specifications for Geodetic Control Networks).*

No value (reading) should be rejected if it is within the rejection limits, unless it was rejected at the time of observation, If a value was rejected at time of observation, check the field notes for the observer's reason for rejection.

Once a value is rejected, it cannot be used again.

If one of two or more readings on a position is outside the rejection limits, do not use the mean of the readings. Use only the reading which is within the rejection limits.

If two readings are outside the rejection limits (one high, the other low, and the mean is within the limits), the readings must be rejected.

If there is a progressive change in the values of the positions of a direction, or if the mean of the first half of the positions differs appreciably from the mean of the last half of the positions, attempt to observe another complete set of positions before leaving the SCP.

If repeat positions are observed at any circle setting during the same occupation of a station, combine the result of each additional observation with that of the original circle position. If, on second-order Class I triangulation, 12 or more additional positions are observed, they should be meaned separately and combined by sets.

On second-order Class I triangulation, two or more sets of 12 or more positions must be given equal weight, regardless of whether they are observed on the same or different nights. When two sets of 12 or more positions differ by more than 1 second, the set which best closes the triangle(s) is retained and the other set is rejected. In the case of three sets, sometimes two sets which agree with each other must be rejected and the third retained. Usually, the set or sets retained are those which are observed under the least harmful conditions of horizontal refraction. When there are more than two sets, any set which falls within 0.5 second of the individual or mean value which best satisfies the triangle(s) should also be meaned with that value.

If it appears that the initial is causing a large number of rejections, the observations can be listed by positions and directions on the abstract form, with some other station as the zero initial. In this case, the angle between the new initial and the original initial should be added to the listed circle settings to obtain the correct values to use when reobserving rejections, unless a complete new set of observations is to be made with anew initial. (See Table 6-1, pages 6-14 and 6-15.)

ABSTRACT OF HORIZONTAL DIRECTIONS

For use of this form, see TM 5-237; the proponent agency is TRADOC.

LOCATION	ORGANIZATION	STATION
MISSOURI	99th ENG DET (Survey)	LAKE (USC&GS) 1932
OBSERVER	**DATE**	**INST. (TYPE) (NO.)**
SGT SMITH	2 APRIL 1989	WILD T-2 #28234

POSITION NO	STATIONS OBSERVED							
	BROOK (USACE) 1956	BASS (USGS) 1972	TROUT (DMA) 1989					
	(Initial) 0° 00′	47° 46′	91° 34′	° ′	° ′	° ′	° ′	°
1	0″ 00	21.5″	48.0″	″	″	″	″	″
2	0.00	22.0	46.5 (42.0)R1					
3	0.00	22.0	46.5					
4	0.00	21.0	46.5					
5	0.00	21.5	46.0					
6	0.00	22.5 (36.0)R0	48.5					
7	0.00	21.0	48.5					
8	0.00	21.5	48.5					
9	0.00	22.0	46.0					
10	0.00	21.5	48.5					
11	0.00	22.0	46.5					
12	0.00	21.5	49.5					
13	0.00							
14	0.00							
15	0.00							
16	0.00							
Sum,		260.0	569.5 (565.0)R1					
Mean,		21.7	47.5 (47.1)R1					

COMPUTED BY	DATE	CHECKED BY	DATE
J R Jones SPC JONES	2 Apr 89	SGT WD Smith	2 Apr 89

sample

DA FORM 1 FEB 57 1916

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Figure 6-9. **Abstracting horizontal directions**

Table 6-1. **Circle settings**

	5-minute micrometer drum			10-minute micrometer drum			Circle	Wild T-3*	Micrometer
Two positions of circle									
1				0°	00′	10″			
2				90	05	40			
Four positions of circle									
1	0°	00′	40″	0°	00′	10″	0°	00′	15″
2	45	01	50	45	02	40	45	02	45
3	90	03	10	90	05	10	90	04	15
4	135	04	20	135	07	40	135	20	45
Six positions of circle									
1	0°	00′	10″	0°	00′	10″	0°	00′	15″
2	30	01	50	30	01	50	30	02	35
3	60	03	30	60	03	30	60	00	50
4	90	00	10	90	05	10	90	04	15
5	120	01	50	120	06	50	120	00	35
6	150	03	30	150	08	30	150	20	50
Eight positions of circle									
1	0°	00′	40″	0°	00′	10″	0°	00′	10″
2	22	01	50	22	01	25	22	00	25
3	45	03	10	45	02	40	45	02	35
4	67	04	20	67	03	55	67	00	50
5	90	00	40	90	05	10	90	04	10
6	112	01	50	112	06	25	112	00	25
7	135	03	10	135	07	40	135	20	35
8	157	04	20	157	08	55	157	00	50
Twelve positions of circle									
1	0°	00′	40″	0°	00′	10″	0°	00′	10″
2	15	01	50	15	01	50	15	00	25
3	30	03	10	30	03	30	30	02	35
4	45	04	20	45	05	10	45	00	50
5	60	00	40	60	06	50	60	00	10
6	75	01	50	75	08	30	75	00	25
7	90	03	10	90	00	10	90	04	35
8	105	04	20	105	01	50	105	00	50
9	120	00	40	120	03	30	120	00	10
10	135	01	50	135	05	10	135	00	25
11	150	03	10	150	06	50	150	20	35
12	165	04	20	165	08	30	165	00	50
Sixteen positions of circle									
1	0°	00′	40″	0°	00′	10″	0°	00′	10″
2	11	01	50	11	01	25	11	00	25
3	22	03	10	22	02	40	22	00	35
4	33	04	20	33	03	55	33	00	50
5	45	00	40	45	05	10	45	02	10
6	56	01	50	56	06	25	56	00	25
7	67	03	10	67	07	40	67	00	35
8	78	04	20	78	08	55	78	00	50
9	90	00	40	90	00	10	90	04	10
10	101	01	50	101	01	25	101	00	25
11	112	03	10	112	02	40	112	00	35
12	123	04	20	123	03	55	123	00	50
13	135	00	40	135	05	10	135	02	10
14	146	01	50	146	06	25	146	00	25
15	157	03	10	157	07	40	157	00	35
16	168	04	20	168	08	55	168	00	50

Table 6-1. **Circle settings (continued)**

Sets	Instrument** 10″ setting			Instrument*** 20″ setting			Instrument*** 30″ setting		
1	0°	00′	00″	0°	00′	00″	0°	00′	00″
2	90	05	30	90	10	20	90	10	30
1	0	00	00	0	00	00	0	00	00
2	60	03	30	60	06	20	60	06	30
3	120	07	00	120	13	00	120	13	00
1				0	00	00	0	00	00
2				45	05	20	45	05	30
3				90	10	00	90	10	00
4				135	15	20	135	15	30
1				0	00	00	0	00	00
2				36	04	20	36	04	30
3				72	08	00	72	08	00
4				108	12	20	108	12	30
5				144	16	00	144	16	00
1							0	00	00
2							30	03	30
3							60	07	00
4							90	10	30
5							120	14	00
6							150	17	30
1							0	00	00
2							25	02	30
3							51	05	30
4							76	08	00
5							102	10	30
6							128	14	30
7							153	17	00
1							0°	00′	00″
2							22	02	30
3							45	05	00
4							67	07	30
5							90	10	00
6							112	12	30
7							135	15	00
8							157	17	30

The Kern DKM-3 theodolite is an example of an instrument with a micrometer drum range of 5′.
The Wild T-2 and the Kern DKM-2 theodolites are examples of instruments with a micrometer drum range of 10′.
* For Wild T-3 theodolites, with a 2′ micrometer graduated to 0.″2, the micrometer readings shown in the table as units would be in seconds.
** Repeating theodolite with a 10′circle.
*** Transit with a 20′circle.

RECORDING VERTICAL OBSERVATIONS

Recording vertical observations will be the same for all orders of accuracy. Vertical observations will be recorded in *DA Form 4446, Level, Transit, and General Survey Book;* authorized single sheet recording forms; or appropriate media when operating AISI. In all cases, complete documentation will be performed in the field. In addition to the recording requirements stated on page 6-1, the following information will be recorded:

1 The HI above the station will be measured and recorded to the nearest 0.01 meter.

2 The target observed will be sketched in the bottom of the Object Observed column, and the point of the target observed will be indicated.

3 The height of target observed (HT) above the station being observed will be measured and recorded to the nearest 0.01 meter.

4 If the observer and recorder show a target to adjoining stations, the target shown will be sketched at the bottom of the Remarks column. All possible points that may be observed on the target will be measured and recorded to the nearest 0.01 meter as heights above the mark at the station. If the observer and recorder change the the target shown, they will remeasure all possible points, and record the new heights above station and the time of day when they changed the target.

5 If the target shown is not plumbed over the station, whether on line or eccentric, the recording requirements on page 6-1 will be strictly complied with.

During vertical observations, the time of the first observation of the first position and the time of the last observation of the last position will be recorded. The times will be recorded to the nearest whole minute.

The recording formats for the more commonly used instruments are shown at Figures 6-3 and 6-4 (pages 6-4 and 6-5). The T-2 theodolite and similar 1-second instruments observe zenith distances (Figure 6-3). The T-3 theodolite observes half-angles (Figure 6-4). The reverse (position) observation is subtracted from the direct (position). The difference is a vertical angle, with the algebraic sign indicating whether the vertical angle is elevated or depressed.

ABSTRACTING VERTICAL OBSERVATIONS

Vertical observations will be abstracted on *DA Form 1943, Abstract of Zenith Distances* (Figure 6-10), at the station site by the observing party.

Targets or signals shown to other stations will be sketched and dimensioned at the bottom of the form. If a target or signal is changed during the day, the time of change and the new dimensions will also be entered.

Vertical observations recorded as vertical angles will be converted to zenith distances prior to abstracting, The zenith distances will be abstracted, including the times of the observations. The abstracted zenith distances will be meaned, The mean zenith distances will be reduced to corrected zenith distances, by applying the **reduction to line-joining stations.** The formula is –

$$\text{Reduction (in seconds)} = \frac{-(t - o)\ \sin mn\ \text{Zenith Distance}}{T \sin 1''}$$

Where:

t = height of telescope above the station (HI)
o = height of object (point) observed above station
T = slope distance between stations (in kilometers)

This computation will also be applied to the vertical observations performed at the station at the other end of the line observed (reciprocal observations). The length of the line (T) will be multiplied by 0.46. Sum the two corrected zenith distances and subtract 180 degrees. Compare the product (T x 0,46) to the difference (corrZD1 + corrZD2 - 180 deg) (express as minutes of arc). If the two values differ by more than one minute of arc, perform a second set of reciprocal zenith distance observations. Differences exceeding one minute of arc are normally due to errors in observations, or unusual refractions in the atmosphere (poor observing conditions).

RECORDING HORIZONTALLY TAPED DISTANCES

Horizontally taped distances will be recorded *in DA Form 4196, Horizontal Distance Book,* or authorized single sheet recording form (Figure 6-11, page 6-18). The recorder will compute the horizontal distance in the recording book or form.

RECORDING ELECTRONICALLY MEASURED DISTANCES

Distances measured by EDME will be recorded on authorized single sheet recording forms (Figure 6-12, page 6-19). If the AISI is used, the appropriate recording media is authorized.

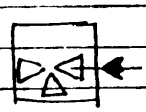
RECORDING DIFFERENTIAL LEVELING

Recording differential leveling is the same for all orders of accuracy. Differential leveling is recorded in *DA Form 4446* or authorized single-sheet recording forms (Figure 6-13, page 6-20). In addition to the

PROJECT 99E/99/TRA 3		ABSTRACT OF ZENITH DISTANCES	
LOCATION Missouri	INSTR. (TYPE) (NO.) WILD T2 #52119	STATION LAKE (USC&GS) 1932	
ORGANIZATION 99th ENG DET (SURVEY)	OBSERVER SGT SMITH		HEIGHT OF STAND —

Date 1989	Hour	Object Observed	Object Above Station =o (Meters)	Telescope Above Station =t (Meters)	Diff of Heights t−o (Meters)	Reduction to Line Joining Stations "	Observed Zenith Distance ° ' "	Corrected Zenith Distance ° ' "
2 Apr	1425	BROOIL	1.54	1.60	+0.04		90 04 47.5	
	1430	(USACE) 1956					48.5	
		OBS CENTER of				MA	90° 04' 48.0"	
		TARGET						

sample

Date	Light Shown to Station	Height of Light* Above Station (Meters)	Date	Light Shown to Station	Height of Light* Above Station (Meters)
2 Apr 89		1.60 m at CENTER			

*Height of Light (or object above station) should also be entered on Abstract of Zenith Distances of station to which light was shown.

COMPUTED BY SFC J Jones	DATE 2 Apr 89	CHECKED BY SGT W. Smith	DATE 2 Apr 89

DA FORM 1 FEB 57 1943

U.S. GPO: 1986—491-003/60457

For use of this form, see TM 5-237; the proponent agency is TRADOC.

Figure 6-10. **Abstracting zenith distances**

FROM STATION TP-4 TO STATION TP-5

CHIEF TAPEMAN SP5 ORTON DATE 14 JUNE 19 85

TAPE NOS. LUFKIN # 5216, LUFKIN # 3114 WEATHER CALM, CLEAR, COOL

STATION FROM	STATION TO	TEMP FRONT	TEMP REAR	DISTANCE	% OF SLOPE FWD	% OF SLOPE BKWD	SET-UP	SET-BACK	TAPE SUPPORT	INCL CORR	TEMP CORR	CAL CORR	REMARKS
TP4		54	56	30.000	2.5				2	-0.013	-0.002	+0.021	
		55	55	30.000	3.0				2	-0.015	-0.002	+0.021	
		55	56	30.000	1.5				2	-0.008	-0.002	+0.021	
		54	56	30.000	1.5				2	-0.008	-0.002	+0.021	
		55	55	30.000	1.5				2	-0.008	-0.002	+0.021	
	TP-5	55		4.779	0				2	-0-	-01	+0.003	
				Σ154.779						Σ-0.052	-0.010	+0.108	
TP-5		55	56	30.000	1.5				2	-0.008	-0.002	+0.021	
		56	55	30.000	1.5				2	-0.008	-0.002	+0.021	
		54	55	30.000	1.5				2	-0.008	-0.003	+0.021	
		55	55	30.000	3.0				2	-0.015	-0.002	+0.021	
		54	55	30.000	2.5				2	-0.013	-0.003	+0.021	
		54		4.802	0				2	-0-	-0-	+0.003	
				Σ154.802									
													E.C = 0.021
													MN DIST = 154.8355
													RC = 1.7300

DA FORM 1 JAN 74 4196 (Blue)

Figure 6-11. **Recording horizontal, taped distances**

Field Sheet, Infrared

For use of this form, see FM 5-232; the proponent agency is TRADOC.

PROJECT: WEST RANGE ARTY 3.79			
ORGANIZATION: 99th ENGR CO.		DATE: 16 MAR 89	APPROX DISTANCE: 1500 m
ZERO CORRECTION *: −0.004	CALIBRATION DATE: 7 MAR 89	OBSERVER: SPC WILSON	RECORDER: PFC WHITE

INSTRUMENT STATION	H.I.	ELEVATION	ELEVATION INSTRUMENT	ECCENTRICITY * TOWARD / AWAY	INST NO
ELKHORN (99th ENGR) 89	1.54 M			AWAY 0.000 M	1268

REFLECTOR STATION	H.I.	ELEVATION	ELEVATION REFLECTOR	ECCENTRICITY * TOWARD / AWAY	PRISM NO
BULLRUSH (99th ENGR) 89	1.60 M			AWAY 0.000 M	R-1268

METEOROLOGICAL READINGS

	TIME	PRESSURE (Hg)	TEMP. (DRY)
		~~IN.~~ mm	~~F~~ C°
INSTRUMENT	0819	762	[illegible]6
REFLECTOR	0817	761	[illegible]
SUM		1523	3[illegible]
MEAN		762	16
CORRECTION FACTOR (PPM)		+5	

ZD INSTRUMENT TO REFLECTOR

DISTANCE (meters)

1	1527	308
2	1527	306
3	1527	311
4	1527	306
5	1527	306
[illegible]	1527	307
[illegible]	1527	304
8	1527	310
9	1527	310
10	1527	307
SUM	15273	075

PRODUCT = UD × PPM

RC = PRODUCT × 10^{-6}

T = UD ± Z ± RC

$H' = (T)^2 - (d)^2$

H′ = SIN ZD × T

$H_{FT} = H' \times 3.280840$

UD	1527.308	MEAN UNCORRECTED SLOPE DISTANCE (UD)	1527	308
PPM	+5	ZERO CORRECTION° (Z)	0	004
PRODUCT	7636.540	REFRACTIVE INDEX CORRECTION (RC)	0	008
RC	+ 0.008	CORRECTED SLOPE DISTANCE (T)	1527	312
DIFF. OF ELEV. (d)		UNCORRECTED HORIZON. DISTANCE (H′)		
		ECCENTRIC CORRECTION * (EC)		
		HORIZON DISTANCE (H_M) / (H_{FT})		

° Obtained from Instrument Calibration.
* Toward Eccentricity must be ADDED.
Away Eccentricity must be SUBTRACTED.

REMARKS

COMPUTED BY	DATE	CHECKED BY	DATE	PAGE OF

Sample

Figure 6-12. **Recording procedures for electronically measured distance (infrared)**

Three-Wire Leveling

For use of this form, use FM 5-232; the proponent agency is TRADOC.

Project	Location	Organization
99/US/3LL/5/89	FT BELVOIR, VA	99th ENG (TOPO)

Observer	Recorder	Instrument	Sun	Wind	Weather
SGT J DOE	SPC W. ROE	WILD N-3 #1268	CLEAR	CALM	WARM

From	To	Date	Time	Line or Net	Page no.	No. of pgs.
RM S-1	TBMS-1	25 Apr 89	0900	MAINLINE, NET "S"	42	79

Station	Backsight Face of rod (+)	Mean (+)	Back of rod	Interval	Sum of intervals	Foresight Face of rod	Mean (−)	Back of rod	Interval	Sum of intervals	Remarks
RM S-1	1.292					(−)3.031					
	1.019	1.0193		273		2.750	2.7503		281		
	0.747			272	545	2.470			280	561	
	3.058					8.251					
	0.718					2.779					
	0.487	0.4873		231		2.556	2.5563		223		
	0.257			230	461	2.334			222	445	
	4.520	1.5066			1006	15.920	5.3066			1006	
	3.001					0.955					
	2.692	2.6917		309		0.619	0.6193		336		
	2.382			310	619	[illegible]			335	671	
	12.595	4.1983			1625	[illegible]	5.9259			1677	
	2.896					[illegible]					
	2.536	2.5360		360		[illegible]	1.5020		368		
	2.176			360	720	1.134			368	736	
	20.203	6.7343			2345	22.284	7.4279			2413	
	2.977					0.861					
	2.612	2.6117		365		0.530	0.5300		331		
	2.246			366	731	0.199			331	662	
	28.038	9.3460			3076	−23.874	7.9579			3075	TBMS-1
						+28.038	9.3460			3076	
						+4.164	+1.3881			6151	
						+1.3880					

INST OP INT JD

1st COMP INT ____

2nd COMP INT ____

DA Form 5820-R, AUG 89

Figure 6-13. **Recording procedures for three-wire leveling** requirements on page 6-1, the names of the rodmen (and umbrellaman, when applicable) will be recorded.

Determining and recording mean centerwire reading to four decimal places –

- If the top interval is LARGER than the bottom, ADD the correction to the recorded centerwire reading to obtain the mean centerwire value to four decimal places.
- If the top interval is SMALLER than the bottom, SUBTRACT the correction from the recorded centerwire reading to obtain the mean centerwire value to four decimal places.

Maximum permissible
interval imbalance = 3 (third-order)

Difference in Intervals	Centerwire Correction
0.000	0.0000
0.001	0.0003
0.002	0.0007
0.003	0.0010

Maximum permissible
interval imbalance = 2 (second-order)

Difference in Intervals	Centerwire Correction
0.000	0.0000
0.001	0.0005
0.002	0.0010

DETERMINATION OF C FACTOR

Each day, just before differential leveling begins or immediately following any instance when the instrument is subjected to unusual shock, the error of the level (C factor) must be determined. The determination of C may be performed as a part of a leveling line or separately. In all cases, the C factor determination recordings must be separate from other recordings and comply with all requirements for note keeping.

It is desirable to determine the C factor under the same conditions that the leveling will be performed, including length of sight, slope of ground, and elevation of the line of sight above the ground.

If C is determined during the first setup of the leveling, perform the following sequence of events:

1. After the regular foresight observations are recorded for the level line, record the foresight readings on the C factor note sheet.
2. Call up the rear rodman to approximately 10 meters behind the level.
3. Observe and record the rear rod readings on the C factor note sheet,
4. Move the level to approximately 10 meters behind the front rod.
5. Read and record the front rod on the C factor note sheet.
6. Read and record the rear rod on the C factor note sheet.

Ensure that the circular bubble is carefully centered and that the observed ends of the bubble in the tubular level vial are in coincidence (when applicable) prior to reading the three wires.

The C factor is determined using the formula:

$$C = \frac{(\text{sum of near rod mean readings}) - (\text{sum of corrected far rod mean readings})}{(\text{sum of far rod intervals}) - (\text{sum of near rod intervals})}$$

The total correction for curvature and refraction (Table 6-2) must be determined for each far rod reading, using the distance from the instrument to the far rod as the argument. Distances equal the product of the sum-of-the intervals (for a single set of three-wire readings) times the stadia interval factor (SIF). The two corrections for curvature and refraction are algebraically added to the sum of the mean wire readings for the distant rod. The maximum permissible C factor varies with the SIF. Instruments with an SIF of 1:100 may not have a C factor of greater than ± 0.004. Instruments with a SIF of 1:200 may not have a C factor of greater than ± 0,007. Instruments with a SIF of 1:333 may not have a C factor of greater than ± 0.010. If the C factor is determined to be greater than what is permitted for the instrument's SIF, the instrument must be adjusted and the C factor redetermined before performing differential leveling operations. The notes for the C factor determination become a part of the administrative notes for the leveling operation (Figure 6-14, page 6-23).

CENTERWIRE ADJUSTMENT

If the C factor exceeds the limits (as established by the SIF), a correction to the centerwire must be made.

The correction to the centerwire is determined by multiplying the total rod interval of the last foresight (distant rod) by the computed C factor. Compute the correction to three places to the right of the decimal point and include the algebraic sign of the C factor.

The correction to the centerwire is algebraically added to the last foresight mean wire reading. The result will be the corrected centerwire reading, Compute the corrected centerwire reading to three places to the right of the decimal point (Figure 6-14).

Following the manufacturer's manual, adjust the level until the corrected centerwire reading is observed on the distant rod. Perform the C factor determination again to ensure that the new C factor is within the acceptable limits.

DETERMINATION OF STADIA INTERVAL FACTOR

The SIF is required to compute the length (horizontal distance) from the stadia intervals and to determine the maximum allowable error for a level line. The SIF must be determined if the reticle (which contains the etched stadia wires) is replaced or changed in the level. The notes from the SIF determination become a permanent part of the records kept with the level, as well as being kept with the project files (Figure 6-15, page 6-24).

The SIF determination is made by comparing the stadia intervals observed over a course of known distances. Lay out the course on a reasonably level track, roadway, or sidewalk. Place nails or other marks in a straight line of measured distances of 0, 25, 35, 45, 55, 65, and 75 meters. Plumb the optical zero point of the level over the zero marker on the ground and level the instrument. The optical zero point of the level will be found in the manufacturer's manual. Read the rod at each of the six points and record the intervals. Compute the half-wire intervals as a check against erroneous readings. Compute the sum of the total intervals for the six readings. The SIF will be the sum of the measured distances (300 meters) divided by the sum of the six total intervals.

To check for errors, compute the SIF for each of the six readings and divide the measured distance by the total interval observed for that distance. The average of the six computations will serve as a numerical check. A tendency for the six computed values to creep in one direction indicates an error in plumbing the optical zero point of the level over the zero point on the ground.

Table 6-2. **Correction for curvature and refraction (leveling)**

This table of total correction for curvature and refraction is for use in computing "C" and in general wherever the total correction is required. In computing this table, the refraction was assumed to equal one-eighth the curvature.

Distance (meters)	Correction to rod (mm)	Distance (meters)	Correction to rod (mm)	Distance (meters)	Correction to rod (mm)
0 to 27	0.0	125 to 130	–1.1	210	–3.0
28 to 47	–0.1	131 to 136	–1.2	220	–3.3
48 to 60	–0.2	137 to 141	–1.3	230	–3.7
61 to 72	–0.3	142 to 146	–1.4	240	–4.0
73 to 81	–0.4	147 to 150	–1.5	250	–4.3
82 to 90	–0.5	160	–1.8	260	–4.7
91 to 98	–0.6	170	–2.1	270	–5.0
99 to 105	–0.7	180	–2.3	280	–5.4
106 to 112	–0.8	190	–2.6	290	–5.8
113 to 118	–0.9	200	–2.8	300	–6.2
119 to 124	–1.0				

Three-Wire Leveling

For use of this form, use FM 5-232; the proponent agency is TRADOC.

Project 99/FLW/7802	Location FLW MISSOURI	Organization 99th Engr Det	
Observer SFC J. DOE	Recorder SPC W. ROE	Instrument WILD N3 #96866	Sun CLEAR / Wind CALM / Weather COOL
From / To	Date 13 FEB 78 / Time 0830	Line or Net "C" CHECK	Page no. / No. of pgs.

Station	Backsight Face of rod	Mean	Back of rod	Interval	Sum of intervals	Foresight Face of rod	Mean	Back of rod	Interval	Sum of intervals	Remarks
	1.568					2.169					STADIA
A.	1.508	1.5080		60		1.837	1.8370		332		CONSTANT=
	1.448			60		1.505			332		0.100
	4524				120	5511		Ref.=	-0.3	664	
	1.636					1.606					
B.	1.587	1.5870		49		1.263	1.2630		343		
	1.538			49	98	0.920			343	686	
	9285	30950			218	9300	31000	Ref. =	-0.3	1350	
							-0.6	Tot Ref		-218	
							30994			1132	
							-30950				
							4.4	÷1132=	.0039	= C	
											ROD # 100A
											ROD # 100B

INST OP INT J. D.

