

ATP 3-09.02

Field Artillery Survey

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Preface

This publication is a guide for commanders, survey personnel, and personnel whose duties include planning, supervising, and performing field artillery (FA) surveys or training in those areas. This manual provides—

- Techniques for instruction and employment of survey sections.
- Guidance and reference in survey principles.
- Techniques used to operate and maintain equipment.

The principal audience for this publication is FA commanders, staffs, and personnel at the field artillery brigade (FAB), division artillery (DIVARTY), and brigade combat team (BCT) and separate FA battalions and below.

Commanders, staffs, and subordinates ensure their decisions comply with applicable United States (U.S.), international, and, in some cases, host-nation laws and regulations. Commanders at all levels ensure their Soldiers operate in accordance with the law of war and the rules of engagement (See Field Manual [FM] 27-10).

Army Techniques Publication (ATP) 3-09.02 uses joint terms where applicable. Selected, joint and Army terms and definitions appear in both the glossary and the text. Terms for which ATP 3-09.02 is the proponent publication (the authority) are marked with an asterisk (*) in the glossary. Definitions for which ATP 3-09.02 is the proponent publication are boldfaced in the text. For other definitions shown in the text, the term is italicized and the number of the proponent publication follows the definition.

ATP 3-09.02 applies to the Active Army, the Army National Guard, Army National Guard of the United States, and United States Army Reserve unless otherwise stated.

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

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Introduction

Active component divisions now have a division artillery (DIVARTY), each corps and 8th Army has an associated field artillery brigade (FAB), and FA battalions are organic to brigade combat teams (BCT). FA Survey teams now belong to the target acquisition platoons of the DIVARTY, FAB, and all FA battalions.

Another significant change since 1993 is the digitization of our weapons and radar systems. The M109-series, M777A2, and the M119-series cannons all have position and direction locating ability. These systems require survey control points (SCPs) to initialize and update data to ensure accuracy levels are maintained. See Technical Manuals (TMs) 9-2350-314-10, TM 9-1025-215-10, and TM 9-1015-252-10 for specific initialization and update requirements. The M270A1 multiple launch rocket system, M142 high mobility artillery rockets system, and all weapons locating radars (WLR) have similar systems that provide location and direction data. For more information on the multiple launch rocket system and high mobility artillery rocket system see ATP 3-09.60.

FA Survey teams use the Improved Position Azimuth Determining System (IPADS) and the Improved Position Azimuth Determining System Global Positioning System (IPADS-G) to provide the necessary common grid. IPADS-G must be used with the current crypto keys installed to ensure the most accurate data.

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Chapter 1

Mission, Responsibilities, and Duties

The mission of FA survey is to provide a common grid that will permit the massing of fires, delivery of surprise observed fires, delivery of effective unobserved fires, and transmission of target data from one unit to another to aggressively neutralize or destroy enemy targets. Establishing a common grid and the single operational datum within the common grid is a command responsibility.

SURVEY PLANNING

1-1. FA survey must provide indirect fire assets and target locating assets with a common grid. ***Common grid*** Refers to all firing and target-locating elements within a unified command located and oriented to prescribed accuracies with respect to a single three-dimensional datum. Common survey allows the maneuver commander to employ fire support resources with a guarantee of accurate and timely fire support. ***Common control*** (artillery) **Horizontal and vertical map or chart location of points in the target and position area, tied in with the horizontal and vertical control in use by two or more units.** Survey planning within the force is based on the following tactical considerations:

- The commander's target adjustment policy (that is, if the element of surprise is an important aspect of his tactical plan).
- The requirement for transfer of adjusted target locations to higher and lower echelons.
- The required attack of high-payoff targets onto which fire cannot be adjusted (or if surprise is a factor).
- The planned positioning of indirect fire units during each phase of the operation.
- The planned tasking of target acquisition (TA) sensors and the processing of targets to an attack system.