1st COMP INT ______

2nd COMP INT ______

DA Form 5820-R, AUG 89

Figure 6-14. **Determination of C factor and centerwire adjustment**

Three-Wire Leveling

For use of this form, use FM 5-232; the proponent agency is TRADOC.

DESIGNATION 51F DATE 25 APR 19 76

⊼ SP5 S. DOE — WILD N-3 #1268
SP4 W. ROE — CLEAR, CALM, WARM

STATION		ROD READING		INTERVAL	SUM OF INTERVALS
		1355			
25		1230		125	
		1106		125	250
		1425			
35		1250		175	
		1075		175	350
					600
		1486			
45		1260		226	
		1034		226	452
					1052
		1505			
55		1230		275	
		0955		275	550
					1602
		1595			
65		1270		325	
		0945		325	650
					2252
		1675			
75		1300		375	
		0926		374	749
300 =	TOTAL				3001

	CHECK		REMARK
	25/250	= 0.100	
	35/350	= 0.100	
	45/452	= 0.100	
	55/550	= 0.100	
	65/650	= 0.100	
	75/749	= 0.100	
300/3001	= 0.100		
	SUM	0.600	÷ 6 = 0.100
		CHECK	

DA Form 5820-R, AUG 89

Figure 6-15. **Determination of stadia interval factor**

Chapter 7

Airfield Obstruction and Navigational Aid Surveys

The purpose of this chapter is to acquaint the Army surveyor with the terminologies and requirements for navigational aid (NAVAID). It is assumed in this chapter that the airfield to be surveyed has already been constructed and that all equipment has been installed and is readily available. (For new construction, refer to *TM 5-330.)*

The requirement for the team chief and NCOIC to be knowledgeable in airfield terminology NAVAIDs and their location, and the development of charts is essential for proper management. Due to vast differences in airfield instrumentation, customer requirements, and FAA regulations, this chapter will be general in content.

Section I
GENERAL REQUIREMENTS

Airport/heliport obstruction and NAVAID surveys are required by a Memorandum of Agreement between the FAA and the US Army, as specified in AR 95-14. Army obstruction and NAVAID surveys embrace those surveying operations involved in obtaining accurate and complete NAVAID and associated airport/heliport obstruction and geodetic positioning data. A precise geographic position of these navigational facilities is required to support the FAA Semiautomated Flight Inspection and Automated Terminal Government Procedures program, The final product consists of the following charts:

- Runway data and profile
- Obstruction
- Glide slope approach/departure clearance

Various areas, surfaces, and reference points, and certain dimensions used in airfield surveys, together with specification requirements, are outlined in the following publications:

- *FAA Publication 7400.2c*
- *FAA Publication 405*
- *FAA Publication 8260.3*
- *FAR-77*
- *TM 5-803-4*
- *TM 5-803-7*
- *TM 95-226*

RUNWAYS

All runway length and width measurements are determined to the nearest foot. If the runway threshold is displaced, give the distance, in feet, from the beginning of the runway surface. Determine the coordinates (latitude and longitude) of the runway threshold and stop end at the runway centerline. Elevations at the runway threshold, stop end, and highest elevation within the first 3,000 feet of each runway touchdown zone elevation (TDZE) should be determined to the nearest 1/10 foot from mean sea level (MSL). In addition, runway profiles should be prepared showing the elevations listed above, plus runway high and low points, grade changes, and gradients. The elevation of a point on the instrument runway centerline nearest to the instrument landing system (ILS) and glide path transmitter will be determined to the nearest 1/10 foot MSL.

AIRPORT DATA

The airport reference point (ARP) location (in degrees, minutes, and seconds of longitude and latitude) will be determined in accordance with FAA *Publication 405, Appendix A2.2.*

Field elevation is the highest point on any of the airport landing surfaces.

NAVIGATIONAL AIDS

Airports requiring obstacle and NAVAID surveys are instrumented runways. The exact point on the radar. reflectors, runway intercepts, or components of the ILS and the microwave landing system (MLS) depends on the types, locations, and accuracy required. The requirement to verify existing ILS/MLS, their proper noun description, and all components on or near the runway, is mandatory. With help from airfield operations, maintenance sections, and control tower personnel, all information may be obtained for locating and describing all airfield features.

NAVAIDs located on airports –

- Instrument landing system (ILS)
- Microwave landing system (MLS)
- Precision approach radar (PAR)
- Airport surveillance radar (ASR)

NAVAIDs not located on airports –

- Tactical air navigation (TACAN)
- Very high frequency omnidirectional range (VOR)
- Nondirectional radio beacon (NDB)
- Very high frequency omnidirectional range/tactical air navigation (VORTAC)

OBSTRUCTIONS

An obstruction is defined as an object or feature located within a 10-nautical mile radius of the ARP and protruding through or above any navigational imaginary surfaces which pose a threat to the safe operation of aircraft.

Section II
SPECIFIC SURVEY LOCATIONS

RUNWAYS

Runway landing lengths, threshold, and stop end locations will be determined from the touchdown side of the threshold stripe to the stop end of the usable runway. Runway true bearing will be determined from the runway threshold centerline to the runway stop end centerline.

POSITIONING OF NAVIGATIONAL AIDS

The exact positioning of NAVAIDS should be determined as follows:

- The ILS/MLS localizer elevation and coordinates will be determined at the center of the course array antenna.
- The ILS/MLS glide slope elevations and coordinates will be determined at the base of the glide slope antenna and also at the point on the runway centerline served by the ILS/ MLS that is closest to the glide slope antenna.
- The PAR and ASR positions will be determined at the center of the antenna arrays.
- The VOR, TACAN, and DME positions will be determined at the center of the antenna arrays.
- The MLS positions will be determined at the center of the elevation and azimuth antenna arrays.
- The NDB and marker beacon positions will be determined at the center of the transmitting antenna arrays.

OBSTRUCTIONS

The horizontal and vertical positions of the obstructions will be the highest point of each obstruction within a radius of 10 nautical miles from the ARP.

Section III
AIRFIELD DATA ACCURACY REQUIREMENTS

AIRPORT REQUIREMENTS

All contiguous continental United States, Alaskan, and Caribbean area coordinates should be determined based on the North American datum. Geodetic accuracy of all points on the airport should be determined to within ± 10 feet horizontal accuracy, and 1/10 foot relative vertical accuracy should be referenced to MSL. The following points will be determined to this accuracy:

Runways

- Center point of approach threshold
- Center point of depart threshold
- Midpoint of runway
- Displaced approach threshold (if applicable)

NAVAIDs Located on Airfield

- Microwave landing system (MLS)
- Precision approach radar (PAR)
- Nondirectional radio beacon (NDB)
- Airport surveillance radar (ASR)
- Distance measuring equipment (DME)
- Very high frequency omnidirectional range (VOR)
- Tactical air navigation (TACAN)

EN ROUTE NAVAIDS NOT ON AIRPORT

En route facilities such as VOR. VORTAC, TACAN, and NDBs which are located 6 nautical miles or more from the associated airport will be positioned within ± 40 feet horizontal)' and within ± 100 feet vertically.

OBSTRUCTIONS

In primary or transitional areas, horizontal accuracy is ± 15 feet; vertical accuracy is ± 2 feet. Also, the same tolerance applies for approach zones in the first 20,000 feet, Beyond 20,000 feet. horizontal accuracy is ± 40 feet; vertical accuracy is ± 20 feet.

Horizontal surfaces are ± 20 feet for horizontal and ± 5 feet for vertical.

Conical surfaces are ± 40 feet horizontal and ± 20 feet vertical.

Radio and television towers should be horizontally located within ± 20 feet in the primary approach surface or ± 40 feet in the secondary transitional surface. In both cases, ± *2* feet vertical accuracy is required.

Section IV
RECOMMENDED FIELD PROCEDURES

HORIZONTAL REQUIREMENTS

The horizontal accuracy requirements can be met through third-order, Class 11 traverse or two-point intersection methods.

VERTICAL REQUIREMENTS

The vertical accuracy requirements dictate a minimum of third-order differential leveling methods.

Section V
REPORTING

The required reporting for airfield-related surveys is not significantly different from that required from other survey operations. All of the reports listed in Chapter 8 will normally be required by the parent unit. In addition to these routine reports, a special report will be required to submit the final data. This report will be in accordance with *AR 95-14*, and the required documentation, including samples of the drawings, is listed here for quick reference.

REQUIRED DOCUMENTATION

The final report will contain the following information:

- Official airport name, location, and 1:50,000 map sheet designation.
- The ARP location with coordinates (latitude; longitude in degrees, minutes, and seconds).
- Runway profiles, including elevation of runway ends and displaced thresholds, high and low points, grade changes, gradients, and highest elevation within the first 3,000 feet of each runway landing surface.
- Description of existing runway markings on each runway.
- Description of the type and extent of airport lighting such as runway, taxiway, approach, rotating beacon, visual approach slope indicator (VASI), and runway end identifier lights (REIL), If lighting systems are operational only on a part-time basis. describe how pilot obtains lights. Depict these lighting systems on engineering drawings:
- Control tower and rotating beacon location.
- Location of helicopter landing areas.
- Location of all existing instrument landing instrumentation on airfield.

FORMS

Complete the following forms for each airfield:
DA Form 5821-R, Airfield Compilation Report
DA Form 5822-R. Precision Approach Radar (GCA) Data
DA Form 5827-R. Instrument Landing Systems Data

Airfield Compilation Report

This report is a tabulation of all information obtained as a result of the survey, Instructions for completing the form are keyed to Figure 7-1, page 7-5, and are as follows:

1 Survey Agency: Agency conducting the field survey,
2 Airport Name: The official airport name as determined by the FAA.
3 Identifier: Airport location identifier designator as listed in *FAA Publication 7350.5-C.*
4 City: Self-explanatory.
5 State: Self-explanatory.
6 Edition: The number of times the airfield has been surveyed by the agency listed in Block #1 The original survey is 1: subsequent surveys will be 2, 3. and so on.
7 Survey Date: Year of declination.

8 Airport Reference Point: The physical location of the ARP.
9 Latitude: Latitude of the ARP.
10 Longitude: Longitude of the ARP.
11 Delta Az Or Theta Angle: Grid convergence for the ARP.
12 Airport Location Point (ALP): Physical location of the ALP.
13 Latitude: Latitude of the ALP.
14 Longitude: Longitude of the ALP.
15 Declination: Magnetic declination of the ARP.
16 Airport Elevation: See Glossary, Section II.
17 Located: Short narrative description. Include latitude and longitude.
18 Control Tower Floor Elevation: Self-explanatory.
19 Datum: Self-explanatory.
20 Airport Data: Object or airfield feature observed. Use additional sheets as required.
21 Elevation: Self-explanatory
22 Latitude: Self-explantory
23 Longitude: Self-explanatory
24 Year-Code: Year and month surveyed (for example, April 87 is written 8704).
25 Remarks: Self-explanatory
26 Office Code: Leave blank. Maybe used by other offices.
27 Runway: Numerical designation of runway.
28 Displaced Threshold Length: See Glossary, Section II.
29 Runway End Elevation: Self-explanatory
30 Latitude: Self-explanatory.
31 Longitude: Self-explanatory.
32 Width/Length: Physical length and width of runway surface.
33 Geodetic Azimuth/Magnetic Bearing: Self-explanatory.
34 Office Code: Leave blank.

Figure 7-2, page 7-6 shows an example of a completed airfield compilation report.

Precision Approach Radar (GCA) Data

This form is self-explanatory (Figure 7-3, page 7-7).

Instrument Landing System Data

This form is self-explanatory (Figure 7-4, page 7-8).

CHARTS

Certain drawings or charts are required to be submitted with the final technical report:

- Runway data and profile chart.
- Obstruction chart.
- Glide slope approach/departure clearance chart.

Runway Data and Profile Chart

This chart shows the graphical location of all runway features, to include runway descriptive markings (Figure 7-5, page 7-9). This chart is normally not drawn to scale. The symbols are keyed to a legend that must be included on the chart.

Obstruction Chart

This chart is drawn to scale and shows all obstructions within a 50-kilometer radius of the ARP (Figure 7-6, page 7-10). All symbols depicted on the chart are keyed to the legend.

Glide Slope Approach/Departure Clearance Chart

This chart is a horizontal and vertical profile of the glide slope drawn to scale (Figure 7-7, page 7-11). The glide slope is divided into several imaginary surfaces. The vertical profile depicts the runway surface, with a glide slope of 50 to 1 extended to 10 nautical miles (Figure 7-7). Additionally, all obstructions penetrating the imaginary surface are shown. The horizontal profile shows the imaginary surfaces and the horizontal location of the obstructions. All symbols are labeled, keyed to the legend, or both.

ADDRESSES

One copy of each form and chart is required for each airfield. In addition to being submitted with the final project report, one copy of each report should be submitted to the following addresses:

Director
US Army Aeronautical Services Office
ATTN: ASQ-AS-AI
Cameron Station
Alexandria, VA 22304-5050

Director
DMA Aerospace Center
ATTN: ADL
3200 South Second Street
St. Louis, MO 63118-3399

DOT/FAA
Mike Monroney Aeronautical Center
ATTN: AVN-233
PO Box 25082
Oklahoma City, OK 73125

One complete copy will also be sent to the Air Traffic and Airspace Officer of the surveyed airfield as well as to the associated installation Master Planning Office.

(Addresses are continued on page 7-12)

Airfield Compilation Report

For use of this form, see FM 5-232; the proponent agency is TRADOC.

SURVEY AGENCY: (1)						
AIRPORT NAME (2) MCCOY ARMY AIRFIELD				IDENTIFIER (3) USE LATEST EDITION		
CITY (4)		STATE (5)	EDITION (6)	SURVEY DATE (7)		
AIRPORT REFERENCE POINT	(8)	LATITUDE (9)	LONGITUDE (10)	Δ CL OR Θ ANGLE (11)		
AIRPORT LOCATION POINT	(12)	LATITUDE (13)	LONGITUDE (14)	DECLINATION (15)		
AIRPORT ELEVATION (In feet) (16)	LOCATED (17)			CONTROL TOWER FLOOR ELEVATION (In feet) (18)		
(19) DATUM			POSITION CODE – 1. Field Survey 2. Photogrammetric 3 .Other			

AIRPORT DATA	ELEVATION	LATITUDE	LONGITUDE	YR–CODE	REMARKS	OFFICE CODE
(20)	(21)	(22)	(23)	(24)	(25)	(26)

RUNWAY	DSPLCD THR LENGTH	RWY END ELEVATION	LATITUDE	LONGITUDE	WIDTH / LENGTH	GEODETIC AZ. (N) / MAG. BEARING (N)	OFFICE CODE
(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)

DA Form 5821-R, AUG 89

Figure 7-1. **Key for airfield data reporting**

Airfield Compilation Report

For use of this form, see FM 5-232; the proponent agency is TRADOC.

SURVEY AGENCY: 30th Engineer Battalion-AV 354-1082				
AIRPORT NAME McCoy Army Airfield			IDENTIFIER CMY	
CITY Fort McCoy		STATE Wisconsin	EDITION #1	SURVEY DATE Oct 1986
AIRPORT REFERENCE POINT	ARP	LATITUDE 43° 57′ 33″.458	LONGITUDE -90° 44′ 14″.641	Δ CL OR Θ ANGLE -01° 34′ 15″.6
AIRPORT LOCATION POINT		LATITUDE	LONGITUDE	DECLINATION
AIRPORT ELEVATION (In feet) 837.3 MSL	LOCATED End of runway 01			CONTROL TOWER FLOOR ELEVATION (In feet) 871.2 MSL
			POSITION CODE –	1. Field Survey 2. Photogrammetric 3 .Other

AIRPORT DATA	ELEVATION	LATITUDE	LONGITUDE	YR–CODE	REMARKS	OFFICE CODE
NDB (CMY)	1020.1	43° 56′ 16″.1N	-90° 38′ 30″.3W	86/01		
Windsock (1)	860.4	43 57 35.7	90 43 58.5	86/01		
Beacon (13)	896.4	43 57 14.5	90 44 05.8	86/01		
WDI	845.8	43 57 35.7	90 43 58.1	86/01		
Tetrahedron	834.7	43 57 36.1	90 43 58.4	86/01		
Control Tower (9)	911.6	43 57 22.5	90 44 05.9	86/01		
Maltese Cross #1	830.5	43 57 30.8	90 43 59.7	86/01		
Maltese Cross #2	829.8	43 57 26.4	90 44 15.9	86/01		
Maltese Cross #3	832.9	43 57 22.8	90 43 51.6	86/01		

RUNWAY	DSPLCD THR LENGTH	RWY END ELEVATION	LATITUDE	LONGITUDE	WIDTH / LENGTH	GEODETIC AZ. (N) / MAG. BEARING (N)	OFFICE CODE
EOR 29 TDZE	N/A	831.8	43° 57′ 27″.478	-90° 43′ 48″.699	100.00 4211.00	292° 09′ 26″.2 290° 58′ 26.2	
EOR 11	N/A	822.4	43 57 43.164	90 44 42.017	75.00 4211.00	112° 09′ 25″.8 110° 58′ 25″.8	
TDZE 11/29	N/A	829.5	43 57 32.027	90 44 03.899	N/ A	N/A	
EOR 19	N/A	824.7	43 57 44.922	90 44 08.802	90.00 2962.90	195° 25′ 26″.5 194° 14′ 26″.5	
EOR 01	N/A	837.3	43 57 16.715	90 44 19.574	90.00 2962.90	15° 25′ 27″.3 14° 14′ 27″.3	
EOR 01 DT	1326.7	835.7	43 57 04.089	90 44 24.408	50.00 1326.70	N/A	
TDZE 19/01	N/A	837.3	43 57 16.715	90 44 19.574	N/A	N/A	

DA Form 5821-R, AUG 89

Figure 7-2. **Example of reporting airfield data**

Precision Approach Radar (GCA) Data

For use of this form, see FM 5-232; the proponent agency is TRADOC.

AIRPORT NAME McCOY ARMY AIRFIELD		
CITY FT McCOY	STATE WISCONSIN	SURVEY DATE (Mo./Day/Year) OCT 15, 1986

PAR COMPONENTS AND PERTINENT RUNWAY DATA Numbered items correspond to the diagram below.	LATITUDE (1 / 100 Second)	LONGITUDE (1 / 100 Second)	ELEVATION (1 / 10 Foot)
1. PAR Antenna	43°57'14.51"	90°44'05.79"	896.4
2. Touchdown Reflector	43°5[illegible]6.10"	90°43'58.40"	834.7
3. The point on runway C/L closest to the Touchdown Reflector (Item 2).	43°57[illegible]"	90°43'58.40"	831.4
4. Runway C/L End. EOR 11	43°57'43.[illegible]	[illegible]°44'42.02	829.5
5. Runway C/L End.	43°57'27.48"	[illegible]48.70"	831.8
6. The point on runway C/L closest to PAR Antenna.			
7. Displaced Threshold (If applicable).	—	—	—

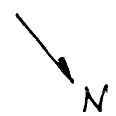
Sample

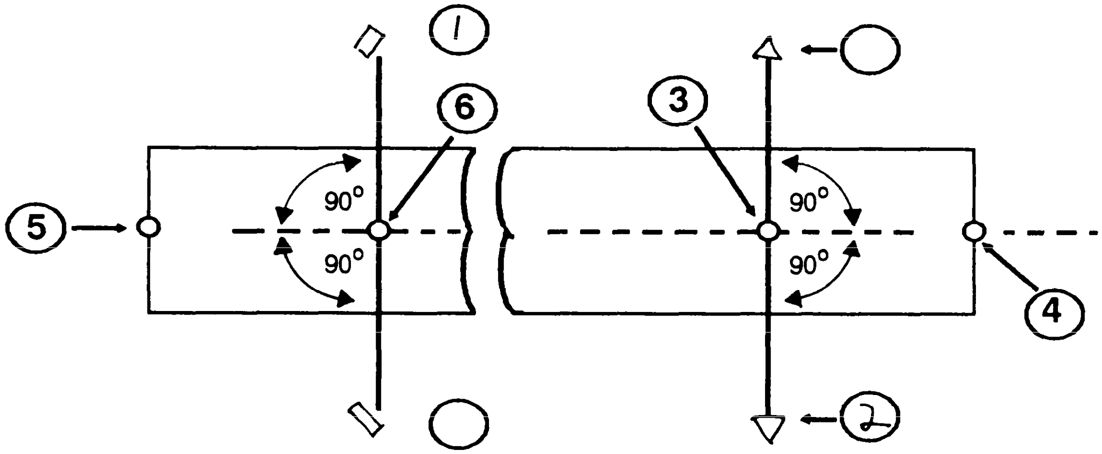
▱ PAR Antenna – Enter Numeral 1 in circle to indicate PAR Antenna Position.

△ Touchdown Reflector – Enter Numeral 2 in circle to indicate Touchdown Reflector.

PAR – GROUND DISTANCE			
3 to 7 FEET (If applicable)	1 to 6 FEET	2 to 3 FEET	GEODETIC AZIMUTH SOUTH
	3 to 6 FEET	3 to 4 FEET	4 to 5 ° ' "

ADD APPLICABLE NUMBERS TO CIRCLES AND RUNWAY ENDS. SHOW NORTH ARROW.





DA Form 5822-R, AUG 89

Figure 7-3. **Reporting airfield instrumentation**

Instrument Landing System Data

For use of this form, see FM 5-232; the proponent agency is TRADOC.

AIRPORT NAME McCOY ARMY AIRFIELD		
CITY FT McCOY	STATE WISCONSIN	SURVEY DATE (Mo./Day/Year) OCT 15 1989

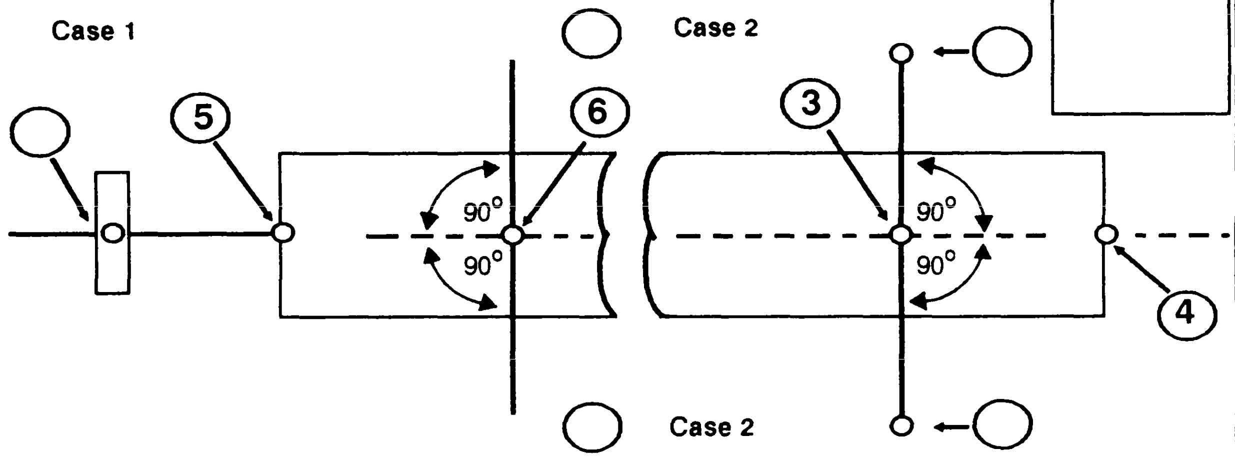
ILS COMPONENTS AND PERTINENT RUNWAY DATA Numbered items correspond to the diagram below.	LATITUDE (1 / 100 Second)	LONGITUDE (1 / 100 Second)	ELEVATION (1 / 10 Foot)
1. Localizer Antenna (Course Array): Point on ground beneath the localizer antenna.			
2. Glide Slope Indicator (GSI): Center of the base supporting the antenna.			
3. The point on runway C/L closest to the base of the Glide Slope Indicator Antenna (Item 2).			
4. Runway C/L End.	43°57'43.1"	°44'42.02"	829.5
5. Runway C/L End.	43°57'27.48"	48.70"	831.8
6. The point on runway C/L closest to the base of the offset Localizer (Case 2).			

sample

MARKERS	LATITUDE (1 / 10 Second)	LONGITUDE (1 / 10 Second)	GROUND DISTANCE TO END OF RUNWAY
INNER OR B. C. MARKER (RUNWAY END)			feet
MIDDLE MARKER (RUNWAY END)			feet
OUTER MARKER (RUNWAY END)			feet

LOCALIZER – GROUND DISTANCE			
Case 1 (normal)	Case 2 (offset)		
1 to 5 FEET	1 to 6 FEET	2 to 3 FEET	GEODETIC AZIMUTH SOUTH ° "
	5 to 6 FEET	3 to 4 FEET	4 to 5

ADD APPLICABLE NUMBERS TO CIRCLES AND RUNWAY ENDS. SHOW NORTH ARROW.



DA Form 5827-R, AUG 89

Figure 7-4. **Reporting airfieid markers**

Figure 7-5. **Runway data and profile chart**

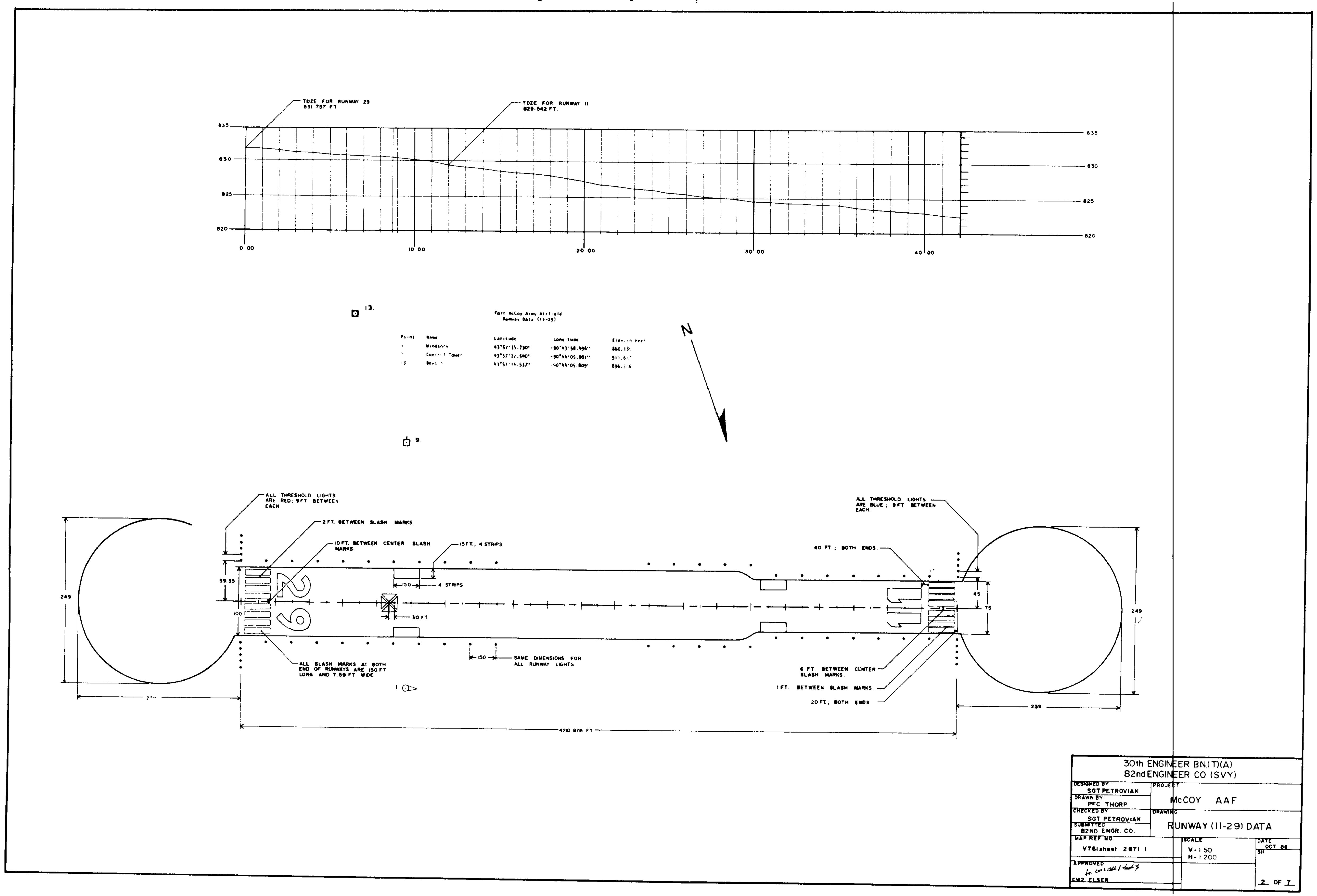
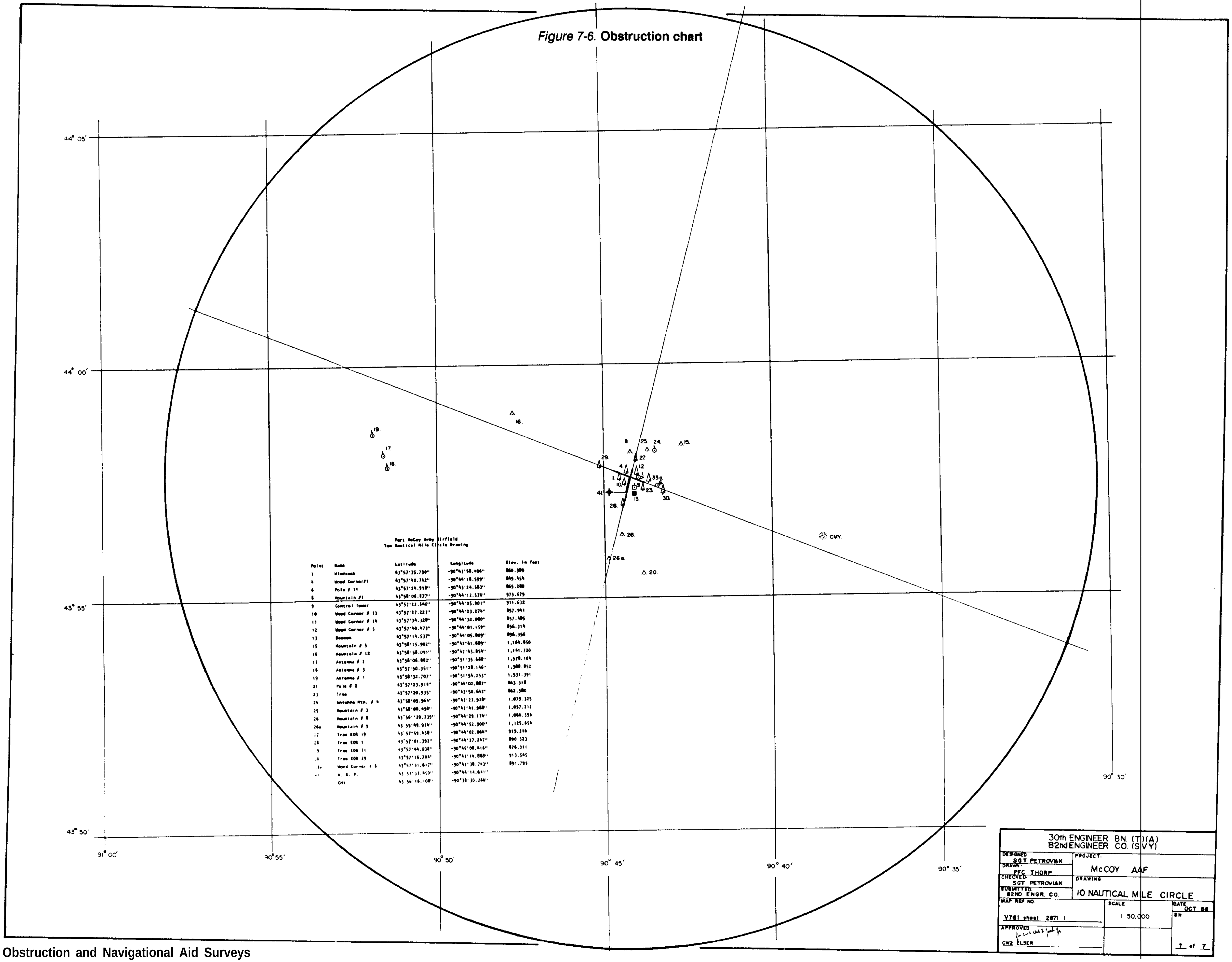


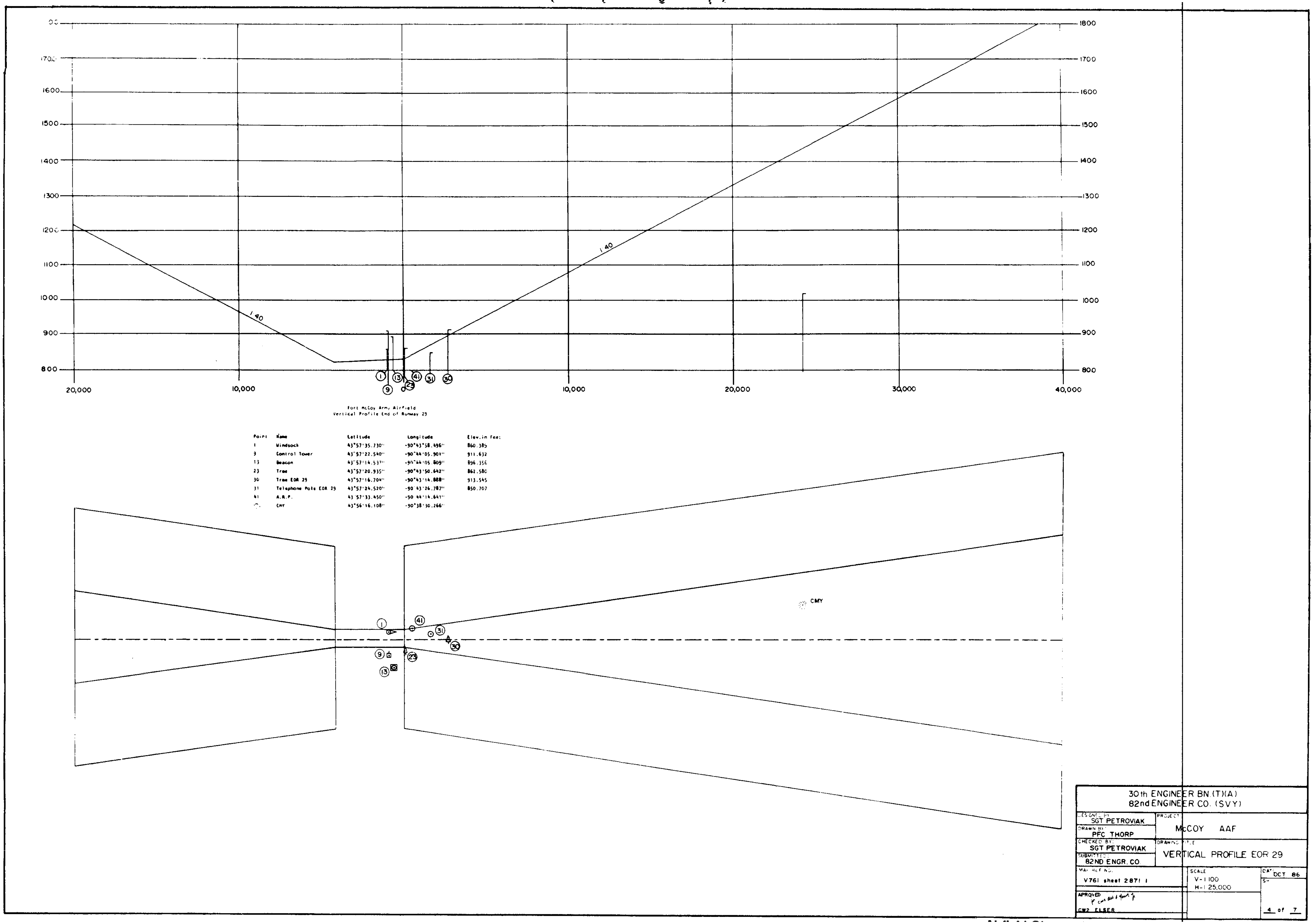
Figure 7-6. **Obstruction chart**



Fort McCoy Army Airfield
Ten Nautical Mile Circle Drawing

Point	Name	Latitude	Longitude	Elev. in feet
1	Windsock	43°57'35.730"	-90°43'58.496"	860.309
4	Wood Corner#1	43°57'42.712"	-90°44'18.599"	849.454
6	Pole # 11	43°57'24.910"	-90°43'24.583"	865.200
8	Mountain #1	43°58'06.877"	-90°44'12.576"	973.679
9	Control Tower	43°57'22.540"	-90°44'05.901"	911.632
10	Wood Corner # 13	43°57'27.223"	-90°44'23.274"	857.941
11	Wood Corner # 14	43°57'34.320"	-90°44'32.080"	857.405
12	Wood Corner # 5	43°57'40.473"	-90°44'01.159"	856.314
13	Beacon	43°57'14.537"	-90°44'05.809"	896.356
15	Mountain # 5	43°58'15.902"	-90°42'41.889"	1,164.850
16	Mountain # 12	43°58'58.091"	-90°47'43.854"	1,141.720
17	Antenna # 2	43°58'06.882"	-90°51'35.680"	1,570.104
18	Antenna # 3	43°57'50.351"	-90°51'20.146"	1,300.052
19	Antenna # 1	43°58'32.707"	-90°51'54.253"	1,531.391
21	Pole # 2	43°57'23.914"	-90°44'02.882"	863.318
23	Tree	43°57'20.935"	-90°43'50.642"	862.580
24	Antenna Mtn. # 4	43°58'09.964"	-90°43'27.920"	1,079.325
25	Mountain # 3	43°58'08.498"	-90°43'41.980"	1,057.212
26	Mountain # 8	43°56''20.239"	-90°44'29.174"	1,066.396
26a	Mountain # 9	43 55'49.914"	-90°44'52.900"	1,125.654
27	Tree EOR 19	43 57'59.430"	-90°44'02.064"	919.316
28	Tree EOR 1	43°57'01.392"	-90°44'27.247"	890.323
29	Tree EOR 11	43°57'44.038"	-90°45'08.416"	876.311
30	Tree EOR 29	43°57'16.704"	-90°43'14.888"	913.545
33a	Wood Corner # 6	43°57'31.617"	-90°43'30.743"	891.795
41	A. R. P.	43 57'33.450"	-90°44'14.641"	
	CMY	43 56'16.108"	-90°38'30.266"	

Figure 7-7. **Glide slope approach/departure clearance chart**
(Vertical profile of glide slope)



Point	Name	Latitude	Longitude	Elev. in Feet
1	Windsock	43°57'35.730"	-90°43'58.496"	860.385
9	Control Tower	43°57'22.540"	-90°44'05.901"	911.632
13	Beacon	43°57'14.537"	-90°44'05.809"	896.356
23	Tree	43°57'20.935"	-90°43'50.642"	862.580
30	Tree EOR 29	43°57'16.704"	-90°43'14.888"	913.545
31	Telephone Pole EOR 29	43°57'24.520"	-90°43'26.787"	850.707
41	A.R.P.	43°57'33.450"	-90°44'14.641"	
	CMY	43°56'16.108"	-90°38'30.266"	

For airfields in Korea, one copy of the completed survey will be sent to –

District Engineer
US Army District, Far East
APO San Francisco 96301

For airfields in Europe, one copy of the completed survey will be sent to –

Commander
USAASD-E
APO New York 09102

One copy of the completed survey forms and records, without charts, will be sent to-

HQDA
ATTN: DAEN-ECE-1
Washington, DC 20314-1000

Additionally, one copy, with charts, will be furnished to the regional US Army Aeronautical Services Office. The addresses for these offices are in *AR 95-14*, Table 1-1.

Chapter 8
Reports and Briefings

As in all military operations, all survey and survey support activities must be documented, Additionally, the unit commander or visiting dignitaries will have to be informed about the status of a project. The most common methods of accomplishing these two tasks are in the form of reports and briefings. The guidance given in this chapter is general in nature and is not intended to replace unit SOPS, but rather to supplement them and provide for a more standardized procedure and format.

Section I
REPORTS

All reports should be treated as For Official Use Only (FOUO) and safeguarded accordingly. In many instances, reports will be classified. In this event, appropriate safeguard measures are mandatory, All activities and events on a survey project are documented on a report. Reports can take many forms. Their primary uses are to –

- Provide documentation of the project.
- Serve as a historical record of accomplishment on problems.
- Inform the commander of project status.
- Provide information and data to planners and users.

All reports may not address each subject but they will serve at least one of the above functions.

A well-planned survey project can be broken down into phases (Chapter 2). Each phase will require at least one report. The phases include –

1. Initial site visitation.
2. Field reconnaissance.
3. Project execution.
4. Compilation and computing.

In some situations, it may be convenient and practical to combine one or more of these phases. In this case, a consolidated report would be more prudent. Reports are written to provide information and should not be written to fulfill a requirement.

INITIAL SITE VISITATION TRIP (ISVT) REPORT

The initial site visitation (often called initial or preliminary reconnaissance) is usually a preliminary visit that is used to gather basic general information (Chapter 2). The information collected is generally used from a logistics standpoint more than a technical one. This does not mean that no technical information is gathered, but gathering information is not necessarily the primary function of the visit. The initial site visitation will normally be conducted by the survey technician, the project noncommissioned officer (NCO), and a driver. Depending upon the nature of the project, the battalion plans officer, the S3 representative, the survey company/detachment commander, or the platoon leader may also be included. In all cases, an ISVT report will be required. The battalion or company SOP will usually designate the individual responsible for completing the report as well as the exact format to be used. Annex A of the Appendix is a sample format of an ISVT report.

Any information that could be used at a later date should be included. At a minimum, the report should be broken down into readily identifiable numbered and titled paragraphs, as follows:

1 References – The project directive or technical operations order number.

2 Personnel- The names, ranks, and telephone numbers of personnel involved in the reconnaissance.

3 Key Personnel Contacted- The names, ranks, or position title, address, and telephone numbers of all key individuals contacted while conducting the visitation. Quite often this paragraph is combined with that of the personnel performing the ISVT.

4 Objective – The objectives of the visitation.

5 Discussion – The discussion paragraphs will be the most extensive. Exactly what occurred and what discussions took place must be listed. This section will contain subparagraphs concerning both logistical and technical information. All arrangements for billeting, messing, medical, and other support must be listed and should have specific details. Any technical information should be listed but if extensive technical details are available, it maybe advisable to include them in an appendix to the basic report. The key to the discussion paragraph is to list all information that is available. The report may be the only source of information for later activities on the project.

6 **Recommendations** – Specific recommendations for the conduct of the next phase of the project should be made. These should include the number of personnel and the start date as well as what should be accomplished during that phase.

7 **Funding–** This short paragraph will contain the fund citation information. It may also include funds expended on the ISVT and any information concerning funding of the next phase of the project.

8 **Man-hours** – The total number of man-hours, Sometimes it may be advisable to break this figure down by rank. This information can be used for projection of time required for similar future projects. (See Annex A, Paragraph 5.h.)

8 **Equipment Used** – This should include the type of vehicles, vehicle number, miles, and petroleum, oils, and lubricants (POL) information. (See Annex A, Paragraphs 5.e. and 5.h.(2)(d).) In all cases, the report must be signed. A standard military signature block should be used. Any required appendix should be attached. A copy of the report should be placed in the project folder and the original forwarded to the appropriate commander.

RECONNAISSANCE REPORT

The reconnaissance or recon report will typically be more lengthy than the ISVT report. It will generally contain logistical and technical information, each receiving equal consideration. The recon report can be broken down into three major sections: narrative, graphic, and control cards.

Narrative

The narrative section is a written report that is somewhat similar to the ISVT report in that it will contain much of the same type of information, However, it will be greatly expanded. The paragraphs and subparagraphs of this section are listed below. Some of the subparagraphs may be deleted provided they serve no purpose.

1 References – This will typically be the project directive or order. Additionally, the ISVT report should be listed, if available.

2 Personnel – The names, ranks, unit of assignment, and telephone numbers (both home station and remote site) of all personnel involved in the reconnaissance should be listed.

3 Key Personnel Contacted – The names, rank or position title, address, and telephone numbers of all personnel, offices, or agencies contacted during the reconnaissance must be listed. Include military message addresses. This paragraph is extremely important, particularly for rights of way and access to private lands. Agreements made with landowners and/or property custodians should be listed, and a written permission document should be prepared and signed and a copy included as the last annex of the report.

4 **Objective** – The objective of the reconnaissance should be very specific. It should include the nature of the reconnaissance (for example, triangulation. traverse, levels, and plane table).

5 **Discussion** – This paragraph will typically be the most lengthy and will normally be broken down into subparagraphs. Any and all details must be listed and specified. The subparagraphs should include –

Administrative, legal, and logistical support. This section should include a complete listing of all support that has been arranged to support the project. The list must include –

- **Medical facilities** – The nearest military medical facility for routine medical problems and the nearest emergency medical facilities.
- **Billeting and messing** – On military installations that can provide billeting and messing, the arrangements for billeting and messing, location, and condition of the facilities should be listed. The POCs should be listed under paragraph (3). Indicate whether or not use of the mess facilities will enhance the prosecution of the project, or cause the rate of progress to be reduced.
- **Contracts** – Copies of all legal contracts that authorize the surveyors' entrance onto private and other nonfederally owned land. Include a POC at the Staff Judge Advocate Office that coordinated or generated the documents if future complications or disagreements may occur during the project.
- **Controlled areas** – If the surveyors must enter secure or sensitive areas (classified equipment or systems), list the requirements. Will the names and security classifications of the surveyors need to be provided to the customer's security officer prior to starting the project? Must the surveyors be escorted? Who is the primary escort, and can he or she take the surveyors into the controlled area at any time? How will access to the controlled areas affect the scheme of extending survey control?
- **Morale factors** – All arrangements that have been made for mail delivery, pay, and financial assistance should be listed.
- **Other logistic information** – Any other support information should be specifically listed. The MOAs for POL and other expendable supplies, and vehicle maintenance support should be listed and then included as annexes, Include coordination for an area to secure survey equipment (for example, a fenced in area that is locked after duty hours).

Environmental factors. Any environmental factor that could affect the project should be specifically listed. These include but are not limited to –

- **Weather**– Expected weather conditions, to include long-range forecasts and normal weather patterns for the project area.
- **Terrain**– The type of terrain to be expected and how it will affect access to existing and proposed SCPs. How will landforms affect intervisibility and the proposed survey scheme.
- **Flora and fauna**– The types of plants and animals that inhabit the area, Particular attention should be given to poisonous plants and animals that have the potential for harm.
- **Danger areas/restricted zones**– The type and location are briefly described and must be annotated on the overlay.

Technical information. This subparagraph should contain a listing of all work that was accomplished (for example, recovery, check angles, check distances). It should also contain —

- A list of all proposed starting and ending stations and their conditions.
- Line of sight information (also included in graphic section).
- Strength of figure (if applicable).
- Any other information of a technical nature that the field survey party may need to know.

Source materials. A complete list of all source materials such as trig list, data cards, map sheets, overlays, and the agency or office of origin. A copy of these materials should usually be attached behind the station description cards.

6 Recommendations – This paragraph will also be lengthy and should be very detailed. The recommendations should be based on sound technical principles and be within the capabilities of the unit. Detailed information must be listed, to include –

Methods of survey. The exact methods, procedures, and accuracy requirements must be listed and justified (for example, second-order, Class II traverse).

Job estimates. The estimated amount of personnel and time should be listed. Using this information, a cost estimate should be prepared and contained within this paragraph. If it is lengthy, include the data sheets in an annex.

Equipment. The estimated equipment required to do the job. This will normally be authorized TOE equipment but in some cases it may be necessary to obtain other equipment (for example, chain saws). Indicate how the equipment is being obtained and the source (for example, cement mixer from Directorate of Engineering and Housing (DEH) roads and grounds).

Time schedule. The project time schedule (if start date is known) is based on the information from subparagraph Job Estimates. For lengthy projects that must be broken down into phases, a milestone schedule should be developed and enclosed in Annex E of the recon project.

7 Funding – This paragraph should contain information as to funds expended during the recon. It will also include information such as the fund citation and the source of funding.

8 Man-hours Spent – Break out by both rank and activity performed (POC meetings, POL and maintenance support, administrative requirements, and field reconnaissance). This information is helpful in planning and estimating future similar projects.

9 Equipment – A list of all equipment used to conduct the recon. This includes vehicles, vehicle serial numbers, miles, and POL data. All other equipment actually used by the recon party should be listed. Once again, this information is helpful for future planning purposes.

Graphic **Report**

This report will usually take the form of overlays and/or maps. At a minimum, the overlay should contain the following information:

- Known usable survey control stations (horizontal and vertical).
- Proposed survey stations and line of sight information.
- Danger areas and restricted zones, This information should be shown on both the overlay and on all maps that are available.
- Other information that will assist the survey project: Possible landing fields for small aircraft or helicopters that are near proposed SCPs; possible intersection stations that will be visible from several main scheme stations.

When annotating maps and overlays, use standard topographic and military symbols, as listed in *FM 21-31* and *FM 101-5-1*.

Control Cards

This section of the report is a compilation of *DA Form 1958, Description or Recovery of Bench Marks*, and *DA Form 1959* cards that were completed during the reconnaissance. The cards must be complete, accurate, correctly formatted, and of high enough quality to permit them to be reproduced with minimal expenditure of time and labor.

PROGRESS REPORTS

All reports are designed to convey information. Progress reports are generally less formal than the other types of reports but are no less important. They are designed to keep the commander informed of the progress of the project. The time interval for progress reports will be established by the commander and included in the project directive. Normally, progress reports will be submitted on a weekly basis. In some cases, daily telephonic reports may be required, For small projects, none may be required. Progress reports will generally take two forms: written and telephonic.

Written

The written progress report is normally a cover DA *Form 2496, Disposition Form,* and a data sheet. The *data sheet is a* **fill-in-the-blank** type of form. Those areas not required are left blank. All information must be as accurate as possible. The tendency to **hold back** production or **pad** production levels cannot be tolerated. Annex D of the Appendix is a recommended guide for determining progress. A copy of this report is forwarded to the parent unit and one is included in the project file.

These reports are essential for the compilation of the final project report.

Telephonic

When required, the telephonic report follows the identical format as the written progress report. Both sender and receiver should have a premade copy of the format. OnIy those lines that are applicable are filled in; the others are ignored. The field copy is included in the project file for use in compiling the written weekly or end-of-project report.

END-OF-PROJECT REPORT

The end-of-project report (sometimes called an after-action report) is used to inform the commander and the customer that the project has been completed. It will also contain the results of the project. These results will generally be listed on *DA Form 1962, Tabulation of Geodetic Data.* Additionally, copies of *DA Form 1959,* map overlays, and other graphics may be included. Annex E of the Appendix is an example of an end-of-project report. The paragraphs and subparagraphs must include –

References – This is a complete listing of all orders, letters, project directives, and memorandums for record (MFR) concerning the project. Normally, the other reports will not be listed as references.

Personnel – This should contain the names and ranks of all personnel participating in the project, The inclusive dates of their involvement should also be listed. This paragraph can be broken down further, as follows:

- Field crew personnel from parent unit.
- Visiting or inspecting personnel (the unit or office should also be included).
- Local officials directly involved in the project,

Objective (or Mission) – This is the specific mission statement.