1-2. The maneuver headquarters establishes survey time lines and accuracy requirements in the initial planning stages of an operation based on the commander's guidance. The maneuver commander gives the FA battalion commander targeting priorities and the effects he requires on high-payoff targets. This information translates into survey requirements for the TA sensors and the designated attack systems, which must be on a common grid by the time required. The effects on the target and inherent system inaccuracies determine the survey accuracy requirement (hasty, fourth-order, or fifth-order survey).

SURVEY OPERATIONS

1-3. Control is an important part of Army doctrine. Planning, communications, and coordination are essential parts of controlling survey operations. Control systems bring all information together for collation and decision making to support the execution of fire support missions. With access to real-time intelligence, improved targeting information, and accelerated automated information processing, maneuver commanders can attack more rapidly, more accurately and in greater depth than ever before. Survey planning begins with understanding the maneuver commander's intent and receiving his guidance. During planning, full consideration must be given to the commander's concept, priorities, tactical situation, survey control available, desired accuracy, number of installations, and mission, enemy, terrain and weather, troops and support available, time available, and civil considerations (METT-TC) factors. This information can be translated into survey requirements for the target acquisition sensors and the designated attack systems, which must be on a common grid by the time required. Aggressive survey planning that answers who, what, where, when and why is essential to ensure mission success. FA survey planning and coordination begins with the battalion or brigade operations staff officer (S-3) and Chief Surveyor of the FAB, DIVARTY or BCT. Communications is the key to the up, down, and lateral flow of information. The

FAB, DIVARTY or BCT S-3 and Chief Surveyor further coordinate the survey plan down to FA battalion level with the battalion S-3 and Chief Surveyor.

RESPONSIBILITIES

1-4. FA survey must provide indirect fire platforms as well as target locating assets with a common position and direction (common grid). With the proliferation of global positioning system (GPS) technology in conjunction with onboard navigation systems, desired location accuracy is easily attained. However, while the proliferation of these systems facilitates self-location, it places on the FA commander the additional responsibility to ensure that enough survey control points (SCP) exist throughout the area of operations (AO) to maintain common grid. Additionally, the current operational environment and emerging threats requires the fires community to conduct GPS denied and or systems degraded operations.

ORGANIZATIONAL RESPONSIBILITIES

1-5. Survey teams are found in the target acquisition platoon of the FAB, DIVARTY, and FA battalion. Figure 1-1 shows the breakdown of a target acquisition platoon. Target acquisition platoons at all levels are the same except the DIVARTY has two AN/TPQ-50 radars and not four.

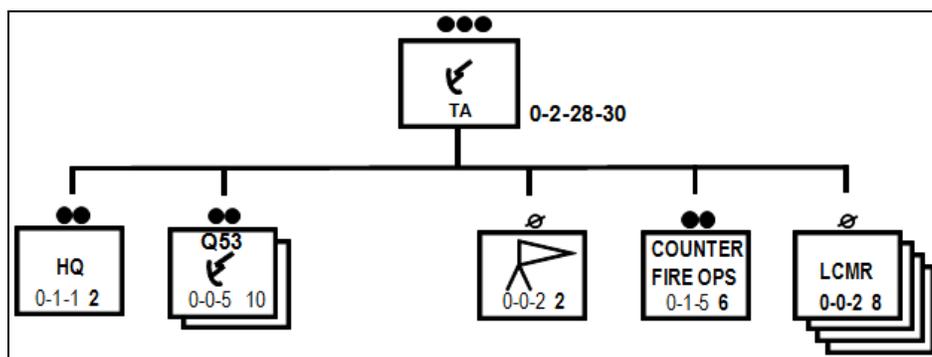


Figure 1-1. Target acquisition platoon

1-6. The force field artillery (FFA) headquarters (HQ) is responsible for survey planning and coordination within the AO. Survey planning and coordination begins with an interface between topographic survey engineers located within an engineer brigade or engineer battalion, and the FFA HQ. Communication is critical to the success of the up, down, and lateral flow of information. The FFA HQ coordinates dissemination of the survey plan down to FA battalion level and to all other consumers via the battalion S-3.