Discussion – This paragraph will be a detailed discussion of exactly what transpired during the conduct of the project. Specific dates and details should be included. The milestone objectives outlined in the recon report should be discussed concerning whether the project was kept on schedule, or the reasons for falling behind schedule should be fully explained.

Problem Areas – Specific problem areas and the solutions to the problems should be discussed. This information becomes a historical record to be used for future planning purposes. Technical information will be included in the narrative and graphics of the recon report.

Funding– All fund citations and a total of all funds should be listed. This total should reflect all funds expended during all phases of the project. The ISVT and recon reports are the source for this information. Copies of all travel vouchers and other expenses should be included.

Man-Hours– The total man-hours expended should be listed by rank and whether they are productive or nonproductive. A composite of all progress reports should be compiled.

Conclusions – The conclusions and any recommendations should be listed. These should be specific in nature.

INCIDENT REPORTS

An incident report should be submitted at any time there is an unusual occurrence that could have an impact on the project. Incidents such as vehicular accidents, equipment damage, and personnel injuries must be reported. There is no set format for this report. It will generally take one of two forms: telephonic notification or a written incident report.

Telephonic Notification

The parent unit should be notified as soon as possible, This should be accomplished using the telephone, radio, or an electronic message. Simply stated, the notification should answer the following questions:

- **Who?** Who was involved.
- **What?** What happened.
- **Where?** The location and circumstances.
- **When?** The time and date of the incident.
- **Remarks.** What is being done to correct or repair.

The telephonic report may be fragmentary because all information may not be available or verified.

Written Incident Report

In all cases, a written report is prepared and forwarded to the parent unit with copies going to the local POC, if appropriate, and the project file. The written report will address the same questions as the telephonic report, the significant difference being the details. The written report should contain all details concerning the incident and must include written statements from any or all witnesses to the incident. In the case of accidents or equipment damage, preventive measures to preclude recurrence should be included. A copy of the written report should be enclosed in the project file and, if significant, the incident should be listed in the problem area paragraph of the final project report.

DISPOSITION OF REPORTS

The reports are usually submitted through the project operations officer for technical evaluation and completeness. The reports will then be forwarded to the company commander and the battalion S3 operations and S3 production information and approval, Copies of the reports will be kept in the project files for documentation (audit trail) and historical purposes.

Section II
BRIEFINGS

In addition to reports, commanders and other key visitors receive up-to-date information on project status via briefings. There are two general categories of briefings: deliberate and impromptu.

NOTE: All junior-grade NCOs should have received some formalized training in speaking as part of their NCO professional development. However, this training is not always adequate. Most installations have courses available such as instructor training or public speaking courses. These are generally short courses that will aid the NCO in presenting briefings and should be used.

IMPROMPTU BRIEFING

The simplest and yet the most difficult type of briefing is the impromptu. It is simple because there is a minimum of support facilities and materials to be concerned with. It is difficult because a thorough knowledge of all aspects of the projector topic is absolutely essential and preparation time is usually very short. The scenario for an impromptu briefing is very simple. The commander or other visiting official arrives for a site visitation and requests an update. The NCOIC or other designated individual is expected to bring this person up to date as to the project status. The project progress reports will be an invaluable source of information. Additionally, it is recommended that maps of the project be kept up to date solely for the purpose of briefings. Other charts and statistical data that can be updated are also advisable. The success of the briefing will depend primarily on the professionalism and knowledge of the briefer. The importance of the briefing cannot be overemphasized. An impressive impromptu briefing earns the respect of the commander or official and builds their confidence that the survey team can accomplish its missions.

INFORMATION BRIEFING

The information briefing is designed to inform the listener. Examples of instances in which an information briefing might be used are –

- Information of high priority requiring immediate attention.
- Information of a complex nature such as complicated plans, systems, statistics, or charts requiring detailed explanation.
- Controversial information requiring elaboration and explanation.

The information briefing deals primarily with facts. It includes a brief introduction to define the subject and orient the listener. It does not include conclusions or recommendations.

DECISION BRIEFING

The decision briefing is designed to obtain an answer or a decision. In higher headquarters, corps or above, the decision briefing is employed in most matters requiring command decisions, including tactical matters. In division headquarters and below, a more informal type of the decision briefing is used. At the outset, the briefer must state that the object of the briefing is to secure a decision. At the briefing's conclusion, if not given a decision, the briefer asks for it. The briefer should be certain of understanding the decision thoroughly. If uncertain, the briefer asks for clarification. The decision briefing may be compared to the oral staff study in that it contains each of the major elements of a staff study. The following sequence is usually the most logical order:

1 Isolate, define, and state the problem and state that the purpose of the briefing is to secure a decision. Include background information to show what led to the problem and why a decision is necessary.
2 State the assumptions, if necessary. Assumptions must be both reasonable and supportable.
3 Present the facts bearing on the problem. This portion of the briefing is essentially the same as that for the information briefing and the same rules generally apply to both types of briefings. The briefer should be objective and should state all the important facts accurately and fully. Facts having a direct bearing on the problem and already known to the person being briefed should be reviewed. Since this briefing should result in a decision, the listener is reminded of all the pertinent facts directly related to the problem. New facts unknown to the person being briefed are limited to those that have a direct bearing on and might influence the decision.
4 Discuss the courses of action. The courses of action are stated and briefly analyzed. The advantages and disadvantages of each course are pointed out and compared as in the discussion paragraph of the staff study. The briefer indicates possible results of each course of action and potential dangers involved.
5 State conclusions. The briefer states the degree of acceptance or the order of merit of each course of action.
6 Make recommendation(s). The briefer's recommendation is worded so that it maybe used as a decision on the commander's approval. On presenting the recommendations, the briefer should be prepared to discuss the coordination involved. Following the breifing, if the chief of staff is not present, the briefer informs the staff secretary, executive officer, or other appropriate administrative assistant of the commander's decision.

MISSION BRIEFING

The mission briefing is a type of military briefing used under operational conditions to impart information, to give specific instructions, or to instill an appreciation of a mission.

In an operational situation or when the mission is of a critical nature, it may become necessary to provide individuals or smaller units with more data than the orders provide.

This may be done by means of the mission briefing. The mission briefing reinforces orders, provides more requirements and instructions for the individuals, and provides an explanation of the significance of their role. This type of briefing is presented with care to ensure that it does not cause confusion or conflict with orders. The mission briefing is usually conducted by a single briefing officer who may be the commander, an assistant, a staff officer, or a special representative, depending on the nature of the mission or the level of the headquarters.

STAFF BRIEFING

The purpose of the staff briefing is to secure a coordinated or unified effort. This may involve the exchange of information, the announcement of decisions within a command, the issuance of directives, or the presentation of guidance. To accomplish these purposes, the staff briefing may include characteristics of the information briefing, the decision briefing, and the mission briefing, or any combination of these.

Attendance

Attendance at staff briefings varies with the size of the headquarters, the type of operation being conducted, and the personal desires of the commander. Generally, the commander, the deputy or executive officer, the chief of staff, the administrative assistant, and the senior representative of each coordinating and special staff section attend. Representatives from major subordinate commands may be present.

Scheduling

In garrison, staff briefings are normally scheduled periodically. Unscheduled staff briefings are called as the need arises.

In headquarters of larger units, staff briefings are often held on a regularly scheduled basis. In combat, staff briefings are held when required by the situation; however, at corps and higher levels, staff briefings normally are regularly scheduled events. Staff briefings are valuable in operational situations in that full appreciation of the situation by commander and staff is difficult to achieve by other means.

Topics

Matters discussed at staff briefings will vary. At lower levels, topics of immediate concern to the unit and its operations will be discussed, while at higher levels the briefing may deal more with matters of policy. In field or combat operations, tactical matters will predominate. When staff briefings are held on a regularly scheduled basis, the substance of each staff officer's presentation may be an updating of material previously presented.

Procedure

The chief of staff usually presides over the staff briefing, calling staff representatives to present matters that interest those present or that require coordinated staff action, Each staff officer is prepared to brief on their area of responsibility.

Staff Estimates

The presentation of staff estimates culminating in a commander's decision to adopt a specific course of action is a form of staff briefing used in combat headquarters. In this type of briefing, staff officers involved follow the general pattern prescribed for the staff estimate being presented.

BRIEFING TECHNIQUES

There are four steps in executing a briefing assignment: analyzing the situation, structuring the briefing, delivering the briefing, and following up.

Analyzing the Situation

This step includes analyzing the audience and the occasion, determining the purpose, allocating time, surveying facilities, and scheduling the preparatory effort.

Audience and occasion. The nature of the occasion and the characteristics of the audience include such considerations as —

- Who is to be briefed and why?
- What is their official position?
- How much knowledge of the subject does the individual have?
- What is expected of the briefer?

Before briefing an individual the first time, the briefer should inquire as to the desires of the particular individual to be briefed.

Purpose. The briefer must understand the purpose of the briefing to be delivered. Is it to present facts or to make a recommendation? The purpose determines the nature of the briefing,

Time allocated. The time allocated for a briefing will frequently dictate the style, physical facilities, and preparatory effort required. The briefer must know the approximate time allocated for the briefing before constructing the briefing.

Facilities. The briefer should consider the physical facilities available. For example, if the briefing is held in an office, the use of heavy equipment maybe impossible.

The availability of visual aids, draftsmen, and time are considerations. The briefer prepares a detailed presentation plan and ensures that assistant briefers, if used, know what is expected of them.

Preparatory effort. The preparatory effort is carefully scheduled. Each briefing officer should formulate a **briefing checklist.** The briefer makes an initial estimate of the deadlines that must be established for accomplishment of each task, schedules facilities for practice, and requests critiques.

Structuring the Briefing

The structure of the briefing will vary with the type and purpose of the briefing. The analysis provides the basis for this determination. When the briefing is to be informational, it will, among other things, consist of assembling information, selecting key points, deciding how to present the key points, and selecting visual aids. When the briefing is to be a decision type, the briefer must state the problem as well as stating facts and must isolate and analyze the courses of action, reach conclusions, make recommendations, and obtain an understandable decision. The following are major steps in preparing a briefing:

1 Collect material.
2 Know the subject thoroughly.
3 Isolate the key points.
4 Arrange the key points in logical order.
5 Provide supporting data to substantiate validity of key points.
6 Select visual aids.
7 Establish the wording.
8 Rehearse in detail.

Delivering the Briefing

The success of the briefing depends greatly on its reamer of presentation. A confident, relaxed, and forceful delivery, clearly enunciated and obviously based on a full knowledge of the subject, helps convince the audience. The briefer maintains a relaxed but military bearing, and delivers a briefing that is concise, objective, and accurate. The briefer must be aware of the following specifics:

1 The basic purpose of the briefing is to present the subject as directed and to ensure that the audience fully comprehends it.
2 Brevity precludes a lengthy introduction or summary.

3 Conciseness permits no attention-getters. Illustrations should be used as backup information if questions arise.

4 The briefer uses logic in arriving at conclusions and recommendations; there must be no personal or emotional involvement.

5 The briefer expects and is prepared for interruptions and questions at any point. If and when these interruptions occur, the briefer answers each question before proceeding or indicates that the question will be answered later in the presentation. At the same time, the briefer does not permit questions to distract him from getting back rapidly to the planned presentation. If the question will be answered later in the presentation, the briefer should so state and make specific reference to the earlier question when such material is introduced. The briefer must be prepared to support any part of the briefing. Before presenting the briefing, the briefer anticipates possible questions and prepares to answer them.

Following Up

When the briefing is over, the briefer prepares an MFR. This MFR should be brief but it should record the subject, date, time, and place of the briefing as well as the ranks, names, and positions of those present. The substance of the briefing may be recorded in a concise form. However, it maybe omitted, depending on local custom. Recommendations and their approval, disapproval, or approval with modifications are recorded as well as any instructions or directed action resulting from the briefing and who is to take action. When there is doubt as to the intent of the decisionmaker, a draft of the MFR is submitted to that individual for correction before it is prepared in final form. The MFR is distributed to staff sections or agencies that must take action on the decision or instructions contained in it or whose operations or plans may be influenced. Another copy should be included in the project file.

Appendix
Survey SOP and Supporting Annexes

The survey SOP is intended as a guide and source of information that may be the difference between an exemplary survey project and a very intensive learning experience for a survey crew, Not all eventualities have been addressed in the SOP and the annexes, nor can one SOP and set of annexes cover the diverse survey projects encountered worldwide, The intent of the SOP is to keep surveyors (and their supervisors) out of trouble survey-wise.
The following is an SOP designed for survey operations, which includes the following annexes:

The SOP and the annexes are important for two reasons:

1 The formats area guide to ensure uniformity and completeness of survey orders and reports.

2 The examples of the orders and reports are from actual survey projects. A thorough reading of the annexes for content will provide insight into various types of surveys, the extent and depth of planning needed for surveys, and a means of learning from previous surveys.

(SOP Survey)

DEPARTMENT OF THE ARMY
Engineer Company/Platoon/Squad/Detachment
Engineer Battalion (Topo) (Army)

SUBJECT: Unit Survey Operations SOP

1. INTRODUCTION:

a. This SOP has been designed to clarify and expedite mission accomplishment, specifically survey projects, on time and meeting specifications at minimum cost.

b. The tasks identified herein must be accomplished. The format of this SOP is a flowchart with an explanation of activities, formats of reports, and information flow of reports. The SOP will be used as a checklist and management control document for all levels of operation: squad, platoon, and company.

2. PROJECT REQUEST AND S3 TASKING: No project will be undertaken unless directed by the Engineer Battalion Operations Officer. All projects must go through S3, regardless of the source of the request (Defense Mapping Agency, FORSCOM, Major Commands, Installation/Community Staff Elements, or Allied Nations).

3. OPERATIONS SECTION PROJECT EVALUATION: The company operations section must evaluate the project directive and advise the company commander in the following areas:

a. Resources — What are the required manpower and equipment available to complete the project as specified?

b. Appropriateness – Does the project require skills which emphasize military occupational specialty (MOS) skills required of 82D surveyors? Does the company currently have the expertise required by the project?

c. Scheduling – What is the project priority and duration? How will the current work schedule be affected? How will annual training requirements be affected? Can the work be done in any season?

d. Final Product – What does the customer really want and need? What does the company have to produce?

e. Funding – How will the project be funded? How much money is available and what may it be used to purchase (billeting, rations, marketing, materials, POL, repair parts, equipment rental).

4. RESEARCH AND COORDINATION: The operations will conduct an "Office Reconnaissance" for the project, including –

a. Customer contact to determine exact project requirements and the form of the final product.

b. Research for reference data, to include trigonometric station lists, maps, aerial photography, and climate data. Sources for data may be the Defense Mapping Agency, Corps of Engineers, US Geological Survey, National Geodetic Survey, National Oceanic and Atmospheric Administration, Engineer Topographic Laboratory, and the customer. Additional sources are state, county, and municipal records. When working in another nation, request information from the host nation.

5. WARNING ORDER: The company operations section will issue a warning order to the appropriate platoon based on project priority requirements, existing projects, available resources and training requirements. The warning order will identify project requirements and time of execution. The warning order will direct a reconnaissance mission and ISVT report in the format at Annex A. Upon receipt of the warning order, the platoon will begin reporting the project status weekly to company operations.

6. PLATOON HEADQUARTERS ASSIGNS SQUAD: Platoon headquarters will select a squad and/or personnel for the project based on availability, equipment, experience, familiarity with project area, and training time available.

7. ON-SITE RECONNAISSANCE: The platoon is responsible for their initial on-site reconnaissance, A squad representative will assist with the reconnaissance. An ISVT report in the format of Annex A will be rendered through the platoon leader to the company commander with an information copy provided to the Commander, Engineer Battalion (topographic), ATTN: S3. The report is normally due five working days after the completion of the reconnaissance, and will be prepared by the squad assigned and turned in to the platoon headquarters. The company commander will advise the battalion commander on the appropriateness of the project.

NOTE: If no further site reconnaissance occurs between the initial on-site reconnaissance and the arrival of the advance party, the most likely squad leader is a MUST to be with this reconnaissance. If this reconnaissance is for support, it must be firm and documented. If this reconnaissance is only to determine acceptance of the project, another reconnaissance WILL BE required to determine the survey plan and confirm the support.

8. OPERATIONS ORDER: The operations section will prepare and issue an operation order (OPORD) in standard military five-paragraph format of Annex B. The OPORD will direct the platoon to perform the survey mission. Company operations will issue all maps, trig lists, and overlays at this time if not previously issued to the platoon.

9. FRAGMENTARY ORDER: Platoon headquarters will issue a fragmentary order (FRAGO) to the assigned squad, instructing them to perform the survey mission. The FRAGO will contain all information required by the squad leader to complete the project. This format is at Annex C.

10. RESEARCH, COORDINATION, RECONNAISSANCE: The squad leader is responsible for detailed examination of applicable trig lists, past project reports in the area, maps, deeds, and any other pertinent source data. Platoon headquarters and the survey information center may be tasked to assist in assembling information. Using this information and any on-site reconnaissance information, the squad leader will design the project. Weekly progress reports will be submitted through platoon headquarters to company operations from this point until project completion. The format for this report is at Annex D. The squad leader will choose the method he will use to meet project specifications and time requirements and prepare a written survey plan, to include drawings/overlays of survey schemes as information permits. This plan should reflect the squad leader's best estimate of survey design, based on the information he has. If no comprehensive survey reconnaissance has been accomplished, the survey plan will not be final. The final plan will be designed on site as part of the advance party's tasking. Any changes from the original plan will be submitted to the platoon headquarters telephonically, and in writing if so instructed. The project plan will be written in the format of the project briefing.

11. CREW AND EQUIPMENT PREPARATION: The squad leader selects personnel based on job requirements, experience, expertise, training requirements, and equipment. The crew begins to train in specific skills needed for the project. The squad leader will identify specific items of equipment to be used on the job and will ensure their operational readiness, to include performing required maintenance. The squad leader will identify and order all required supplies for the project.

12. PROJECT BRIEFING: The squad leader will brief, in turn, the platoon leader and the company commander. The briefing will contain at a minimum –

a. Mission: What will the final product be? Who is the customer?

b. Concept of Operation: How will the squad complete the project?

1. Design – What methods (triangulation, traverse, levels) will be used?
2. Where will the lines of survey be run? Use a map to show existing control and proposed lines of survey.
3. Time estimation – Show proposed work estimation. Indicate departure and return dates.
4. Cost estimation – Break down cost categories (POL, billeting, per diem, contingency) and show total cost.
5. Travel to site – What methods will be used and how long will it take?

c. Personnel and Equipment Requirements:
1. What personnel are required? Provide a by-name listing.
2. What major items of equipment are necessary and how many?

d. Service Support:
1. Billeting
2. Messing
3. Medical
4. Maintenance
5. Materials and supplies
6. POL
7. Transportation

e. Command and Signal: Reporting procedures

f. Training:
1. List specific MOS skills and ARTEP/AMTP tasks required and exercised by the project.
2. What training is necessary to prepare the squad to execute the project?

13. PREPARATION FOR TEMPORARY DUTY (TDY): The squad will usually have 14 calendar days to prepare for a TDY project, The squad leader is responsible for scheduling and executing preparations in the following areas for his squad members. The platoon sergeant and first sergeant are responsible for assisting in these preparations.

a. Request for TDY Orders:
1. The squad leader will write a request for orders, to include –
a. Name
b. Rank
c. Social security number
d. Security clearance
e. Project directive number
f. Dates
g. Modes of transportation
h. Special considerations such as authorizations for telephone calls, rental vehicles, and extra baggage.
2. This request will be forwarded to platoon headquarters.
3. Platoon headquarters will review the request, add any necessary information, and forward to company operations.
4. Company operations is responsible for obtaining the finalized orders and returning copies to the platoon.

b. Barracks:
1. Turn in sheets, pillow case, pillow, blankets, and bedspread.
2. Store oversized and high value items.
3. Inventory items in wall locker (three copies: individual, supply, and inside locker), by squad leader and officer.
4, Have wall locker banded.
5. Turn in room keys.

c. Health Records:
1. Pick up medical records and dental records.
2. Reschedule any pending appointments.
3. Update shot records.

d. Personal Gear:

1. Pack those items appropriate for the project area climate. (Consider, for example, that nighttime temperatures in a desert can be as much as 30 degrees LOWER than peak day temperatures).

2. Arrange for safeguarding of POV if left behind. Through prior coordination, it may be allowed to be stored in the motor pool. If it will need to be inspected, reregistered, or have insurance renewed before you return, make written notarized authorization for your proxy before leaving.

e. Mail:

1. Mail will not be forwarded unless requested differently.

2. A statement must be filed with the mail clerk in order for spouses to pick up mail in the event the soldier does not want it forwarded.

3. Have a squad member designated as mail handler.

f. Finances:

1. Only personnel with check to bank are authorized to perform TDY missions away from the installation.

2. After receipt of TDY orders, draw advance pay at finance if desired.

3. If flying to project site, use your TDY orders to obtain a transportation request and ticket at the Scheduled Airline Ticket Office (SATO).

4. Brief squad on travel voucher procedures (keeping copies of the original of all orders, travel requests, lodging receipts, official telephone receipts, contingency purchase receipts, and rental receipts.

g. Drivers' Licenses:

1. Get a license for all squad vehicles plus possible TMP vehicles (pickups, vans CJ-5s, and carryalls).

2. Take a copy of your *DA Form 348, Equipment Operator's Qualification Record,* to the project site.

h. Squad Equipment Inventories:

1. The equipment the squad leaves behind must be inventoried in writing and signed by the master hand receipt holder, or acting squad leader, as appropriate.

2. All equipment taken on the project will be inventoried in writing by the squad leader/team chief.

3. Copies of the above hand receipts will remain with the individuals concerned.

i. Military Vehicles:

1. Each vehicle will receive a thorough technical inspection prior to departure.

2. Each vehicle will have a complete set of organization vehicle maintenance (OVM).

3. Each vehicle will be dispatched for the length of the project.

j. Briefings:

1. Give a project briefing to the squad members.

2. Receive safety and personal conduct briefings from platoon and/or company headquarters.

k. Signing Out:

1. All personnel will sign out of the battalion at S1 or the SDNCO upon departure.

2. Meal card holders will turn in their meal cards.

l. Credit Card: Obtain a government credit card from S4 if required.

m. Instrument Calibration: Perform/obtain adjustments and calibrations for the surveying equipment to be used on the project.

n. Assemble Administrative Project File:

1. Copy of project directives

2. Copy of survey plan

3. Copy of reconnaissance report

4. Copies of all subsequent trip reports
5. Copies of all TDY orders/advances related to project
6. Emergency data on all personnel assigned to the project
7. Company's officer and NCO rosters, especially telephone numbers
8. File copies of all forms used (to be kept for reproducing additional copies)
9. Copy of each driver's *DA Form 348.*
10. Travel vouchers
11. Copy of current battalion access roster

o. General Support Equipment/Supplies:
1. Office supplies
2. *DA Form 2404, Equipment Inspection and Maintenance Worksheet,* and other support forms
3. Survey forms
4. General first aid kit
5. Drawing paper, chart paper
6. Typewriter
7. Calculators, paper, and batteries
8. Counseling statements
9. Official mailing envelopes
10. Weekly report forms

p. Reference Materials:
1. Maps and trig data
2. SQT and common task test (CTT) manuals
3. Job books
4. Survey manuals
5. Company survey project SOP
6. Survey equipment manuals/manufacturer's manuals

q. Complete/Reschedule Other Training:
1. Annual training requirements (mission)
   a. Weapons qualification
   b. Army physical readiness test (APRT)
2. Annual training requirements (personal knowledge)
   a. CTT Packet
   b. Scheduled training for TDY period
3. Weight control
4. Vehicle (POV)
   a. Registration current
   b. License current
   c. License plate current
5. Defensive driver card
6. Field 201 file update
7. Off duty classes

r. Married Personnel:
1. Power of attorney, if needed
2. Arrangement for nonlicensed dependents
   a. Commissary
   b. Hospital
   c. General shopping
   d. PX

14. ADVANCE PARTY:

a. Generally, the squad leader and one or two squad members will depart approximately one week prior to the entire project crew. The assistant squad leader will do final administrative preparations with the remaining squad members.

b. The squad leader will inspect and sign for quarters and administrative space. Equipment will be secured and telephonic communications with the company will be established upon arrival. If calling after duty hours, call platoon headquarters personnel at home or the SDNCO as a last resort.

c. All POCs from the initial reconnaissance should be contacted. Additionally, the military police or local police should be informed of mission requirements, areas of operations, vehicle types, and bumper/license numbers.

d. Further detailed recon/station recovery and verification should begin and final project design be completed. Consideration should be given to access requirements (keys, escorts, range control operation times) and finding local personnel with intimate knowledge of the project area. Further local data maybe required (local surveyors, courthouse).

e. If the squad can begin work as soon as they arrive, the advance party has been successful.

15. SQUAD MOVEMENT TO PROJECT:

a. The squad leader/assistant squad leader will conduct the movement to the project. Both military vehicles and POVs will move as a group under the NCOIC's control. All posted speed limits will be obeyed. If the project is 450 miles or less away, the movement time will be one day. At distances greater than 450 miles, the movement rate will be approximately 300 miles per day. All overnight billeting arrangements will be at one location if possible. All equipment will be secured and each individual must obtain an individual receipt.

b. Fuel should be obtained at service stations that accept military credit cards for military vehicles, All POVs will be filled at the owner's expense. Use of military credit cards should be kept at a minimum. Use self-service pumps when possible.

c. The platoon headquarters or SDNCO will be notified daily of location and telephone number of overnight billeting area, and will be notified upon arrival at project site.

d. If movement is by commercial air, ensure that all baggage claim checks are safeguarded until all equipment is received at the final destination.

e. If movement is by military aircraft, make every attempt to move the equipment with the personnel. If equipment must be moved independently, the equipment will be submitted with a "Priority, No-Bump" statement. At least one person will observe the physical loading of the survey equipment onto the aircraft. Copies of all movement documents will be retained until the equipment is received after movement. At a minimum, the following information will be obtained and written:

1. Type (model) of aircraft.
2. Tail number of aircraft.
3. Mission number.
4. Transportation control management document (TCMD) number.
5. Date and time of departure.
6. Route of the aircraft, including all intermediate stops before the survey equipment is to be unloaded.

16. PROJECT EXECUTION:

a. All recordings and computations will be in black ink and will be double-checked and initialed to indicate the checks have been performed.

b. Maintenance – Perform daily maintenance on each vehicle and weekly PMCS on all survey equipment. Report immediately to platoon headquarters each time equipment readiness status changes. All accidents must be reported to the company commander within 24 hours. Accident reports and statements from all concerned parties will be prepared immediately and forwarded to the company commander.

c. Safety – Follow all guidelines set forth in the unit safety SOP.

d. Inventories – Inventory daily those items used in the field survey. Inventory daily all sensitive items of equipment (survey instruments, binoculars, compasses, and OVM). Inventory weekly all hand-receipted equipment. Report any damaged, lost, or inoperational equipment to the platoon headquarters within 24 hours of the incident.

e. Physical Training – Physical training will be conducted, Type and schedule will be determined by the squad leader. Generally, the training should be equivalent to the daily dozen and a two-mile run. Upper and lower body should be exercised and the cardiovascular system should be taxed.

f. Common tasks and SQT manuals should be taken to the project. During inclement weather, training in these skills can be conducted.

g. A weekly progress report will be submitted to platoon headquarters. The format is at Annex D and will include vehicle mileage, fuel used, man-hours expended, and percent completed.

h. The squad leader is responsible for daily checks of field work and computations.

i. The squad leader will keep a written daily log of the progress, activities and problems that relate directly to the the mission. All other occurrences such as personnel insubordinate behavior will be recorded on *DA Form 4856, General Counseling Form.*

j. The squad leader will be prepared at all times to present an informal progress briefing to any visitors/inspectors.

17. SURVEY HEADQUARTERS: Survey headquarters section will be responsible for on-site edit, if possible, during the last phase of the project, Edit will include but not be limited to checking–

a. Computations – Math and procedures done correctly, to include all headings and signatures.

b. Field Sheets/Books – Verify checks and headings.

c. Station Descriptions – Completed sketch, reference features, proper grammar, sequence of paragraphs, and field checked.

d. Airfield Drawings – Complete, accurately plotted, and field checked.

e. Ensure project meets customer requirements.

f. All corrections/notations made by edit personnel will be in red ink.

g. All pages checked will include the editor’s initials in red ink.

h. Notes/lists will be kept free of any glaring or repetitive errors.

18. SQUAD MOVEMENT FROM PROJECT:

a. After all field observations and computations are completed, the squad will clear the project site and return to its home installation. The squad leader will ensure that all borrowed equipment is turned in, billets are cleaned, equipment is inventoried, preoperational vehicle checks are conducted, all outstanding bills are paid, and all vehicles are properly dispatched. The customer will not normally be provided a copy of the unedited project unless so directed by platoon/company headquarters, When required to leave a copy with the customer, ensure that a statement is attached indicating that the data provided is preliminary and unadjusted data.

b. Movement will be conducted under the same conditions as movement to the project. Platoon headquarters will be informed of your departure from the work site before you depart the job site.

19. SQUAD RECOVERY: Upon return to your home installation, the following will be accomplished:

a. A platoon representative will meet the returning squad with main and any special instructions.

b. Soldiers sign in at S1 or SDNCO.

c. Soldiers sign for keys, linen, and inventory wall lockers.

d. Vehicles are topped off, secured, cleaned, and technically inspected in the motor pool.

e. The TOE equipment is cleaned, inventoried, inspected, and secured. Any required maintenance will be scheduled.

f. Finance vouchers are completed, inspected at platoon headquarters, and filed for payment at the finance office. Unless otherwise instructed by the installation finance office, the voucher packets will include the following items:

DOCUMENT	OFFICERS	ENLISTED
DD Form 1610	Original + 4	Original + 5
DD Form 1351-2	Original + 4	Original + 5
DD Form 1351-3	Original + 2	Original + 2
DD Form 1351-5	Original + 2	Original + 2
Receipts	Original + 2	Original + 2

g. Verbally brief platoon headquarters on project status.

h. When final finance vouchers are received, a copy of each person's voucher will be forwarded through platoon headquarters to company operations.

i. Ensure adequate time is scheduled for personal affairs and missed training.

20. EDIT AT HEADQUARTERS:

a. Upon return from the project, the squad leader will submit the completed survey packet to the survey's headquarters element. The headquarters element will check all final computations, drafting, and recovery card preparation. An after-action report, in the format shown at Annex E, will be submitted by the squad leader to platoon headquarters three working days after the survey packet is submitted, and will be included in the survey packet.

b. The survey packet should contain the following items, in order:

1. After-action report.
2. Detailed narrative (packet introduction), explaining the contents of the packet.
3. Sketch, or overlay of all work done.
4. Index.
5. Tabulated data/DA Form 1959 cards.
6. Check angles, distances, levels, and starting inverse computations.
7. All traverses and level lines in a logical sequence (main control extension, connecting control, side or loop extensions).

8. Level lines will contain the following items, in order:
   a. Sketch of level line.
   b. *DA Form 1942, Computation of Levels.*
   c. Field notes.
9. Traverses will contain the following items, in order:
   a. Sketch of traverse.
   b. Final position computations *(DA Form 1923, Position Computation Order Triangulation For Calculating Machine Computation,* and *DA Form 1940, Traverse Computation on the Universal Traverse Mercator Grid).*
   c. Final inverse position/astronomic azimuth computations.
   d. Elevation computations.
   e. Abstracts.
   f. Distance measurement/reduction field sheets.
   g. Horizontal direction field notes.
   h. Vertical angle/zenith distance field notes.
   i. Astronomic observation field notes.
   j. Intersection/side-shot field notes.
10. Satellite receiver data will include the following items:
   a. Sketch.
   b. Printed tape of position computations and datum transformations.
   c. Magnetic tapes containing all recorded data.

21. PLATOON REVIEW

a. The platoon headquarters will review the final project and make a file of all pertinent records, vouchers, forms, reports, and a copy of the final project.

b. Platoon headquarters will make appropriate award recommendations and ensure all soldiers' finance transactions (meal cards, separate rations, BAQ) are followed through to completion.

c. Upon completion of the platoon review, a first endorsement to the after-action report will be prepared by platoon headquarters and forwarded with the report and final project packet to company operations. The endorsement will contain a report of any additional man-hours expended during the edit and review, inspection results, and any other pertinent data.

22. COMPANY OPERATIONS FINAL REVIEW: The company operations will review the final project for accuracy and completeness. A file copy will be made and pertinent data will be stored in the survey information center. The project will be forwarded with a letter of transmittal to battalion operations. Additionally, a second endorsement to the after-action report will be prepared and forwarded to battalion operations. This endorsement will contain a report of any additional man-hours expended during the edit and review, inspection results, and all final project data. Copies of the after-action report, with all endorsements and enclosures will be forwarded for information and filing, to the platoon and battalion operations. A file copy will also be kept in company operations.

(ANNEX A: Initial Site Visitation Trip Report Format)

EXAMPLE EXAMPLE EXAMPLE EXAMPLE EXAMPLE

DEPARTMENT OF THE ARMY
99th Engineer Company (Survey)
99th Engineer Battalion (Topo) (Army)
Fort Belvoir, Virginia 22060-5000

AFFA-TA-S

03 February 1986

SUBJECT: Initial Site Visitation Trip Report Narrative
(Ft. Bliss, Biggs AAF, TX, 28-31 Jan 86)

Commander
99th Engineer Company (Survey)
ATTN: Operations
Fort Belvoir, Virginia 22060-5000

1. Reference: PD#85-2075, FAA Airfield Obstruction Survey

2. Personel:

a. WO1 John Doe, Survey Technician, 99th Engineer Company (Survey), 99th Engineer Battalion (T) (A), Fort Belvoir, VA 22060 AVN: 555-1212 FTS: 544-XXXX

b. Mr. John Doe, DEH, Engineer Plans& Services Division, Master Planning, Bldg 1165, Fort Bliss, TX 79916 AVN: 555-1212 FTS: 478-XXXX

c. Ms. Jane Doe, Billeting Office, Bldg 504A, Fort Bliss, TX 79916 AVN: 555-1212 FTS: 478-XXXX

d. SGT Doe, HQ, USAADACENFB, DPT/G3, Bldg 2, Room 19, Fort Bliss, TX 79916 AVN: 555-1212 FTS: 478-XXXX

e. MSG Doe, Operations SGT, DIO, TMP, Bldg 1332, Fort Bliss, TX 79916 AVN: 555-1212 FTS: 478-XXXX

f. CPT Doe, Operations Officer, Biggs AAF, Bldg 11210, Fort Bliss, TX AVN: 555-1212 FTS: 478-XXXX

g. CW4 Doe, Asst Operations Officer, Biggs AAF, Bldg 11210
Fort Bliss, TX AVN: 555-1212 FTS: 478-XXXX

h. SFC Doe, Operations NCOIC, Biggs AAF, Bldg 11210, Fort Bliss, TX 79916 AVN: 555-1212 FTS: 478-XXX

i. Mr. John Doe, Survey Division, US Army Corps of Engineers, Albuquerque District, Albuquerque, NM FTS: 555-1212

j. Jane Doe, Bogus Rental Car, 6012 Hollow Brook Road, El Paso, TX COMM: (915) 555-1212

3. Objectives:

a. Determine the scope of work to be performed.

b. Make a thorough reconniassance of the areas to be surveyed, to include locating existing survey control.

c. Complete liaison for all types of support requirements ranging from billeting to vehicle support.

4. Mission: The 1st Survey Platoon, 99th Engineer Company (Survey), will dispatch a survey team of eight soldiers to Fort Bliss, Texas, on or about 19 February 1986 after receipt of funding for the project. They will conduct a complete survey of all NAVAIDs and airfield obstructions IAW specifications established by the US Army Air Traffic Control Activity, Aeronautical Services Office, Cameron Station, Alexandria, VA 22304-5050. Additionally, if time and funding permit, the team will revalidate the aging compass rose located on Biggs AAF.

5. Discussion:

a. Location: Biggs Army Airfield is located adjacent to Fort Bliss, Texas on three sides and by El Paso International Airport on the fourth side.

b. Environmental Factors: The terrain is basically flat, with the airfield being located on a high desert plateau. The Franklin Mountains are located approximately four miles west of the airfield and the Hueco Mountains are approximately fifteen miles to the east, Vegetation is sparse and is limited to scrub brush. Normal daily temperatures for this time of year are 40 degrees to 50 degrees (F) during the day and 20 degrees to 30 degrees (F) at night. Precipitation is minimal throughout the year.

c. Medical Facilities: Emergency medical treatment is available 24 hours a day at the William Beaumont Army Medical Center. Routine sickcall may be accomplished at the consolidated troop medical clinic located in Bldg 2496. Dental care will be provided for emergencies only, at the dental clinic located at Bldg 2699.

d. Commissary/PX Facilities: Complete commissary and PX facilities are available on Fort Bliss. Additionally, small branch exchanges are located throughout the post and on Biggs AAF. Both accept checks as payment and the PX will cash personal checks for up to $100.00 per day. Additionally, the main exchange will accept certain specified credit cards, as payment.

e. Vehicle Support: Fort Bliss TMP is unable to support our vehicle requirements. We will rent two sedans and one pick-up truck from the Bogus Rental Car Company, El Paso, Texas. Fuel will be procurred through the TMP fuel point with DEH reimbursing the TMP for fuel we use.

f. Billieting/Office Space: As of this date, the only billeting available on Fort Bliss is through the BEQ. The billeting office is located in Bldg 504A on Forth Bliss. SGT Doe at DPT/G3 is currently working on finding free billeting space for the survey team. Office space and equipment storage space is available on Biggs Army Airfield. The POC is the airfield operations office.

g. Dining Facilities: The dining facilities on Fort Bliss are crowded and it would cause considerable delays daily if the survey team were to use them. It is strongly recommended that all personnel be placed on per diem. There are numerous restraints and fast food establishments in the Fort Bliss and El Paso area. Additionally, there is a food concession next to the main exchange on Fort Bliss.

h. Cost Parameters:

(1) Parameters for Cost Estimates –

(a) Advance Party	Depart 19 Feb 86 (survey technician and 2 soldiers)
	Return 25 Feb 86 (survey technician to Belvoir)
	Return 17 Mar 86 (2 soldiers to Belvoir)
(b) Remainder of crew	Depart 24 Feb 86 (6 soldiers)
	Return 17 Mar 86 (to Belvoir)
(c) Rental cars	2 rental cars for 27 days
	2 rental pick-ups for 27 days
	1 rental car for 3 days

(2) Actual Costs -

(a) Air fare

Advance party	3 persons x $373.00 =	$1,119.00
Crew	6 persons x $373.00 =	2,238.00
Inspector	1 person x $373.00 =	373.00
	TOTAL	**$3,730.00**

(b) Lodging

Advance party		
1 officer x 6 nights x $12.00 =		$ 72.00
2 enlisted x 26 nights x $11.00 =		572.00
Crew		
6 enlisted x 21 tights x $11.00 =		**$ 1,386.00**
Inspector		
1 officer x 2 nights x $12.00 =		24.00
	TOTAL	$ **2,054.00**

(c) Per diem

Advance party		
1 person x 7 days x $23.00 =		$ 161.00
2 persons x 27 days x $23.00 =		1,242.00
Crew		
6 persons x 22 days x $23.00 =		3,036.00
Inspector		
1 person x 3 days x $23.00 =		69.00
	TOTAL	**$4508.00**

(d) Transportation on site

Rental cars		
Crew 2 each x 27 days x $14,00 =		$ 756.00
Rental pick-up		
Crew 1 each x 27 days x $18.00 =		486.00
Rental car		
Inspector 1 each x 3 days x $26.00 =		78.00
	TOTAL	**$ 1,320.00**

(e)	Shipment of equipment – Bogus Shipping Company $ 0.80/lb x 400 lb x 2 trips =	$ 640.00
(f)	Contingency fund	$ 150.00
(g)	Total estimated cost	**$12,402.00**

6. Technical Information: (not included in this narrative)

7. Recommendations and Conclusions: The project should be accepted by this unit. It will provide training in the following SQT tasks:

a.	051-260-1101	Observe Horizontal Directions (1” Theodolite)
b.	051-260-1102	Observe Zenith Distances (1” Theodoiite)
c.	051-260-1105	Operate Infrared EDME Instrument
d.	051-260-1108	Operate Semiprecise Level
e.	051-260-1109	Determine Level Error C for Levels
f.	051-260-1110	Use Level Rod
g.	051-260-1112	Set Up a Wild T-2 Target
h.	051-260-120	Record Horizontal Directions
i	051-260-1202	Record Zenith Distances
j.	051-260-1203	Record Level Field Notes
k.	051-260-120	Record Infrared EDME Field Notes
l.	051-260-1301	Recover Survey Control Station

n. 051-260-1401 Compute Grid Coordinates
o. 051-260-1402 Compute Geographic Coordinates
p. 051-260-1403 Compute Azimuth and Distances From Grid Coordinates
q. 051-260-1405 Compute Difference in Elevation From Reciprocal Observations
i. 051-260-1406 Compute Difference in Elevation From Nonreciprocal Observations
s. 051-260-1407 Compute Differential Level Line
t. 051-260-1408 Compute and Adjust Grid Traverse

JOHN DOE
WO1, WU
Survey Technician

2 Incl
1 Ltr, AFFA-TA-S, dtd 31 Jan 86
1 NAVAID Survey Specs.

CF: Cdr, 99th Engr Co.
Party Chief
Survey Opns
Mr. Doe, DEH, Ft Bliss, TX

(Annex A, Incl 1)

DEPARTMENT OF THE ARMY
99th Engineer Company (Survey)
99th Engineer Battalion (Topo) (Army)
Fort Belvoir, Virginia 22060-5000

AFFA-TA-S 31 January 1986

SUBJECT; Biggs AAF Safety Survey Cost Estimate

Commander
USAADACENFB
ATTN: ATZC-DEH-P
Fort Bliss, Texas 79916-6104

1. After performing a thorough reconniassance for this project, I estimate the cost of the project at $12i,000.00. This cost estimate reflects the fact that no vehicle or free billets support is available from Fort Bliss.

2. The cost estimate does not reflect the amount that DEH will need to reimburse the Fort Bliss TMP for 200 gallons of Mogas. This fuel will be needed for use by the three rental vehicles to be utilized on this project.

3. Request that a DA Form 2544, (Intra-Army Order for Reimbursable Services) be prepared for the amount of the estimate and forwarded to: Commander, 99th Engineer Battalion (Topo) (Army)
ATTN: AFFA-TA-PCS (CW2 Doe) Fort Belvoir, Virginia 22060-5000.
Request this action be expedited to allow the project to begin on 19 February 1986.

JOHN DOE
WO1, WU
Survey Technician

(Annex B: Technical Operations Order Format)

EXAMPLE EXAMPLE EXAMPLE EXAMPLE EXAMPLE

Copy # 4 OF 6 Copies

99th Engineer Battalion(T) (A)
Fort Belvoir, (UT1387), VA

TECHOPORD (Fort Bliss)

References:

A. Letter, ASQ-AS-AI, dated 17 May 85. SUBJECT: Engineering Surveys of Army Airfields.
B. Letter, AMCEN-F, dated 29 May 85, SUBJECT: Engineering Surveys of Army Airfields.
C. Letter, AFFA-TA-PCS, dated 8 Nov 85, SUBJECT: Mission Capability of the 99th Engineer Company (Survey).

Time zone used throughout the order: ROMEO

1. SITUATION

A. Enemy Forces: NA
B. Friendly Forces: Directorate of Engineering and Housing, Fort Bliss, TX, 99th Engineer Battalion (T)(A) with subordinate units: HHC, 99th Engineer Company (Carto), and 99th Engineer Company (Survey).
C. Attachments and Detachments: None.

2. MISSION: The 99th Engineer Company (Survey) will perform a NAVAID/obstruction survey of Biggs AAF at Fort Bliss, TX.

3. EXECUTION:

A. Concept of Operation: 99th Engineer Company (Survey) coordinates, schedules, and performs survey operations to accomplish the above mission NLT 30 Apr 86. The S3 will monitor project progress and coordinate external requirements upon request.
B. Coordinating Instructions: Direct coordination with the following point of contact is authorized:
1LT Doe, Master Planners Office. AUTOVON 555-1212

4. SERVICE SUPPORT:

A. Unit equipment and supplies will be used. If economically feasible, rental vehicles are authorized.
B. Submit support request(s) to this Headquarters, ATTN: AFFA-TA-OP, as needed.

5. COMMAND AND SIGNAL:

A. Command: Per Battalion SOP
B. Reports. 99th Engineer Company (Survey) will:
1. Submit to S3 a reconnaissance report within 30 days of receipt of this OPORD.
2. Report project status weekly to S3 NLT 1200 hours each Friday.
3. Submit to S3 an end-of-project report within 15 days after completion of project.

JOHN DOE
LTC, EN
COMMANDING

(Annex C: Fragmentary Order Format)

EXAMPLE EXAMPLE EXAMPLE EXAMPLE EXAMPLE

FRAGO # 85-2009-1

References:

A. Technical Operations Work Order # 85-2009

B. TM 5-237, Surveying Computer's Manual, Chapter 5

C. STP 5-82D14-SM-TG, Soldier's Manual, Task # 051-260-2421

Time zone used throughout the order: ROMEO

1. SITUATION:

A. Friendly Forces: 99th Engineer Battalion (T) (A)

B. Enemy Forces: None

C. Assumptions: This unit maybe tasked to perform high-order survey work in the near future. Personnel should become familiar with the computations associated with this type of work.

2. MISSION: Each squad within the 1st and 2d Survey Platoons, 99th Engineer Company has been tasked to compute geodetic azimuth from north and geodetic distance for each set of coordinates on the attached sheets.

3. EXECUTION:

A. Concept of Operations:

1. Transcribe positions for each set to DA Form 1923.
2. Compute geodetic azimuth from north and geodetic distance for each set of coordinates.
3, Distance will be computed to 0.001 meter, and azimuth to 0.01 second.
4, All points are in northern Alabama.
5. This is a third-order Class I traverse project.
6. Maximize use of personnel unfamiliar with this computation.
7. Submit progress report, to include man-hours expended and a by-name list of personnel working on the computations by 1100 hours each Friday until completion of project.
8. Return completed data to Survey Platoon Technician (WO1 Doe) by COB 27 Feb 85.

B. Coordinating Instructions:

1. Calculators and reference materials are available from WO1 Doe.
2. All technical questions/problems should be directed to WO1 Doe.

4. ADMINISTRATION AND LOGISTICS: The only available resources are those contained within the 1st and 2d Survey Platoons.

5. COMMAND AND SIGNAL:

A. Command: Squad leaders are responsible to ensure all required data and reports reach the Survey Technician by the required times.

B. Signal: NA

DOE

(Annex D: Percentage of Survey Project Completion Guide)

EXAMPLE EXAMPLE EXAMPLE EXAMPLE EXAMPLE

FA-TA-S Survey Projects, Percentages of Completion

TO: SEE DISTRIBUTION

FROM: Commander
99th Engr Co (Survey)
Fort Belvoir, VA 22060

DATE: 26 Feb 86
dr/1092

1. To standardize company operating procedures, projects will be reported using the percentages listed under your type of project.

2. This project status is due to company operations each Friday by 1000 hours. Request immediate attention be given to this suspense.

3. General breakdown for each project consists of eight key areas.

Percentages of Area	Percentages	Percentages of Total Projects
S3	0 - 2	2
Company Operations	3 - 6	4
Office Recon	7-10	4
Field Recon	11-20	10
Field Survey	21-75	55
Platoon Edit	76-90	15
Company Edit	91-97	7
S3	98-100	3

4. The field survey percentage of 55 is further broken down for each type of project, and reported as such.

a. Traverse for extension of control.

Area	Percentages	Percentages of Total Projects
Recover/Verify Control	21-30	10
Monument Stations	31-35	5
Horizontal/Vertical Angles	36-45	10
Distances	46-55	10
Computations	56-70	15
DA Form 1959 Cards	71-75	5

b. Level line for control extension or cross sections/profiles.

Area	% Control Ext	% X-Section Percentage	Total
Recover/Verify Control	21-30	21-30	10
Monument BMs	31-35	31-35	10
Field Observations	36-55	36-50	20, 15
Computations	56-71	51-60	15, 20
DA Form 1958 Cards	71-75	61-65	5
Drafting Charts	0	66-75	0, 10
(Total of%)	(55)	(55)	(55)

c. Doppler point positioning.

Area	Percentages	Percentage of Total
Recover/verify control	21-30	10
Monument observation points	31-35	5
Doppler observations	36-55	20
Computations	56-70	15
Doppler station description cards	71-75	5
	55	55

d. APPS supporting projects.

Area	Percentages	Percentage of Total
APPS observations	21-60	40
Data reduction/transform	61-75	55
	55	55

e. Airfield obstruction surveys or NAVAIDs.

Area	Percentages	Percentage of Total
Recover/verify control	21-26	6
Monument stations	27-28	2
Horizontal/vertical angle observation	29-33	5
Distances observation	34-38	5
Side shot/intersection	39-43	5
Levels	44-48	5
Computations	49-63	15
DA Form 1959 Cards	64-65	2
Drafting	66-75	10
	55	55

f. INS surveys - reported as: traverse for extension of control.

5. Encl 1 (graphic breakdown for survey projects)

JOHN DOE
CPT, EN
Commanding

Distribution:

S3 (CWO2 Doe)
1st Survey Platoon
2d Survey Platoon
Cdr, 99th Engr Co

(Annex E: End-Of-Project Report Format)
EXAMPLE EXAMPLE EXAMPLE EXAMPLE EXAMPLE

DEPARTMENT OF THE ARMY
99th Engineer Company (Survey)
99th Engineer Battalion (T) (A)
Fort Belvoir, VA 22060-5000

AFFA-TA-S 18 April 1984

SUBJECT: End-of-Project Report (New Cumberland Army Depot, PA, 19 Jan 84-2 Apr 84)

THRU: Commander
99th Engineer Company (Survey)
Fort Belvoir, VA 22060

TO: Commander
99th Engineer Battalion (T) (A)
Fort Belvoir VA 22060-5000

1. References:

a. Letter, SDSNC-AF, dated 29 Sep 83, SUBJECT: Topographic Survey Requirements (Encl 1)

b. Letter, AFOP-OCR, dated 10 Nov 83, SUBJECT: Topographic Support PD # 2-84 (Encl 2)

c. OPORD, 99th Engineer Battalion (T)(A), dated 30 Nov 83, OPORD 83-148. (Encl 3)

d. Letter, AFFA-TA-S, dated Oct 83, SUBJECT: Preliminary Reconnaissance Trip Report. (Encl 4)

e. Letter, AFFA-TA-S, dated 22 Dec 83, SUBJECT: Reconnaissance Trip Report (Encl 5)

f. Letter, AFFA-TA-S, dated 24 Feb 84, SUBJECT: Inspection Trip Report (Encl 6)

g. Letter, AFFA-TA-S, dated 12 Mar 84, SUBJECT: Inspection Trip Report (Encl 7)

2. Personnel:

a. Inspectors:

SFC John Doe	Platoon Sergeant	2 Feb 84
1SG John Doe	First Sergeant	16 Feb 84-17 Feb 84
2LT John Doe	Platoon Leader	16 Feb 84-17 Feb 84
CW2 John Doe	Survey Technician	1 Mar 84 - 2 Mar 84 21 Mar 84
SFC John Doe	Battalion S3	14 Mar 84

b. Field Crew:

SSG John Doe	Party Chief	19 Jan 84 - 2 Apr 84
SGT John Doe	Computer	19 Jan 84 - 2 Apr 84
PFC John Doe	Computer/Drafting	19 Jan 84 - 2 Apr 84
SP5 John Doe	Field Crew Chief	19 Jan 84 - 2 Apr 84
SP4 John Doe	Surveyor	19 Jan 84 - 2 Apr 84
PFC John Doe	Surveyor	19 Jan 84 - 2 Apr 84
PFC John Doe	Surveyor	19 Jan 84 - 2 Apr 84
PFC John Doe	Surveyor	2 Feb 84 - 2 Apr 84
PFC John Doe	Surveyor	19 Jan 84 - 5 Feb 84
PFC John Doe	Surveyor	19 Jan 84 - 2 Apr 84

3. Requirements:

a. The original requirements for the project were –

(1) A verification of the entire boundary. The missing corners were to be monumented by Facilities Engineering Division.