1-7. In the absence of a designated FFA HQ, the BCT FA battalion will be responsible for survey planning and coordination within the AO.

INDIVIDUAL RESPONSIBILITIES

1-8. The FFA HQ commander at all levels is responsible to the maneuver commander for the total integration of fire support to include survey planning and the establishment of the common grid. However, subordinate fires unit's survey leaders must keep the FFA HQ informed. Aggressive survey planning that answers who, where, when, why, and what is absolutely essential to ensure mission success.

1-9. The FFA commander and subordinate fire unit commanders at all echelons through their S-3 and fire support officer are responsible for ensuring survey control, consisting of GPS, and inertial (both horizontal and vertical position location and an orienting line of known direction) is furnished to subordinate units by the time required and to the required accuracy. The maneuver S-3 and FFA HQ must issue instruction to supporting FA units of the detailed operational plans and commanders' guidance. Guidance must include: priorities, threat analysis, accuracies; suspense to include time of

completion; primary, secondary and tertiary survey means, operations during GPS denied and other degraded conditions, as well as future plans. Survey support should also include mortar platoons within the BCT.

1-10. Coordination and planning originates at the corps, division, and the BCT Operations Cells for the FAB, DIVARTY, BCTs, and supporting units requiring survey control. The S-3 is the interface between the Engineer Brigade or Engineer Battalion, Technical Headquarters Section or the Survey Design Detachment for topographic support. The coordination and planning effort at all levels is the responsibility of the S-3 and chief surveyor. The brigade survey plan is further coordinated at the FA battalion level with the FA battalion S-3 and Chief Surveyor. Interface between all echelons of command must be maintained to ensure that common survey control can be provided to units to support maneuver commanders where and when it is needed. Coordinating and synchronizing the survey plan is essential to mission success.

1-11. The target acquisition platoon leader of the FAB, DIVARTY, and FA battalion is responsible for the direct supervision of survey personnel. The target acquisition platoon leader issues orders and provides guidance based on the commander's intent, S-3 and fire support officer's (FSO) requirements. The target acquisition platoon leader advises the commander on any deviations from previous orders. Survey operations must be started as soon as the requirement for survey has been identified. The goal is to establish survey control before occupation by the firing or acquisition elements. All training should point toward this end. The S-3 with input from the FSO is responsible for coordinating the movement of survey teams with the Chief Surveyor and target acquisition platoon leader.

1-12. The Chief Surveyor (13T40/30) determines methods of survey in order to obtain required accuracy, participates, prepares, organizes, and schedules the survey parties. Serves as the principal assistant to the target acquisition (survey) officer and performs his duties in his absence. Provides leadership, expertise, and inspects section equipment and vehicles to ensure the proper application of preventative maintenance checks and services (PMCS). Develop training plan to accomplish training objective. Direct collection, evaluation, and dissemination of FA survey information. Coordinates survey operations with other units and maintains survey maps/overlays.

1-13. The improved position and azimuth determining system (IPADS) Team Chief (13T20), supervises and coordinates IPADS/ improved position and azimuth determining system-global positioning system (IPADS-G) vehicle operations. Computes survey data, plots geographic/ universal transverse mercator (UTM) grid coordinates and performs azimuth transfer with IPADS or IPADS-G. Operates IPADS or IPADS-G system, performs calibrations, zero velocity updates, and PMCS on the IPADS or IPADS-G system. The team chief assists in the collection, evaluation, and dissemination of survey information.