(2) Third-order elevations were to be required on the boundary monuments.

(3) Topographic maps of the two areas where Buildings 87 and 92 would be relocated.

b. After the final reconnaissance was made, the requirements had been changed to –

(1) A verification survey of the entire boundary. The missing corners were to be monumented by the survey crew with monuments premade by Facilities Engineering Division.

(2) Third-order elevations were required on the boundary monuments.

(3) The topographic maps were no longer needed.

(4) A drawing of the base boundary would be provided by the survey team, as well as station descriptions for each corner and bench mark.

c. As the project neared its end, and the monuments for the boundary corners were still not made; the requirements for elevations on each boundary monument changed to establishing bench marks near the boundary corners (for example, nails in headwalls) and on as many boundary monuments as time would permit. All other requirements remained the same as stated in paragraph 3b of this report.

4. Methods Used: In order to accomplish the mission, it was broken down into five main areas:

a. Reconnaissance: The reconnaissance was conducted approximately one month in advance of beginning the field work. It consisted mainly of a deed search at the courthouse, obtaining additional information from adjoining landowners (for example, CONRAIL, Pennsylvania Turnpike Authority), an on-ground search for existing boundary corners and starting control, and arranging logistical support. This phase of the operation resulted in a reciprocal request from the Pennsylvania Turnpike Authority for two copies of our final drawings (see Encl 8).

b. Traversing: All traverse work was performed using third-order Class I procedures. In total, there were seven traverses, one of which was the main control traverse. It contained 25 stations and was run from station Shuey, a first-order horizontal control point, through boundary corners number 4, 5, and 6, stations T-4 and T-5, and closed on station Fishing, a second-order point. This established a common coordinate system for the existing boundary corners, and the other traverses we ran to place control near where the remaining boundary corners should have been. The azimuths were checked and verified by performing astronomic azimuth observations to third-order specifications at station Shuey and at station T-4 to T-5. The main control traverse had a position closure of 1:17,000 and the poorest closure obtained on any of the other six traverses was 1:5,000.

c. Locating Corners/Placing Monuments: The lost/destroyed boundary corners were recovered and/or replaced by the following procedures:

(1) Coordinates were computed for all boundary corners using the coordinates we established on boundary corners 4, 5, and 6, and the bearings and distances from the deeds.

(2) Inverses were computed from our traverse stations nearest the desired corner to that boundary corner.

(3) The traverse station was occupied, the computed angle was turned, and the distance was horizontally taped, thus locating the corner in question. This point was then temporarily marked by either a piece of rebar, a railroad spike, or a P-K nail depending on the type of ground encountered.

(4) After the monuments had been made, we built plumbing benches over the temporary marks, removed the markers, dug the holes and placed the monuments in their proper positions. After the dirt was tamped down and the plumb was checked, concrete collars were poured around the monuments to ensure that they would not move.

d. Leveling: The requirement for third-order elevations was met by running two third-order lines. The first line started on bench mark NC-2 and ran around the perimeter of the southern half of the depot to bench mark NC-1. This line established 13 bench marks, had an error of closure of 0.065 feet, and was 4.8 miles long. The second line started on bench mark NC-1 and ran around the perimeter of the northern half of the depot to station T-4. This line established elevation on seven points, had an error of closure of 0.003 feet, and was 1.7 miles long.

e. Computing/Drafting Computing for this project was an ongoing endeavor from the time of the final reconnaissance until two weeks after the end of the project. This was due largely to the vast number of deeds for the land surrounding and now comprising New Cumberland Army Depot and the fact that some of the final data was needed on site at the completion of the project. The drafting was accomplished in the last two weeks of the project and consisted of three drawings. Copies of all drawings were provided to Facilities Engineering Division prior to departing New Cumberland. Station descriptions were an ongoing effort throughout the project.

5. Equipment Used: The equipment used on this project falls into two categories – organizational and borrowed.

a. Organizational equipment: Three M892 vehicles, two wild T-2 theodolites, one berger military level, one cubic DM-60 infrared EDME, two Philadelphia rods, two T-2 target sets, one 50-meter steel tape, one 100-foot steel tape, one tape tension handle, one taping pin set, and an HP-97 programmable calculator.

b. Borrowed equipment: The following was borrowed from FED, NCAD: three FM handie talkies, one posthole digger, one auger truck with operators, and on two or three occasions when our vehicles were down, a carryall from TMP.

6. Achievements: Excellent training was gained by all personnel in traverse, leveling, taping, and monument setting procedures. All personnel gained valuable experience at operating under extreme cold and wet conditions. SGT Doe and PFC Doe received valuable experience in all types of survey computations, to include curve layouts. SP5 Doe gained experience as a field crew chief. Facilities Engineering Division, NCAD gained much needed field data that should prove useful any time projects requiring survey data are undertaken by their office. In addition, all personnel assigned to the project, and the 99th Engineer Company (Survey), were each awarded a certificate of appreciation from the depot commander, Colonel John Doe.

7. Technical Difficulties: The majority of the technical problems encountered were a direct result of the vast number of deeds we were dealing with. Many of those deeds listed magnetic bearings, while others used true bearings. Ordinarily this would have been no problem, but the catch was that out of all the deeds we had, only two specified what type of bearings they were listing. This left us with a large jigsaw puzzle with many variables. It became a matter of trial and error until we were finally able to get the boundary to close on itself. Another problem encountered was that one of the reference drawings provided to us by Facilities Engineering Division had the numbers within a given distance scrambled; that is, 1307 feet was really 1370 feet. Additional problems were encountered when our only EDME went down and no replacement was available. The problems encountered in this area were due directly to a lack of training in taping procedures. After about two days of intensive on-site training, this problem was resolved.

8. Administrative/Other Problem Areas: The largest single problem encountered on this project was vehicles and vehicle maintenance support. The maintenance support that was promised **verbally** by the TMP at NCAD never developed. As a result, I would strongly recommend a written agreement be established during the recon phase of all future projects. As for the problems we encountered with our vehicles (for example, not starting, exhaust systems, tune-ups), I cannot understand how they could have gone through a complete **A** service prior to departing on the project and still be in such a poor state of repair. The only other real problem encountered was the adverse weather conditions that repeatedly plagued us. In total, we lost 13 work days to snow, ice, rain, or fog.

9. Summary: All in all, this was an excellent project. It fulfilled a vast amount of training requirements in a wide variety of skills. Once again, it became very obvious as to our weaknesses in the equipment department. These weaknesses include, but are not limited to, a need for rapid mobile communications equipment, medium or long range EDME, and four-wheel drive vehicles.

JOHN DOE
SSG, USA
Party Chief

8 Encl
as

Zenith Distance/Vertical Angle

For use of this form, see FM 5-232; the proponent agency is TRADOC

STATION ______________________ DATE ________ 19 _____

INSTRUMENTMAN ______________________ INSTRUMENT ____________

RECORDER ____________________ WEATHER ____________

OBJECT OBSERVED	CHRON TIME			STOP WATCH	TEL D/R	CIRCLE	
	H	M	S				

MICRO		MEAN	ZEN DIST	REMARKS	LEVELS	
1ST	2D				W	E

DA Form 5817-R, AUG 89

General Survey Notes

For use of this form, see FM 5-232; the proponent agency is TRADOC.

Project		Weather			Wind		Instrument			Date	
Designation		Location			Temp		Organization			Page no.	No. of Pages
Point	H Dist	H Scale	RI	V Scale	Prod ±	RC −	DE ±	HI	Elev.	Remarks	

DA Form 5818-R, AUG 89

Field Sheet, Infrared

For use of this form, see FM 5-232; the proponent agency is TRADOC.

PROJECT						
ORGANIZATION			DATE		APPROX DISTANCE	
ZERO CORRECTION *	CALIBRATION DATE		OBSERVER		RECORDER	
INSTRUMENT STATION	H.I.		ELEVATION	ELEVATION INSTRUMENT	ECCENTRICITY * TOWARD AWAY	INST NO
REFLECTOR STATION	H.I.		ELEVATION	ELEVATION REFLECTOR	ECCENTRICITY * TOWARD AWAY	PRISM NO

METEOROLOGICAL READINGS				ZD INSTRUMENT TO REFLECTOR		
	TIME	PRESSURE (Hg)	TEMP. (DRY)	DISTANCE (meters)		
		IN.	F°	1		
INSTRUMENT				2		
REFLECTOR				3		
SUM				4		
MEAN				5		
CORRECTION FACTOR (PPM)				6		
				7		
				8		
				9		
				10		
				SUM		

$$\text{PRODUCT} = \text{UD} \times \text{PPM}$$
$$\text{RC} = \text{PRODUCT} \times 10^{-6}$$
$$T = \text{UD} \pm Z \pm \text{RC}$$
$$H' = (T)^2 - (d)^2$$
$$H' = \text{SIN ZD} \times T$$
$$H_{FT} = H' \times 3.280840$$

UD		MEAN UNCORRECTED SLOPE DISTANCE (UD)		
PPM		ZERO CORRECTION° (Z)		
PRODUCT		REFRACTIVE INDEX CORRECTION (RC)		
RC		CORRECTED SLOPE DISTANCE (T)		
DIFF. OF ELEV. (d)		UNCORRECTED HORIZON. DISTANCE (H')		
		ECCENTRIC CORRECTION * (EC)		
		HORIZON DISTANCE (H_M) / (H_{FT})		

° Obtained from Instrument Calibration.
* Toward Eccentricity must be ADDED.
Away Eccentricity must be SUBTRACTED.

REMARKS

COMPUTED BY	DATE	CHECKED BY	DATE	PAGE OF

DA Form 5819-R, AUG 89

Three-Wire Leveling

For use of this form, use FM 5-232; the proponent agency is TRADOC.

Project	Location	Organization			
Observer	Recorder	Instrument	Sun	Wind	Weather

From	To	Date	Time	Line or Net	Page no.	No. of pgs.

Station	Backsight Face of rod	Mean	Back of rod	Interval	Sum of intervals	Foresight Face of rod	Mean	Back of rod	Interval	Sum of intervals	Remarks

Station	Backsight Face of rod	Mean	Back of rod	Interval	Sum of intervals	Foresight Face of rod	Mean	Back of rod	Interval

INST OP INT ____________

1st COMP INT ____________

2nd COMP INT ____________

Airfield Compilation Report

For use of this form, see FM 5-232; the proponent agency is TRADOC.

SURVEY AGENCY: 1					
AIRPORT NAME			IDENTIFIER		
CITY 4		STATE 5	EDITION 6	SURVEY DATE 7	
AIRPORT REFERENCE POINT	8	LATITUDE 9	LONGITUDE 10	Δ CL OR Θ ANGLE 11	
AIRPORT LOCATION POINT	12	LATITUDE 13	LONGITUDE 14	DECLINATION 15	
AIRPORT ELEVATION (In feet) 16	LOCATED 17			CONTROL TOWER FLOOR ELEVATION (In feet) 18	
19 **DATUM**			POSITION CODE –	1. Field Survey 2. Photogrammetric 3 .Other	

AIRPORT DATA	ELEVATION	LATITUDE	LONGITUDE	YR-CODE	REMARKS	OFFICE CODE
20	21	22	23	24	25	26

RUNWAY	DSPLCD THR LENGTH	RWY END ELEVATION	LATITUDE	LONGITUDE	WIDTH / LENGTH	GEODETIC AZ. (N) / MAG. BEARING (N)	OFFICE CODE
							34

Precision Approach Radar (GCA) Data

For use of this form, see FM 5-232; the proponent agency is TRADOC.

AIRPORT NAME		
CITY	STATE	SURVEY DATE (Mo./Day/Year)

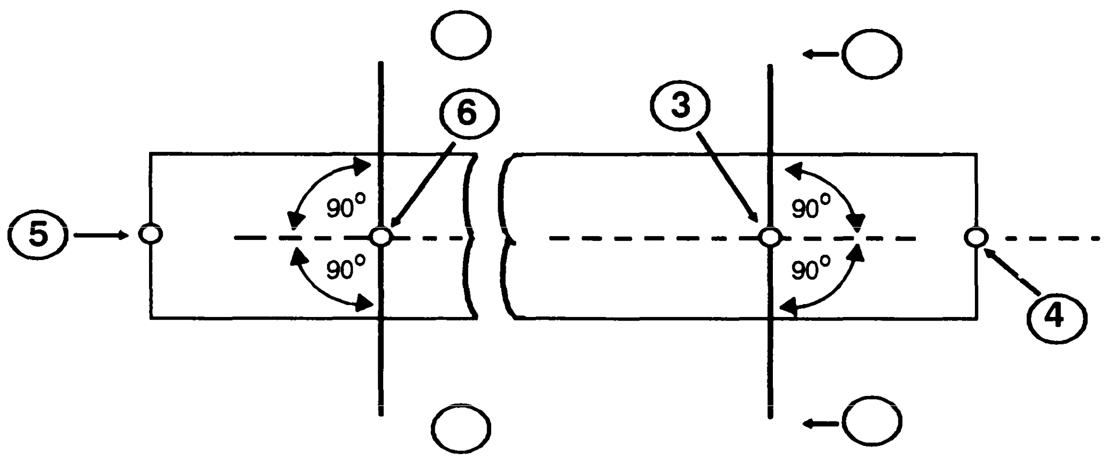
PAR COMPONENTS AND PERTINENT RUNWAY DATA Numbered items correspond to the diagram below.	LATITUDE	LONGITUDE	ELEVATION
	(1 / 100 Second)		(1 / 10 Foot)
1. PAR Antenna			
2. Touchdown Reflector			
3. The point on runway C/L closest to the Touchdown Reflector (Item 2).			
4. Runway C/L End.			
5. Runway C/L End.			
6. The point on runway C/L closest to PAR Antenna.			
7. Displaced Threshold (If applicable).			

PAR Antenna – Enter Numeral 1 in circle to indicate PAR Antenna Position.

Touchdown Reflector – Enter Numeral 2 in circle to indicate Touchdown Reflector.

PAR – GROUND DISTANCE			
3 to 7 FEET (If applicable)	1 to 6 FEET	2 to 3 FEET	GEODETIC AZIMUTH SOUTH
	3 to 6 FEET	3 to 4 FEET	4 to 5 ° ′ ″

ADD APPLICABLE NUMBERS TO CIRCLES AND RUNWAY ENDS. SHOW NORTH ARROW.



DA Form 5822-R, AUG 89

Instrument Landing System Data

For use of this form, see FM 5-232; the proponent agency is TRADOC.

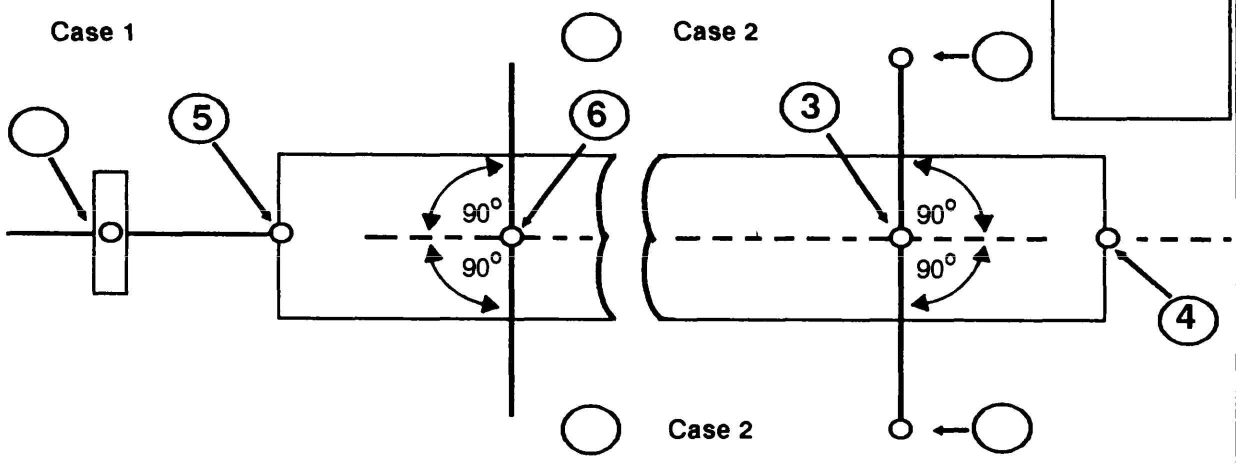
AIRPORT NAME		
CITY	STATE	SURVEY DATE (Mo./Day/Year)

ILS COMPONENTS AND PERTINENT RUNWAY DATA Numbered items correspond to the diagram below.	LATITUDE	LONGITUDE	ELEVATION
	(1 / 100 Second)		(1 / 10 Foot)
1. Localizer Antenna (Course Array): Point on ground beneath the localizer antenna.			
2. Glide Slope Indicator (GSI): Center of the base supporting the antenna.			
3. The point on runway C/L closest to the base of the Glide Slope Indicator Antenna (Item 2).			
4. Runway C/L End.			
5. Runway C/L End.			
6. The point on runway C/L closest to the base of the offset Localizer (Case 2).			

MARKERS	LATITUDE	LONGITUDE	GROUND DISTANCE TO END OF RUNWAY
	(1 / 10 Second)		
INNER OR B. C. MARKER (RUNWAY END)			feet
MIDDLE MARKER (RUNWAY END)			feet
OUTER MARKER (RUNWAY END)			feet

LOCALIZER – GROUND DISTANCE			
Case 1 (normal)	Case 2 (offset)		
1 to 5 FEET	1 to 6 FEET	2 to 3 FEET	GEODETIC AZIMUTH SOUTH
	5 to 6 FEET	3 to 4 FEET	4 to 5 ° ′ ″

ADD APPLICABLE NUMBERS TO CIRCLES AND RUNWAY ENDS. SHOW NORTH ARROW.



DA Form 5827-R, AUG 89

Glossary

Section I
ACRONYMS AND ABBREVIATIONS

AAF Army airfield

AG Adjutant General

AISI automated integrated survey instruments

ALP airpoint location point

ALS approach light system

AMTP Army Mission Training Plan

APO Air Post Office

APPS Analytical Photogrametric Position System

APRT Army physical readiness test

AR Army regulation

ARNG Army National Guard

ARP airpoint reference point

ARSR air route surveillance radar

ARTCC air route traffic control center

ARTEP Army Training and Evaluation Program

ASR airport surveillance radar

ATC air traffic control

AUTOVON automatic voice network

az azimuth

BAQ basic allowance for quarters

BC back course

BCM back course marker

BEQ bachelor enlisted quarters

bkwd backward

bldg building

BLM Bureau of Land Management

BM bench mark

bn battalion

BS backsight

cal calibration

carto cartography, cartographic

cdr commander

CEOI communications-electronics operation instructions

CESI communications-electronics standing instruction

chron chronometer

C/L centerline

co company

COB close of business

CONRAIL Continental Railroad

corr correction

CTI common task test

DD (form), Department of Defense

DE difference in elevation

deg degree

DEH Directorate of Engineering and Housing

DF direction finder

diff difference

DIO Director of Industrial Operations

dir/ang direction/angle

DMA Defense Mapping Agency

DME distance measuring equipment

DPT Director of Plans and Training

dsplcd displaced

D/R direct/reverse

D displaced threshold

EC eccentric correction

EDME electronic distance measuring equipment

elev elevation

encl enclosure

engr engineer

EOR end of runway

exp explement

FAA Federal Aviation Administration

FAO finance and accounting office

FAR Federal Aviation Regulation

FED Facilities Engineering Division

FM field manual

FM frequency modulated

FORSCOM United States Army Forces Command

FOUO For Official Use Only

FRAGO fragmentary order

FTS Federal Telecommunications System

fwd forward

G3 Assistant Chief of Staff, G3 (Operations and Plans)

GCA ground-controlled approach

GPS global positioning system

GSI glide slope indicator

HC horizon closure

H Dist horizontal distance

Hg The symbol for the element mercury

HHC headquarters and headquarters company

HI height of instrument

HQDA Headquarters, Department of the Army

H Scale horizontal scale

HT height of target

IAW in accordance with

IFR instrument flight rules

ILS instrument landing system

IM inner marker

incl inclination

INS inertial navigational system

instr instrument

ISVT initial site visitation trip

kHz kilohertz

km kilometer

lb pound(s)

LDA localizer-type directional aid

L/MF low or medium frequency

LOC Iocalizer

LORAN long range navigation

MACOM major Army command

mag magnetic

MFR memorandum for record

MHz megahertz

micro micrometer

MLS microwave landing system

MM middle marker

mm millimeter

mo month

MOA Memorandum of Agreement

MOS military occupational specialty

MSAW minimum safe altitude warning

MSL mean sea level

NA not applicable

NAD North American Datum

NAVAID navigational aid

NAVD North American Vertical Datum

NCAD New Cumberland Army Depot

NCO noncommissioned officer

NCOIC noncommissioned officer in charge

NDB nondirectional radio beacon

NFDC National Flight Data Center

NFDD National Flight Data Digest

NGS National Geodetic Survey

NGVD National Geodetic Vertical Datum

NLT not later than

no number

NOAA National Oceanic and Atmospheric Administration

OC obstruction chart

ODALS Omnidirectional Approach Light System

OM outer marker

opns operations

OPORD operation order

OVM organization vehicle maintenance

PAC Personnel and Administration Center

PADS position and azimuth determination system

PAPI precision approach path indicator

PAR precision approach radar

PBM permanent bench mark

pgs pages

PLASI pulsating visual approach slope indicator

PMCS preventive maintenance checks and services

POC point of contact

POL petroleum, oils, and lubricants

Pos. Rep. position repetition

POV privately owned vehicle

PX Post exchange

R1 reject value, use first mean value

R2 reject value, use second mean value

RADAR radio detection and ranging

RC rod center

recon reconnaissance

REIL runway end identifier lights

RFI radio frequency interference

RM reference mark

R_o rejected by observation

RT relocated threshold

RTO radiotelephone operator

RVR runway visual range

RW runway visibility value

rwy runway

S1 Adjutant (US Army)

S3 Operations and Training Officer (US Army)

S4 Supply Officer (US Army)

SATO Scheduled Airline Ticket Office

SCP survey control point

SDF simplified directional facility

SDNCO staff duty noncommissioned officer

SIC survey information center

SIF Stadia Interval Factor

SOI signal operation instructions

SOP standing operating procedure

SP Special publication

SQT skill qualification test

SSGCN Standards and Specifications for Geodetic Control Networks

SSI standing signal instructions

sta station

STP Soldier Training Publication

TACAN tactical air navigation

TBM temporary bench mark

TCMD transportation control management document

TDA tables of distribution and allowances

TDY temporary duty

TDZE touchdown zone elevation

TECHOPORD technical operation order

temp temperature

TERPS terminal instrument procedures

TM technical manual

TMP transportation motor pool

TOE table(s) of organization and equipment

topo topographic

TRADOC United States Army Training and Doctrine Command

trig trigonometric

UHF ultra high frequency

US United States

USAADCENFB United States Army Air Defense Center and Fort Bliss

USAASD-E United States Army Aeronautical Services Detachment, Europe

USAASO United States Army Aeronautical Services Office

USAES United States Army Engineer School

USAR United States Army Reserve

USC&GS US Coast and Geodetic Survey

UTM universal transverse mercator (grid)

VASI visual approach slope indicator

vern vernal

VFR visual flight rules

VOR very high frequency omnidirectional range

VORTAC very high frequency omnidirectional range/tactical air navigation

V scale vertical scale

WDI wind direction instrument

WGS World Geodetic System

WWV transmitting station

yr year

zen dist zenith distance

Section II
SURVEY TERMS

Aberration of light-(astronomic) – The apparent displacement in position of a stellar body due to the velocity of light combined with the motion of the earth itself.

Accidental error – Any small error accidentally incurred in a measurement. Unlike systematic errors, accidental errors are not governed by fixed laws. The theory of probability is based on the occurrence of these errors, which could be positive or negative.

Accuracy – The degree of conformity with a standard, or the degree of perfection attained in a measurement. Accuracy relates to the quality of a result, and is distinguished from precision which relates to the quality of the operation by which the result is obtained.

Actual error- The difference between the accepted value and the measured value of a physical quantity.

Adjusted position – An adjusted value for the horizontal or vertical position of a survey station, in which discrepancies due to errors in the observed data are removed. This adjustment forms a coordinated and correlated system of stations.

Aeronautical beacon – A visual navigational aid displaying flashes of white and/or colored light to indicate the location of an airport, a heliport, a landmark, a certain point of a federal airway in mountainous terrain, or an obstruction. (See Airport Rotating Beacon under Airport Lighting.)

Air navigation facility – Any facility used in, available for use in, or designed for use in aid of air navigation, including landing areas, lights, any apparatus or equipment for disseminating weather information, for signaling, for radio-directional finding, or for radio or other electrical communication, and any other structure or mechanism having a similar purpose of guiding or controlling flight in the air or the landing and takeoff of aircraft, (See Navigational Aid.)

Airport – An area on land or water that is used or intended to be used for the landing and takeoff of aircraft and includes its buildings and facilities, if any.

Airport elevation – The highest point of an airport's usable runways measured in feet from mean sea level (technically, *NGVD 1929* or other vertical datum).

Airport lighting – Various lighting aids that maybe installed on an airport. Types of airport lighting include –

- *Airport rotating beacon.* A visual navigational aid operated at many airports. At civil airports, alternate white and green flashes indicate the location of the airport. At military airports, the beacon flashes alternately white and green, but is differentiated from civil beacons by dualpeak (two quick) white flashes between the green flashes.
- *Approach light system (ALS). An* airport lighting facility which provides visual guidance to landing aircraft by radiating light beams in a directional pattern by which the pilot aligns the aircraft with the extended centerline of the runway on his final approach for landing. A number of ALS configurations exist, both with and without sequenced flashing lights. One system is the Omnidirectional Approach Light System (ODALS), which consists of seven omnidirectional flashing lights located in the approach area of a nonprecision approach. Five lights are located on the runway centerline extended and the other two are located one on each side of the runway threshold.
- *Runway end identifier lights (REIL).* Two synchronized flashing lights, one on each side of the runway threshold, which provide rapid and positive identification of the approach end of a particular runway.
- *Visual approach slope indicator (VASI). An* airport lighting facility providing vertical visual approach slope guidance to aircraft during approach to landing by radiating a directional pattern of high-intensity red and white focused light beams which indicate to the pilot if he is above, below, or on the glide path. (The term "visual approach slope indicator" also has a generic connotation, as used below.)
- *Tri-color approach slope indicator.* A visual approach slope indicator consisting of a single light unit projecting a three-color visual approach path into the final approach area of the runway served by the system.
- *Pulsating visual approach slope indicator (PLASI).* A visual approach slope indicator normally consist-

ing of a single light unit projecting a pulsating two-color visual approach path into the final approach area of the runway served by the system.

- *Precision approach path indicator (PAPI).* A visual approach slope indicator consisting of a single row of two or four light units, similar to the VASI, usually installed on the left side of the runway served by the system.

Airport location point (ALP) - The permanent position, usually expressed in latitude and longitude, of an airport for identification and reference purposes. The ALP coincides with the original Airport Reference Point, (See Airport Reference Point.)

Airport reference point (ARP) – The position of the approximate center of mass of all usable runways. This point is not strictly the center of mass of runways, since runway width, thickness, or material is not considered in the computation. The ARP is not monumented, therefore not recoverable on the ground.

Airport surveillance radar (ASR) – Approach control radar used to detect and display an aircraft's position in the terminal area. The ASR provides range and azimuth information but does not provide elevation data. Coverage of the ASR can extend up to 60 nautical miles.

Air route surveillance radar (ARSR) – Air route traffic control center (ARTCC) radar used primarily to detect and display an aircraft's position while enroute between terminal areas. Coverage of the ARSR can extend up to 200 nautical miles.

Altimeter– An aneroid barometer used for the measurement of approximate elevations or approximate differences of elevation.

Altitude – The vertical angle measured between the plane of the observer's true horizon and a line to the object.

Angle of depression – A negative altitude.

Angle of elevation – A positive altitude.

Apron/ramp –A defined area on an airport or heliport intended to accommodate aircraft for purposes of loading and unloading passengers or cargo, refueling, parking, or maintenance. With regard to seaplanes, a ramp is used for access to the apron from the water.

Arithmetical mean – The value obtained by dividing the sum of a series of values by the number of values in the series.

Astronomical latitude – The angle between the plumb line and the plane of celestial equator, Also defined as the angle between the plane of the horizon and the axis of rotation of the earth. Astronomical latitude applies only to positions on the earth and is reckoned from the astronomic equator (0°), north and south through 90°. Astronomical latitude is the latitude which results directly from observations of celestial bodies, uncorrected for deflection of the vertical.

Astronomical longitude – The angle between the plane of the celestial meridian and the plane of an initial meridian, arbitrarily chosen. Astronomical longitude is the longitude which results directly from observations on celestial bodies, uncorrected for deflection of the vertical.

Astronomical triangle – The triangle on the celestial sphere formed by arcs of great circles connecting the celestial pole, the zenith, and a celestial body. The angles of the astronomical triangles are: at the pole, the hour angle; at the celestial body, the parallactic angle; at the zenith, the azimuth angle. The sides are: pole to zenith, the co-latitude; zenith to celestial body, the zenith distance; and celestial body to pole, the polar distance.

Azimuth-(surveying) – The horizontal direction of a line measured clockwise from a reference plane, usually the meridan. Often called *forward azimuth* to differentiate from *back azimuth,*

Azimuth angle-(astronomy) – The angle less than 180° between the plane of the celestial meridian and the vertical plane containing the observed object, reckoned from the direction of the elevated pole. In astronomic work, the azimuth angle is the spherical angle at the zenith in the astronomical triangle which is composed of the pole, the zenith, and the star. In geodetic work, it is the horizontal angle between the celestial pole and the observed terrestrial object.

Azimuth mark – A marked point or adjacent station visible from an occupied station, the azimuth to which is determined for use in dependent surveys.

Backsight–

(1) In *traversing* a backsight (BS) is a sight on a pre-

viously established traverse or triangulation station, which is not the closing sight on the traverse.
(2) In *leveling,* a backsight is a reading on a rod held on a point whose elevation has been previously determined and which is not the closing sight of a level line.

Baseline – A surveyed line established with more than usual care, to which surveys are referred for coordination and correlation.

Base net – A small net of geometric figures used to expand from a baseline to a line of the main scheme of a triangulation net.

Basic control – Horizontal and vertical control of third- or higher-order accuracy, determined in the field and permanently marked or monumented, that is required to control further surveys.

Bearing – The direction of a line within a quadrant, with respect to the meridian. Bearings are measured clockwise or counterclockwise from north or south, depending on the quadrant.

Bench mark– A relatively permanent object, natural or artificial, bearing a marked point whose elevation above or below an adopted datum is known. Usually designated as a BM, such a mark is sometimes further qualified as a PBM (permanent bench mark), or as a TBM (temporary bench mark).

Blast pad – A specially prepared surface placed adjacent to the ends of runways to eliminate the erosive effect of the high wind forces produced by airplanes at the beginning of their takeoff rolls.

Cadastral survey– A survey relating to land boundaries and subdivisions, made to create units suitable for transfer or to define the limitations of title. The term cadastral survey is now used to designate the surveys of the public lands of the United States, including retracement surveys for the identification and resurveys for the restoration of property lines; the term can also be applied properly to corresponding surveys outside the public lands, although such surveys are usually termed land surveys through preference.

Celestial equator- A great circle on the celestial sphere on which any point is equidistant from the celestial poles, The plane of the earth's equator, if extended, would coincide with that of the celestial equator.

Celestial meridian – A vertical circle, passing through both celestial poles, the plane of which is perpendicular to the celestial equator.

Celestial pole – A reference point located at the point of intersection of an indefinite extension of the earth's axis of rotation and the apparent celestial sphere.

Celestial sphere – An imaginary sphere of infinite radius with the earth as a center. It rotates from east to west on a prolongation of the earth's axis.

Central meridian – The line of longitude at the center of a projection. Generally the basis for constructing the projection.
State plane-coordinate system. The meridian used as the axis of Y for computing projection tables for a state coordinate system. The central meridian of the system usually passes close to the center of figure of the area or zone for which the tables are computed.

Chronometer – A portable timekeeper with compensated balance, capable of showing time with extreme precision and accuracy.

Circle position – A prescribed setting (reading) of the horizontal circle of a direction theodolite, to be used for the observation on the initial station of a series of stations that are to be observed.

Circuit closure – In leveling, the amount by which the algebraic sum of the measured differences of elevation around a circuit fails to equal zero.

Circumpolar star– A star in any given latitude which never goes below the horizon; hence, its polar distance must be less than the given latitude. In astronomy only those stars with a polar distance of less than 10° are considered in practical problems.

Clearway – An area beyond the takeoff runway under the control of airport authorities within which terrain or fixed obstacles may not extend above specified limits. These areas may be required for turbine-powered operations, and the size and upward slope of the clearway will differ depending on when the aircraft was certified.

Closed traverse – A traverse that starts and ends at the same point or at stations whose positions have been determined by other surveys. See *loop traverse.*

Collimation – The line of sight or aiming line of the instrument when coincident with the physical alignment of the instrument; thus, collimation error is the angle between the line of collimation (line of sight) of a telescope and the collimation axis of the instrument.

Compass locator– A low-power, low-or medium-frequency (L/MF) nondirectional beacon installed at the site of the outer or middle marker of an instrument landing system. It can be used for navigation at distances of approximately 15 miles or as authorized in the approach procedure.

Control –
(1) The coordinated and correlated dimensional data used in geodesy and cartography to determine the positions and elevations of points on the earth's surface or on a cartographic representation of that surface.
(2) A collective term for a system of marks or objects on the earth or on a map or a photograph whose positions or elevation, or both, have been or will be determined.

Control survey – A survey which provides positions (horizontal or vertical) of points to which supplementary surveys are adjusted.

Coordinates – Linear or angular quantities, or both, which designate the position of a point in relation to a given reference frame. There are two general divisions of coordinates used in surveying: *polar coordinates and rectangular coordinates.* These may be subdivided into three classes: *plane coordinates, spherical coordinates, and space coordinates.*

Culmination, transit – The instant when any point on the celestial sphere is on the meridian of an observer. When it is on that half of the meridian containing the zenith, it is called the upper transit; when it is on the other half, it is called the lower transit.

Datum – Any numerical or geometrical quantity or set of such quantities which may serve as a reference or base for other quantities.
(1) *Geodetic.* A reference surface consisting of five quantities: the latitude and longitude of an initial point, the azimuth of a line from this point, and the parameters of the reference ellipsoid. It forms the basis for the computation of horizontal-control surveys in which the curvature of the earth is considered.
(2) *Leveling.* A level surface to which elevations are referred; usually, but not always, mean sea level.

Declination –
(1) In a system of polar or spherical coordinates, the angle at the origin between a line to a point and the equatorial plane, measured in a plane perpendicular to the equatorial plane.
(2) The arc between the equator and the point measured on a great circle perpendicular to the equator.
(3) Declination, as it relates to astronomy, is the angular distance to a body on the celestial sphere measured north or south through 90° from the celestial equator along the hour circle of the body. Comparable to latitude on the terrestrial sphere.
(4) Often used as a shortened term for magnetic declination although this use is not preferred.

Deflection of the vertical – The angular difference, at any place, between the upward direction of a plumb line (the vertical) and the perpendicular (the normal) to the reference spheroid. This difference seldom exceeds 30 seconds. Often expressed in two components, *meridian and prime vertical.*

Departure – In a plane survey, the difference between the castings of the two ends of the line, which may be either plus or minus. This value is symbolized by a ΔE.

Direction finder (DF) – A radio receiver equipped with a directional sensing antenna used to take bearings on a radio transmitter

Direct leveling– The determination of differences of elevation by means of a continuous series of short horizontal lines. Vertical distances from these lines to adjacent ground marks are determined by direct observations on graduated rods with a leveling instrument equipped with a spirit level.

Direct reading – The reading of the horizontal or vertical circle of a theodolite or engineer transit with the telescope direct. In field notes, a direct reading is indicated by the letter D preceding the observed value.

Direction instrument theodolite – A theodolite in which the graduated horizontal circle remains freed during a series of observations, the telescope being pointed on a number of signals or objects in succession, and the direction of each read on the circle, usually by means of micrometer microscopes. Direction instrument theodolites are used almost exclusively in first- and second-order triangulation.

Distance angle – An angle in a triangle opposite a side used as a base in the solution of the triangle, or a side whose length is to be computed.

Distance measuring equipment (DME) – Equipment (airborne and ground) used to measure, in nautical miles, the slant range distance of an aircraft from the DME navigational aid.

Ecliptic – The great circle on the celestial sphere which the sun appears to describe in its annual motion among the stars. It is inclined to the celestial equator at an angle of about 23°27'.

Elevation – Vertical distance from a datum, usually mean sea level, to a point or object on the earth's surface. Not to be confused with altitude, which refers to points or objects above the earth's surface.

Elongation – That point in the apparent movement of a circumpolar star when it has reached the extreme position east or west of the meridian.

Emulsion – A suspension of either light-sensitive silver salts, Diazos, or photopolymers, in a colloidal medium which is used for coating films, plates, and papers.

Ephemeris time – The uniform measure of time defined by the laws of dynamics and determined in principle from the orbital motions of the planets, specifically in the orbital motion of the earth.

Equation of time – The algebraic difference in hour angle between apparent solar time and mean solar time, usually labeled plus or minus, as it is to be applied to mean solar time to obtain apparent solar time.

Equinox – One of the two points of intersection of the ecliptic and the celestial equator, occupied by the sun when its declination is 0^{o}.

Error –

(1) The difference between an observed or true value of that quantity.

(2) A class of small inaccuracies due to imperfections in equipment or techniques, surrounding conditions, or human limitations; not to be confused with blunders or mistakes.

Error of closure – The amount by which a quantity obtained by a series of related measurements differs from the true or fixed value of the same quantity.

(1) *Angles.* The amount by which the actual sum of a series of angles fails to equal the theoretically exact value of that sum.

(2) *Azimuth.* The amount by which two values of the azimuth of a line, derived by different surveys or along different routes, fail to be exactly equal to each other.

(3) *Leveling.* The amount by which two values of the elevation of the same bench mark, derived by different surveys or through different survey routes or by independent observations, fail to be exactly equal to each other.

(4) *Loop.* The error in the closure of a survey on itself.

(5) *Horizon.* The amount by which the sum of a series of adjacent measured horizontal angles around a point fails to equal exactly 360°. Measurement of the last angle of the series is called closing the horizon; sometimes called closure of horizon.

(6) *Triangle.* The amount by which the sum of the three observed angles of a triangle fails to equal exactly 180° plus the spherical excess of the triangle.

(7) *Traverse.* The amount by which a value of the position of a traverse station, as obtained by computation through a traverse, fails to agree with another value of the same station as determined by a different set of observations or routes of survey.

Final approach course – A straight line extension of a localizer, a final approach radial/bearing, or a runway centerline, all without regard to distance.

Fixed elevation – An elevation which has been adopted, either as a result of tide observations or previous adjustment of spirit leveling, and which is held at its accepted value in any subsequent adjustment.

Flight path – A line, course, or track along which an aircraft is flying or intended to be flown.

Foresight – An observation of the distance and direction to the next instrument station.

(1) *Transit traverse.* A point set ahead to be used for reference when resetting the transit or line or when verifying the alinement.

(2) *Leveling.* The reading on a rod that is held at a point whose elevation is to be determined.

Frequency- The number of complete cycles per second existing in any form of wave motion.

Geodesic line – A line of shortest distance between any two points on any mathematically defined surface. A geodesic line is a line of double curvature, and usually lies between the two normal section lines which the two points determine. If the two terminal points are in nearly the same latitude, the geodesic line may cross one of the normal section lines. It should be noted that, except along the equator and along the meridians, the geodesic line is not a plane curve and cannot be sighted over directly. However, for conventional triangulation the lengths and directions of geodesic lines differ inappreciably from corresponding pairs of normal section lines.

Geodesy – The science which treats of the determination of the size and figure of the earth (geoid) by such direct measurements as triangulation, leveling, and gravimetric observations; which determines the external gravitational field of the earth; and, to a limited degree, the internal structure.

Geodetic control – A system of horizontal and/or vertical control stations that have been established and adjusted by geodetic methods and in which the shape and size of the earth (geoid) have been considered in position computations.

Geodetic latitude – The angle which the normal at a point on the reference spheroid makes with the plane of the geodetic equator. Geodetic latitudes are reckoned from the equator, but in the horizontal-control survey of the United States they are computed from the latitude of station Meades Ranch as prescribed in the *North American Datum of 1927.*

Geodetic leveling – Spirit leveling of a high order of accuracy, usually extended over large areas, to furnish accurate vertical control as a basis for the control in the vertical dimension for all surveying and mapping operations. Spirit leveling follows the geoid and its associated level surfaces which are irregular, rather than any mathematically determined spheroid or ellipsoid and associated regular level surfaces.

Geodetic longitude – The angle between the plane of the geodetic meridian and the plane of an initial meridian, arbitrarily chosen. A geodetic longitude can be measured by the angle at the pole of rotation of the reference spheroid between the local and initial meridians or by the arc of the geodetic equator intercepted by those meridians. In the United States, geodetic longitudes are numbered from the Meridian of Greenwich, but are computed from the meridian of station Meades Ranch as prescribed in the *North American Datum of 1927.* A geodetic longitude differs from the corresponding astronomical longitude by the amount of the prime vertical component of the local deflection of the vertical divided by the cosine of the latitude.

Geographic coordinates – An inclusive term generally used to designate both geodetic coordinates and astronomical coordinates.

Geoid – The figure of the earth considered as a sea-level surface extended continuously through the continents. The actual geoid is an equipotential surface coincident with mean sea level to which, at every point, the plumb line (direction in which gravity acts) is perpendicular. It is the geoid which is obtained from observed deflections of the vertical and is the surface of reference for astronomical observations and for geodetic leveling.

Gravimeter – A weighing device or instrument of sufficient sensitivity to register variations in the weight of a constant mass when the mass is moved from place to place on the earth and thereby is subjected to the influence of gravity at those places.

Gravitation –The acceleration produced by the mutual attraction of two masses, directed along the line joining their centers of masses, and of magnitude inversely proportional to the square of the distance between the two centers of mass.

Gravity – Viewed from a frame of reference freed in the earth, acceleration imparted by the earth to a mass which is rotating the earth. Since the earth is rotating, the acceleration observed as gravity is the resultant of the acceleration of gravitation and the centrifugal acceleration arising from this rotation and the use of an earthbound rotating frame of reference. It is directed normal to sea level and to its geopotential surfaces.

Ground-controlled approach (GCA) – A radar approach system operated from the ground by air traffic control personnel transmitting instructions to the pilot by radio. The approach maybe conducted with airport surveillance radar (ASR) only or with both surveillance and precision approach radar (PAR).

Hachures – A method of portraying relief by short, wedge-shaped marks radiating from high elevations and following the direction of slope to the lowland.

Height of instrument –

(1) *Spirit leveling.* The height of the line of sight of a leveling instrument above the adopted datum.

(2) *Stadia surveying.* The height of the center of the telescope (horizontal axis) of transit or telescopic alidade above the ground or station mark.

(3) *Trigonometrical leveling.* The height of the center of the theodolite (horizontal axis) above the ground or station mark.

Heliotrope – An instrument composed of one or more plane mirrors so mounted at the station being sighted upon that the sun's rays can be reflected to any one observing station.

Horizontal control - Control which determines horizontal positions only, with respect to parallels and meridians or to other lines of reference.

Horizontal refraction – A natural error in surveying which is the result of the horizontal bending of light rays between a target and an observing instrument. Usually caused by the differences in density of the air along the path of the light rays, resulting from temperature variations.

Hour angle – Angular distance west of a celestial meridian or hour circle; the arc of the celestial equator, or the angle at the celestial pole, between the upper branch of a celestial meridian or hour circle and the hour circle of a celestial body or the vernal eqinox measured westward through 360°.

Hour circle – Any great circle on the celestial sphere whose plane is perpendicular to the plane of the celestial equator.

Imaginary surface – Any surface defined in FAR-77, Subpart C.

. *Specified surface.* An imaginary surface, other than a supplemental surface, designated by appropriate FAA authorities for the purpose of defining obstructions. This surface may or may not be the surface specified in *FAR-77* for existing approach minimums.

• *Supplemental surface.* An imaginary surface designated by appropriate FAA authorities as a "supplemental surface." A supplemental surface will normally lie below a specified surface and is intended to provide additional obstruction information. An object that penetrates a supplemental surface only is a supplemental obstruction.

Instrument landing system (ILS) – A precision instrument approach system which normally consists of the following electronic components and visual aids:

- Localizer
- Glide Slope
- Outer Marker
- Middle Marker
- Approach Lights

Instrument runway – A runway equipped with electronic and visual navigational aids for which a precision or nonprecision approach procedure having straight-in landing minimums has been approved.

Intersection – A method of determining the horizontal position of a point by observations from two or more points of known position, thus measuring directions that intersect at the station being located. A station whose horizontal position is located by intersection is known as an intersection station.

Isogonic chart – A chart of which the chief feature is a system of isogonic lines, each for a different value of the magnetic declination.

Isogonic line– A line drawn on a map or chart joining points of equal magnetic variation.

Landing direction indicator – A device which visually indicates the direction in which landings and takeoffs should be made.

Laplace azimuth – A geodetic azimuth derived from an astronomic azimuth by use of the Laplace equation.

Laplace condition– The Laplace condition, expressed by the Laplace equation, arises from the fact that a deflection of the vertical in the plane of the prime vertical will give a difference between astronomic and geodetic longitude and between astronomic and geodetic azimuth; or, conversely, that the observed differences between astronomic and geodetic values of the longitude and of the azimuth may both be used to determine the deflection in the plane of the prime vertical.

Laplace equation – The equation which expresses the relationship between astronomic and geodetic azimuths in terms of astronomic and geodetic longitudes and geodetic latitude. Thus, Laplace correction = $(\lambda_A - \lambda_G)\ \mathrm{Sin}\ \phi_G$.

Laplace station – A triangulation or traverse station at which a Laplace azimuth is determined. At a Laplace station both astronomic longitude and astronomic azimuth are determined.

Level datum – A level surface to which elevations are referred. The generally adopted level datum for leveling in the United States is mean sea level. For local surveys, an arbitrary level datum is often adopted and defined in terms of an assumed elevation for some physical mark (bench mark).

Level net – Lines of spirit leveling connected together to form a system of loops or circuits extending over an area.

Line of sight –
(1) The straight line between two points. This line is in the direction of a great circle, but does not follow the curvature of the earth.
(2) The line extending from an instrument along which distant objects are seen, when viewed with a telescope or other sighting device.

Local hour angle – Angle distance measured on the celestial equator between the celestial meridian and the hour circle that passes through the object. The local hour angle represents physically the amount of rotation of the celestial sphere since the object was last on the observer's celestial meridian, and is always measured westward 0° to 360° from the celestial meridian.

Localizer (LOC) –The component of an ILS which provides course guidance to the runway.

Localizer back course – The course line defined by the Iocalizer signal along the extended centerline of the runway in the opposite direction to the normal localizer approach course (front course).

Localizer-type directional aid (LDA) – A navigational aid used for nonprecision instrument approaches with utility and accuracy comparable to a localizer but which is not part of a complete ILS and is not aligned with the runway.

Long range navigation (LORAN) – An electronic navigation system by which hyperbolic lines of position are determined by measuring the difference in the time of reception of synchronized pulse signals from two fixed transmitters. The LORAN A operates in the 1750-1950 kHz frequency band. The LORAN C and D operate in the 100-110 kHz frequency band.

Loop traverse – A closed traverse that starts and ends at the same station.

Main-scheme station – A station through which the basic survey computations are carried, also called a principal station, The main-scheme stations serve for the continued extension of the survey.

Marker beacon – An electronic navigational aid transmitting a 75 MHz vertical fan or boneshaped radiation pattern. Marker beacons are identified by their modulation frequency and keying code and, when received by compatible airborne equipment, indicate to the pilot, both aurally and visually, that he is passing over the facility.

- *Back course marker (BCM).* When installed, this normally indicates the localizer back course final approach fix where approach descent is commenced.
- *Inner marker (IM)* A marker beacon, used with an ILS category-II precision approach, located between the middle marker and the end of the ILS runway. It also marks progress during an ILS category-III approach. The inner marker is usually located at the point of decision height for ILS category-II approaches.
- *Middle marker (MM).* A marker beacon that defines a point along the glide slope of an ILS usually located at or near the point of decision height for ILS category-I approaches.
- *Outer marker (OM).* A marker beacon at or near the glide slope intercept altitude of an ILS approach. The outer marker is normally located 4 to 7 miles from the runway threshold on the extended centerline of the runway.

Mean sea level (MSL) – The mean surface water level determined by averaging heights at all stages of the tide over a 19-year period. Often used as a reference for general leveling operations.

Meridian angle – Angular distance east or west of the local celestial meridian; the arc of the celestial equator, or the angle at the celestial pole, between the upper branch of the local celestial meridian and the hour circle of a celestial body, measured eastward or westward from the local celestial meridian through 180°, and labeled E or W to indicate the direction of measurement.

Minimum safe altitude warning (MSAW) – A function of ARTS III computer that aids the controller by alerting him when a tracked Mode C-equipped aircraft is below or is predicted by the computer to go below a predetermined minimum safe altitude.

Minimum – Weather condition requirements established for a particular operation or type of operation; for example, IFR takeoff or landing, alternate airport for IFR flight plans, VFR flight.

Missed approach – A maneuver conducted by a pilot when an instrument approach cannot be completed to landing.

Monument – Any object or collection of objects that indicate the position on the ground of a survey station. In military surveys, the term monument usually refers to a stone or concrete station marker containing a special bronze plate on which the exact station point is marked.

Movement area – The runways, taxiways, and other areas of an airport/heliport which are utilized for taxiing/hover taxiing, air taxiing, takeoff, and landing of aircraft, exclusive of apron areas. At those airports/heliports with a tower, specific approval for entry onto the movement area must be obtained from ATC.

Nadir – The point on the terrestrial sphere directly beneath the observer and directly opposite to the zenith; the lowest point.

National Flight Data Center (NFDC) – A facility in Washington, DC established by the FAA to operate a central aeronautical information service for the collection, validation, and dissemination of aeronautical data in support of the activities of government, industry, and the aviation community. The information is published in the *National Flight Data Digest.*

National Flight Data Digest (NFDD) – A daily (except weekends and Federal holidays) publication of flight information appropriate to aeronautical charts, aeronautical publications, Notices to Airmen, or other media serving the purpose of providing operational flight data essential to safe and efficient aircraft operations.

NAVAID survey – The process of determining the position and/or elevation of one or more navigational aids and adjunctive points on associated runways or runway centerlines extended. A NAVAID survey that is performed as part of the OC survey is a Combined NAVAID Survey. A NAVAID survey that is not performed as part of a normal OC survey is a Special NAVAID Survey.

Navigable airspace – Airspace at and above the minimum flight altitude prescribed in the FARs, including airspace needed for safe takeoff and landing.