1-14. The Engineer Brigade/Engineer Battalion is the primary source of topographic support (12T Technical Engineer). Technical Engineers establish and recover existing ground control and extend it by third-order or higher conventional survey or satellite methods and are located within Survey and Design (S&D) Detachments and Brigade Technical Headquarters Sections. The FFA HQ within the area of operation coordinates exact positioning of this high order survey control. The S-3 must be aware of where the engineer units are located and establish communications and coordination procedures. Topographic survey support must be provided to all Artillery units (and other survey consumers) within the AO. The number of SCPs that the Engineer Surveyor must provide is dependent upon unit dispersion, the scheme of maneuver, amount of movement, and commander's priorities and guidance. Initial SCPs must be within 5 kilometers (km) of the FFA HQ. The FA survey teams will further extend control to the vicinity of delivery platforms and target locating systems. The Engineer Surveyor responsibilities to artillery survey are as follows:

- Extend horizontal and vertical control into the AO.
- Provide survey plan to subordinate organizations (below corps).
- Provide mapping survey control where required.
- Advise on topographic issues.
- Assist in lower-level survey to augment FA survey when directed.

FUNDAMENTAL SURVEY OPERATIONS

1-15. Successfully accomplishing the mission depends on the fundamental survey operations in Table 1-1.

Table 1-1. Fundamental survey operations

OPERATIONS	ACTIONS								
Planning	Receive Commander's guidance. Conduct map and ground reconnaissance. Formulate survey plan, and issue orders detailing the following: <table style="width: 100%; border: none;"> <tr> <td style="width: 50%;">Accuracies.</td> <td style="width: 50%;">Priorities of Survey.</td> </tr> <tr> <td>Time to finish.</td> <td>Logistics.</td> </tr> <tr> <td>IPADS and IPADS-G requirements.</td> <td>Future requirements.</td> </tr> <tr> <td></td> <td>Alternate plan.</td> </tr> </table>	Accuracies.	Priorities of Survey.	Time to finish.	Logistics.	IPADS and IPADS-G requirements.	Future requirements.		Alternate plan.
Accuracies.	Priorities of Survey.								
Time to finish.	Logistics.								
IPADS and IPADS-G requirements.	Future requirements.								
	Alternate plan.								
Coordination	Ensure communications requirements are met and survey data are available where and when needed to include the following: <table style="width: 100%; border: none;"> <tr> <td style="width: 50%;">Higher headquarters.</td> <td style="width: 50%;">S-2 and S-3.</td> </tr> <tr> <td>Adjacent headquarters.</td> <td>Commanders.</td> </tr> <tr> <td>Survey information.</td> <td>Lower headquarters.</td> </tr> </table>	Higher headquarters.	S-2 and S-3.	Adjacent headquarters.	Commanders.	Survey information.	Lower headquarters.		
Higher headquarters.	S-2 and S-3.								
Adjacent headquarters.	Commanders.								
Survey information.	Lower headquarters.								
Fieldwork	Establish and mark survey control points. Provide IPADS or IPADS-G update points. Provide update points for stabilization reference package/position-determining system. Establish position and azimuth for all FA systems requiring survey control. Turning angles. Record and sketch field data. Supervise and or synchronize IPADS or IPADS-G. Ensure crypto keys are loaded in the GPS.								
Computations	Compute direction. Compute horizontal and vertical location. Convert to common control. Transform data between grid zones and datums.								
Legend: GPS—global positioning system IPADS—improved position and azimuth determining system IPADS-G—improved position and azimuth determining system-global positioning system S-2—intelligence staff officer S-3—operations staff officer									

1-16. Survey planning begins with understanding the maneuver commander's intent and receiving further guidance from the FA commander, S-3, and FSO. Then a thorough map and ground reconnaissance (recon) is conducted. Using the IPADS or IPADS-G, ground reconnaissance and survey operations are conducted concurrently. During planning, full consideration is given to the following:

- FA battalion commander's concept of operation (support to maneuver operation).
- Priorities.
- Tactical situation.
- Operational datum and survey control available.
- Desired accuracy.
- Number of installations.
- Terrain.
- Weather.
- Personnel.
- Time available.

1-17. The maneuver commander at each echelon is responsible for establishing a common grid and, therefore, accomplishing the survey mission. The senior FA commander at all levels is responsible to the maneuver commander for the total integration of fire support to include survey planning. When the survey plan cannot support the commander's guidance, survey planners must pass the plan to the S3 and the commander. They will review, adjust, and approve the plan. Aggressive survey planning answers the essential questions necessary to plan, prepare, execute and assess the mission to ensure success.