Navigational aid (NAVAID) – Any Visual or electronic device airborne or on the surface which provides point-to-point guidance information or position data to aircraft in flight. (See Air Navigation Facility.)

Nondirectional beacon (NDB) – An L/MF or UHF radio beacon transmitting nondirectional signals whereby the pilot of an aircraft equipped with direction-finding equipment can determine his bearing to or from the station. When the NDB is installed in conjunction with an Instrument Landing System marker, it is normally called a Compass Locator.

Nonprecision approach procedure – A standard instrument approach procedure in which no electronic glide slope is provided; for example, VOR, TACAN, NDB, LOC, ASR, LDS, and SDF approaches.

North American Datum of 1927 – The initial point of this datum is located at Meades Ranch, Kansas. Based on the Clarke spheroid of 1866, the geodetic positions of this system are derived from a readjustment of the triangulation of the entire country, in which Laplace azimuths were introduced.

Observer's meridian – A celestial meridian passing through the zenith at the point of observation and the celestial poles.

Obstruction – Any object that penetrates a specified surface. An object that penetrates a supplemental surface only is a supplemental obstruction. The most obstructing object in a set of objects is the one which penetrates an imaginary surface further than any other object in the set. (See Imaginary Surface.)

Occultation –
(1) *Astronomy.* The disappearance of a celestial body behind another body of larger apparent size. When the moon passes between the observer and a star, the star is said to be occulted.
(2) *Survey.* Name applied to a geodetic survey technique which employs the principle of occultation where repeated observations are made on an unknown position, accurately timed with similar observations at another unknown station, and mathematically reducing this data to determine the exact geodetic position of the unknown stations.

Offset line – A supplementary line close to and roughly parallel with a main line, to which it is referred by measured offsets. Where the line for which data are desired is in such position that it is difficult to measure over it, the required data are obtained by running an offset line in a convenient location and measuring offsets from it to salient points on the other line.

Open traverse – A survey traverse which begins from a station of known or adopted position, but does not end upon such a station.

Order of accuracy – A mathematical ration defining the general accuracy of the measurements made in a survey. The order of accuracy of surveys are divided into four classes labeled first order, second order, third order, and fourth or lower order.

Parallax –
(1) The apparent displacement of the position of a body, with respect to a reference point or system, caused by a shift in the point of observation.
(2) The apparent displacement between objects on the earth's surface due to their difference in elevation.

Permanent bench mark (PBM) – A bench mark of as nearly permanent character as it is practicable to establish. Usually designated simply as a bench mark or BM. A permanent bench mark is intended to maintain its elevation with reference to an adopted datum without change over a long period of time.

Personal equation – The time interval between the sensory perception of a phenomenon and the motor reaction thereto. A personal equation maybe either positive or negative, as an observer may anticipate the occurrence of an event or wait until he actually sees it occur before making a record. This is a systematic error, treated as the constant type.

Personal error– An error caused by an individual's personal habits, his inability to perceive or measure dimensional values exactly, or by his tendency to react mentally and physically in a uniform manner under similar conditions. Contrasted with blunder; mistake.

Picture point – In surveying, a terrain feature that is easily identified on an aerial photograph and whose horizontal or vertical position or both have been determined by survey measurements. Picture points are marked on the aerial photographs by the surveyor and are used by the photomapper.

Plumb line –
(1) The line of force in the geopotential field. The continuous curve to which the direction of gravity is everywhere tangential.
(2) The line indicated by a plumb-bob cord.

Precision approach procedure – A standard instrument approach procedure in which an electronic glide slope is provided; for example, ILS and PAR approaches.

Precision approach radar (PAR) – Radar equipment, usually located at military or joint use airfields, that detects and displays azimuth, elevation, and range of aircraft on the final approach course to a runway. The controller issues guidance instructions to the pilot based on the aircraft's position and elevation relative to the touchdown point on the runway displayed on the radar scope.

Prime meridian – The meridian of longitude 0°, used as the origin for measurement of longitude. The meridian of Greenwich, England, is almost universally used for this purpose.

Prime vertical – The vertical circle through the east and west points of the horizon. It maybe true, magnetic, compass, or grid depending upon which east or west points are involved.

Radar approach – An instrument approach procedure which utilizes Precision Approach Radar (PAR) or Airport Surveillance Radar (ASR).

Radio beacon – See Nondirectional Beacon.

Radio detection and ranging (RADAR) – A device which, by measuring the time interval between transmitted and received radio pulses, provides information on range, azimuth, and/or elevation of objects in the path of the transmitted pulse.

- *Primary radar.* A radar system which uses reflected radio signals.
- *Secondary radar.* A radar system wherein a radio signal transmitted from a radar station initiates the transmission of a radio signal fron another station.

Ramp – See Apron.

Right ascension – The angular distance measured eastward on the equator from the vernal equinox to the hour circle through the celestial body, from 0 to 24 hours.

Runway – A defined rectangular area on a land airport prepared for the landing and takeoff run of aircraft along its length.

Sea Level Datum of 1929 – The current standard datum for geodetic leveling in the United States, based on tidal observations over a number of years at various tide stations along the coasts.

Sexagesimal system – A system of notation by increments of 60; as the division of the circle into 360°, each degree into 60 minutes, and each minute into 60 seconds.

Sidereal day – The interval of time from a transit of the (true) vernal equinox across a given meridian to its next successive transit across the same meridian.

Sidereal time – Time based upon the rotation of the earth relative to the vernal equinox.

Simplified directional facility (SDF) – A navigational aid used for nonprecision instrument approaches. The final approach course is similar to that of an ILS localizer, except that the SDF course may not be aligned with the runway and the course may be wider, resulting in less precision.

Solar day –

(1) The interval of time from the transit of either the sun or the mean sun across a given meridian to the next successive transit of the same body across the same meridian.

(2) The duration of one rotation of the sun.

Solar time -

(1) Time based upon the rotation of the earth relative to the sun.

(2) Time on the sun.

Spheroid – Any figure differing slightly from a sphere. *Geodesy.* A mathematical figure closely approaching the geoid in form and size and used as a surface of reference for geodetic surveys.

Stopway – An area beyond the takeoff runway, no less wide than the runway and centered upon the extended centerline of the runway, able to support the airplane during an aborted takeoff without causing structural damage to the airplane and designated by the airport authorities for use in decelerating the airplane during an aborted takeoff. The location of threshold lights has no bearing on an area being designated a stopway.

Tactical air navigation (TACAN) – An ultra-high frequency electronic rho-theta air navigational aid which provides suitably equipped aircraft a continuous indication of bearing and distance to the TACAN station.

Target –

(1) Any object or point toward which something is directed.

(2) An object which reflects a sufficient amount of a radiated signal to produce an echo signal on detection equipment.

(3) The distinctive marking or instrumentation of a ground point to aid in its identification on a photograph. In photogrammetry, target designates a material marking so arranged and placed on the ground as to form a distinctive pattern over a geodetic or other control-point marker, on a property corner or line, or at the position of an identifying point above an underground facility or feature. A target is also the image pattern on aerial photographs of the actual mark placed on the ground prior to photography.

Tetrahedron – A device normally located on uncontrolled airports and used as a landing direction indicator. The small end of the tetrahedron points into the wind, therefore the direction of landing.

Threshold – The beginning of that portion of the runway usable for landing.

- *Displaced Threshold (DT).* A threshold that is located at a point on the runway other than the designated beginning of the runway. The displaced area is available for takeoff or rollout of aircraft. The displaced threshold paint bar is entirely on the usable landing surface.

- *Relocated Threshold (RT).* A threshold that is located at a point on the runway other than the beginning of the full strength pavement. The area between the former threshold and the relocated threshold is not available for the landing or takeoff of aircraft. The abandoned runway area mayor may not be available for taxiing.

Tidal bench mark – A bench mark set to reference a tide staff at a tidal station and the elevation of which is determined with relation to the local tidal datum.

Tidal datum – Specific tide levels which are used as surfaces of reference for depth measurements in the sea and as a base for the determination of elevation on land. Many different datums have been used, particularly for leveling operations.

Touchdown zone – The first 3,000 feet of the runway beginning at the threshold.

Touchdown zone elevation (TDZE) – The highest elevation in the touchdown zone. The OC program specifications require that the TDZE will be determined only for runways with specially prepared hard surfaces equal to, or greater than, 3,000 feet in length.

Transmissometer – An apparatus used to determine visibility by measuring the transmission of light through the atmosphere. It is the measurement source for determining runway visual range (RVR) and runway visibility value (RVV).

Transit – The apparent passage of a star or other celestial body across a defined line of the celestial sphere, as a meridian, prime vertical, or almucantar. The apparent passage of a star or other celestial body across a line in the recticle of a telescope, or some line of sight. The apparent passage of a smaller celestial body across the disk of a larger celestial body. The transit of a star across the meridian occurs at the moment of its culmination, and the two terms are sometimes used as having identical meanings; such usage is not correct, even where the instrument is in perfect adjustment. At the poles, a star may have no culmination but it will transit the meridians.

Vernal equinox – That point of intersection of the ecliptic and the celestial equator, occupied by the sun as it changes from south to north declination, on or about March 21, Same as first of Aries; first point of Aries; March equinox.

Vertical circle –

(1) A great circle of the celestial sphere, through the zenith and nadir. Vertical circles are perpendicular to the horizon.

(2) A graduated disk mounted on an instrument in such a manner that the plane of its graduated surface can be placed in a vertical plane. It is primarily used for measuring vertical angles in astronomical and geodetic work.

Vertical control – The measurements taken by surveying methods for the determination of elevation only with respect to an imaginary level surface, usually mean sea level.

Vertical-control datum – Any level surface (as, for example, mean sea level) taken as a surface of reference from which to reckon elevations. Although a level surface is not a plane, the vertical-control datum is frequently referred to as the datum plane.

Very high frequency omnidirectional range station (VOR) – A very high frequency navigational aid which provides suitably equipped aircraft a continuous indication of bearing to the VOR station.

Very high frequency omnidirectional range/tactical air navigation (VORTAC) – A navigational facility consisting of two components, VOR and TACAN, which provide three services: VOR azimuth, TACAN azimuth, and TACAN distance.

Zenith – The point where an infinite extension of a plumb (vertical) line, at the observer's position, pierces the celestial sphere above the observer's head.

Zenith distance – The complement of the altitude, the angular distance from the zenith of the celestial body measured along a vertical circle.

References

REQUIRED PUBLICATIONS

Required publications are sources that users must read in order to understand or comply with this publication.

Army Regulations (AR)

310-25 Dictionary of United States Army Terms

310-50 Authorized Abbreviations, Brevity Codes, and Acronyms

Department of the Army Forms (DA Form)

348 Equipment Operator's Qualification Record

1903 Azimuth by Direction Method

1905 Azimuth by Hour Angle Method

1907 Azimuth by Altitude Method

1916 Abstract of Horizontal Directions

1917 List of Directions

1923 Position Computation Order Triangulation for Calculating Machine Computation

1940 Traverse Computation on the Universal Traverse Mercator Grid

1942 Computation of Levels

1943 Abstract of Zenith Distances

1958 Description or Recovery of Bench Mark

1959 Description or Recovery of Horizontal Control Station

1962 Tabulation of Geodetic Data

2028 Recommended Changes to Publications and Blank Forms

2404 Equipment Inspection and Maintenance Worksheet

2496 Disposition Form

2544 Intra-Amy Order for Reimbursable Services

2847 Comparison of Chronometer and Radio Signals

4196 Horizontal Distance Book

4253 Horizontal Direction or Angle Book

4446 Level, Transit, and General Survey Record Book

4648 Station Description Book

4856 General Counseling Form

5817-R Zenith Distance/ Vertical Angle

5818-R General Survey Notes

5819-R Field sheet, Infrared

5820-R Three- Wire Leveling

5821-R Airfield Compilation Report

5822-R Precision Approach Radar (GCA) Data

5827-R Instrument Landing System Data

Department of Defense Forms (DD Form)

1351-2 Travel Voucher

1351-3 Travel Voucher or Subvoucher

1351-5 Government Quarters and Mess

1610 Request and Authorization for TDY Travel of DOD Personnel

Department of the Army Pamphlets (DA Pam)

25-30 Consolidated Index of Army Publications and Blank Forms

310-10 The Standard Army Publications System (STARPUBS) Users Guide

310-13 Posting and Filing Publications

310-15 Forms Management and Standardization

310-32 Index of Graphic Training Aids (GTA)

Defense Mapping Agency Technical Manuals (DMA-TM)

2-5220 Field Operation Manual, Doppler Geodetic Point Positioning

80-001 Operator's Manual for Analytical Photogrammetric Positioning Systems (HP-9825A) (Model) (May 1986)

81-004 Monumenting, Describing, and Recovery (Februay 1981)

81-006 Azimuth Determination

81-007 Distance Measuring Operations

These publications are available through DMA-HTC, Technical Publications Program, 6500 Brookes Lane, Washington, DC 20315-0030.

Defense Mapping School Special Text (DMS ST)

031 Standards and Specifications for Geodetic Control Networks

This publication is available from the Defense Mapping School, Fort Belvoir, VA 22060-5828. It is also available, including information updates, from the National Geodetic Information Branch, code N/CG17x2, NOAA, Rockville, MD 20852.

Department of Commerce Special Publications (SP)

(These publications are reprints of the US Coast and Geodetic Survey (USC&GS) Special Publications.)

64-1 Second-Order Astronomic Position Determination

193 Manual of Plane Coordinate Computation

235 The State Coordinate Systems

237 Manual of Geodetic Astronomy

240 Manual of Leveling Computation and Adjustment

241 Natural Tables for the Computation of the Geodetic Position (Spheroid of 1866)

Geodetic Glossary

These publications are available from the National Geodetic Survey, National Ocean Survey, NOAA, Rockville. MD 20852.

Department of Transportation, Federal Aviation Administration (FAA) Specifications, Publications, and Regulations

7350..5U Location Identifiers

8260.3 US Standard for Terminal Instrument Procedures (TERPS)

FAR-77 Objects Affecting Navigable Airspace

These publications are available from the US Department of Transportation, Federal Aviation Administration, 800 Independence Avenue SW. Washington, DC 20591.

Field Manuals (FM)

5-30 Engineer Intelligence

5-36 Route Reconnaissance and Classification

5-105 Topographic Operations

5-233 Construction Surveying

21-26 Map Reading and Land Navigation

25-2 Unit Training Management

25-3 Training in Units

National Oceanic and Atmospheric Administration (NOAA) Manuals

NOS NGS 3 Geodetic Leveling

NOS NGS 5 State Plane Coordinate System of 1983

These publications are available from the National Geodetic Survey, National Ocean Survey, NOAA, Rockville, MD 20852.

Soldier Training Publications (STP)

5-82D14-SM-TG Soldier's Manual and Trainer's Guide: 82D, Topographic Surveyor (Skill Level 1/2/3/4)

Technical Manuals (TM)

5-232 *Elements of Surveying*

5-235 Special Surveys

5-237 Surveying Computer's Manual

5-241-1 Grids and Grid References

5-241-8 Universal Transverse Mercator Grid

C1 ~~*5-441 Geodetic and Topographic Surveying*~~

5-6675-213-15 Operator's Organizational, Direct Support, General Support, and Depot Maintenance Manual for Theodolite Directional; 1 Sec Graduation 5.9-Inch Length Telescope w/Tripod, Carrying Case and Accessories (Wild Heerbrugg Instruments Models T-2), and (Model T-2-56)

5-6675-224-24 Organizational, Direct Support, General Support, and Maintenance Manual (Including Repair Parts and Special Tools List): Level Surveying; Dumpy, Telescopic, 32 Power w/Accessories and Tripod

5-6675-230-15 Operator's Organizational Field and Maintenance Manual: Level Surveying: Precise Tilting; 3-Level Screws, Electric Illumination, 10-Inch Telescope (Military Model 1O-X) w/Tripod

5-6675-231-15 Operator's, Organizational, Field and Depot Maintenance Manual: Theodolite, Surveying, Directional: 2/10 Second Degree Graduation 10.2-Inch Long Telescope w/Accessories (Wild Heerbrugg Model T-3) and (Wild Heerbrugg Model T-3-1969)

5-6675-233-20P Organizational Maintenance Repair Parts and Special Tools Lists: Theodolite: Directional; 0.002 Mil Graduation; 5.9-Inch Long Telescope: Detachable Tribrach w/Accessories and Tripod (Wild Heerbrugg Models T2-63 Mil) (Model T2-67-Mil) and (Model T2-66-C-Mil)

5-6675-238-24P Organization, Direct Support, General Support, and Depot Maintenance Repair Parts and Special Tools List for Test Set, Position and Azimuth Determining System, AN/USM-427, Part-No. 877400-1

5-6675-239-15 Organizational, Direct Support, General Support, and Depot Maintenance Manual Including Repair Parts for Light, Signal Surveying; 5-Inch Diameter Reflector; Grille Housing for Carrying Case (Military Design)

5-6675-244-15 Organizational, Direct Support, General Support and Depot Maintenance Manual (Including Repair Parts and Special Tools List); Target Set, Surveying, Circular Level and Optical Plummet in Tribrach w/Quick Release Mechanism (Wild Heerbrugg Model T-2)

5-6675-284-15 Operator, Organizational, Direct Support, General Support, and Depot Maintenance Manual for Theodolite, Directional; 2/10 Sec Graduation, First- Order w/Accessories, Trivet, Tripod, and Cases (Kein Model DKM3M)

5-6675-296-14 Operator's, Organizational Direct Support, General Support and Maintenance Manual for Theodolite, Directional: 0.002-Mil Graduation, 5.9-Inch LG Telescope, Detachable Tribrach w/ Accessories and Tripod (Wild Heerbrugg Models T-2-56-C Mil) (Model T-2-56-M-Mil) (Model T-2-63-Mil) (Model T-2-66-C-Mil) (Model T-2-68-Mil); Theodolite, Directional (Reference) (Wild Heerbrugg Models (T-2-56-C-Mil, T-2-56-M-Mil, T-2-63 Mil, T-2-66-C-Mil, T-2-67 Mil and T2-68 Mil)

5-6675-298-15 Operator, Organizational, Direct Support and General Support and Depot Maintenance Manual: Theodolite, Surveying Directional, 0.002 Mil Graduation w/Extension Leg Tripod (Keuffel and Esser Model KE-2 Special)

5-6675-304-12 Operator's and Organizational Maintenance Manual for Survey Electronic Distance Measuring Equipment, Infrared Model DM-60 (M-1)

5-6675-306-14 Operator's, Organizational, Direct Support and General Support Maintenance Manual: Theodolite, Directional; 1-Second Graduation, 5.9-Inch Long Telescope, Detachable Tribrach w/Accessories and Tripod (Wild Heerbrugg Model T2-74 Deg)

5-6675-308-12 Operator's and Organizational Maintenance Manual for Position and Azimuth Determining System, AN/USQ-70, Part No. 880500-1 (TM-08837A-12/1)

5-6675-312-14 Organizational, Direct Support and General Support Maintenance Manual for Theodolite, Surveying Directional, One-Minute (Wild Heerbrugg Model T16-75 Deg)

5-6675-318-14-1&2 Operator's, Organizational, Direct Support and General Support Maintenance Manual for Topographic Support System, Survey Section, Model ADC-TSS-6

5-6675-328-14 Operator's, Organizational, Direct Support and General Support Maintenance Manual for Topographic Support System, Maintenance Section, Model ADC- TSS-7

5-6675-329-13&P-HR Hand Receipt Manual Covering Contents of Components of End Item (COEI), Basic Issue Items (BII), and Additional Authorization List

(AAL) for Self-Leveling Surveying Level (Wild Heerbrugg Model NA 2-80)

95-226 United States Standard for Terminal Instrument Procedures (TERPS)

95-228 United States Interagency Ground Inspection Manual Air Traffic Control and Navigational Aids Facilities

Miscellaneous

US Government Publications

Department of Defense

Glossay of Mapping, Charting, and Geodetic Terms (Fourth Edition, 1981)

Prepared by Defense Mapping Agency, Hydrographic/Topographic Center, 6500 Brookes Lane, Washington, DC 20315

National Oceanic and Atmospheric Administration (NOAA)

Products and Services of the National Geodetic Survey

Geodetic and Charting Publications

These publications are available from the National Geodetic Information Branch, (NOAA) Rockville, MD 20852.

Nautical Almanac Office, United States Naval Observatory

Astronomical Almanac (current year)

This publication is available from the Superintendent of Documents, US Government Printing Office, Washington, DC 20402.

Nongovernment Publications

Apparent Places of Fundamental Stars (APFS) (current year)

Published by Verlag G. Braun, Karl-Friedrichstrasse 14-18, 7500 Karlsruhe 1, Germany

RELATED PUBLICATIONS

Related publications are sources of additional information. They are not required in order to understand this manual.

Army Regulations (AR)

95-14 Army Aviation Aeronautical Information and Terminal Instrument Procedures

95-50 Airspace and Special Military Operation Requirements

115-11 Army Topography

210-20 Master Planning for Army Installations

380-5 Department of the Army Information Security Program

385-95 *Army Aviation Accident Prevention*

405-10 Acquisition of Real Property and Interests Therein

420-90 Fire Protection

Defense Mapping Agency Technical Manuals (DMA-TM)

80-002 Land Gravity Surveys

81-001 JMR-1 Operations

81-002 JMR Supplement

81-003 Magnetic Surveys

8358-1 Datums, Ellipsoids, Grids, and Grid Reference System

These publications are available through DMA-HTC, Technical Publications Program, 6500 Brookes Lane, Washington, DC 20315-0030.

Department of the Army Pamphlets (DA Pam)

310- 17 Joint Interest List of Technical Manuals

310-20 Administrative Publications: Action Officers Guide

310-35 Index of International Standardization Agreements

Department of Commerce Special Publications (SP)

(These publications are reprints of the US Coast and Geodetic Survey (USC&GS) Special Publications.)

62-3 Bilby Steel Tower for Triangulation

247 Manual of Geodetic Triangulation

These publications are available from the National Geodetic Survey, National Ocean Survey, NOAA, Rockville, MD 20852.

Department of Defense Regulations (DOD Reg)

5040-2-C-1 Catalog of Audiovisual Productions–Army

5040-2-C-4 Catalog of Audiovisual Productions – DOD Productions Cleared for Public Release

Department of Transportation, Federal Aviation Administration (FAA) Publications

7400.2C Procedures for Handling Airspace Matters

This publication is available from the US Department of Transportation, Federal Aviation Administration, 800 Independence Avenue SW, Washington, DC 20591.

Field Manuals (FM)

1-100 Combat Aviation Operations

l-400 Aviator's Handbook

5-553 General Drafting

6-2 Field Artillery Survey

21-31 Topographic Symbols

24-1 Combat Communications

34-85 Conversion of Warsaw Pact Grids to UTM Grids

55-10 Movement Control in a Theater of Operations

101-5 Staff Organization and Operations

101-5-1 Operational Terms and Symbols

National Oceanic and Atmospheric Administration (NOAA) Manual

NOS NGS 1 Geodetic Bench Marks

Technical Manuals (TM)

5-240 Compilation and Color Separation of Topographic Maps

5-330 Planning and Design of Roads, Airbases, and Heliports in the *Theater of Operations*

5-803-4 Planning of Army Aviation Facilities

5-803-7 Civil Engineering Programming: Airfield and Heliport Planning Criteria

5-9413 Tower, Triangulation Structural Aluminum 103-foot

95-225 United States Standard: Flight Inspection

Tables of Organization and Equipment (TOE)

05335H600 Engineer Topographic Battalion, Theater Army

05338H600 Survey Company, Engineer Topographic Battalion, Theater Army

05540H3LA Topographic Planning and Control Team

05540H31B Geodetic Survey Team

05540H31C Survey Team

05540H31D Survey Team (Airborne)

05540H31L Survey Platoon

05540LB00 Survey Squad

05606L000 Headquarters and Headquarters Company, Engineer Topographic Battalion, Theater Army (Army of Excellence)

Miscellaneous

US Government Publications

Federal Geodetic Control Committee, NOAA

Input Formats and Specifications of the National Geodetic Survey Data Base (Volume 1 Horizontal Control Data, Volume 2 Vertical Control Data, Volume 3 Gravity Control Data)

This publication is available from the National Geodetic Information Branch, NOAA, Rockville, MD 20852.

National Flight Data Digest

Published daily (except weekends and Federal holidays) by the National Flight Data Center, Federal Aviation Administration, US Department of Transportation, 800 Independence Avenue SW, Washington, DC 20591.

Nongovernment Publications

Chauvenet, William

Manual of Spherical and Practical Astronomy (2 volumes) (Dover Publications, 180 Varick Street, New York, NY 10014 (c.1960]. Unabridged and unaltered republication of the Fifth revised and corrected edition, 1891.)

This publication is held by certain government and university libraries in the United States. It is available on interlibrary loan service through base or post, service school, or local public libraries. This service may not be available overseas.

Moffitt, Francis H. and Bouchard, Harry
Surveying, Harper and Row Publishers Inc., 10 East 53rd Street, New York, NY 10022 (Eighth edition, 1987). (Solutions manual available)

Davis, Foote, Anderson, and Mikhail
Surveying Theory and Practice, (Sixth edition, 1981) McGraw-Hill Book Company, 1221 Avenue of the Americas, New York, NY 10022

Zumberge, Mark Andrew
"A Portable Apparatus for Absolute Measurements of the Earth's Gravity." Author's copyright, 1981. PH.D. thesis. University of Colorado at Boulder, CO (1981)

This publication is available on interlibrary loan service from the University of Colorado at Boulder Library, Boulder, CO 80309.

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The illustrations and tables are shown in boldface type.

FM 5-232
27 SEPTEMBER 1989

By Order of the Secretary of the Army:

CARL E. VUONO
General, United States Army
Chief of Staff

Official:

WILLIAM J. MEEHAN II
Brigadier General, United States Army
The Adjutant General

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☆ U.S. GOVERNMENT PRINTING OFFICE: 1989-627-027/00097