PLANNING RESPONSIBILITIES

1-18. The S-3 with the support of the FSO at all levels are responsible for ensuring that required survey control—consisting of both horizontal and vertical position location and an orienting line of known direction—is furnished to subordinate units by the time required and to the required accuracy. The maneuver S-3 and FSO must issue instructions to any supporting FA units S-3 and Chief Surveyor so detailed planning and coordination may begin. The S-3 and FSO guidance must provide priorities; accuracies; time to be finished; primary, alternate, and supplementary position requirements; and future plans.

1-19. The FAB, DIVARTY, and FA battalion target acquisition platoon leader is responsible for the direct supervision of survey personnel. The target acquisition platoon leader issues orders and provides guidance based on the commander's, S-3's and FSO's requirements. The target acquisition platoon leader advises the commander on any deviations from previous orders.

1-20. Survey operations must be started as soon as the requirement for survey has been identified. The goal is to establish survey control before occupation by the firing or acquisition elements. All training should point toward this end. The S-3 with input from the FSO is responsible for coordinating the movement of survey teams with the target acquisition platoon leader. The S-3 is responsible for ensuring a risk assessment has been completed and that the residual risk is accepted by the commander or elevated as appropriate. First-line leaders and individuals will adhere to emplaced controls as well as conducting hasty risk management at their level. See ATP 5-19 for details on the risk management process.

1-21. When survey control is not immediately available, all efforts should be directed toward establishing common directional control in the position area. Recommended methods of establishing direction by priority are as follows:

- IPADS or IPADS-G.
- Astronomic observation.

1-22. Providing the best available direction and location may take precedence over accuracy of data. In some situations, the commander may have to accept survey accuracies that fall short of the specifications given. This determination is the commander's decision. Survey leaders must advise the commander of the effect of inaccuracies on the desired effectiveness of fire support. Using substandard survey data can affect hitting the target and could result in collateral damage and friendly casualties.

1-23. If the terrain or the tactical situation is such that the survey sections cannot establish survey control by the time required, hasty methods may be used. The effects of using hasty methods and the guarantee of accurate fire support are shown in Table 1-2 on page 1-6. (Hasty survey techniques are explained in ATP 3-09-50.)

Table 1-2. Hasty survey effect on fire support

TYPE OF SURVEY	MEANS OF DETERMINING		EFFECTS
	ORIENTATION	LOCATION	
Battalion hasty	A scheme in which orientation is initiated by theodolite to an accuracy of 0.3 mil and more than one fire unit is put on common orientation. (Can be passed by simultaneous observation.)	Survey process that puts more than one unit on common grid but not necessarily closely related to the map. Scheme not originated from a known survey control point.	<ol style="list-style-type: none"> 1. Units located in the scheme that includes both orientation and location may pass target records and registration data to each other. 2. No guarantee on non-adjusted or unobserved fire unless the acquisition source is also included in the scheme. Fire can be massed by all units in the scheme after adjustment with one gun.
Fifth-order or higher survey	Astronomic or equivalent process.	Survey process that originates at a known survey control.	<ol style="list-style-type: none"> 1. No restriction on the passage of target records or registration data. 2. Unobserved fire is reliable as long as the acquisition source is in the scheme. 3. Minimizes adjustment.

FIELD ARTILLERY SURVEY ORGANIZATIONS

1-24. The survey team provides survey control and executes survey planning and coordination. These responsibilities are carried out by an IPADS or IPADS-G team chief who is responsible for the total survey effort of the team, and a soldier who performs survey functions when required and is the light vehicle driver.

DUTIES OF SURVEY PERSONNEL

1-25. Individual duties of the various survey personnel are shown in Table 1-3.

Table 1-3. Duties of survey personnel

Personnel	Duties
Chief Surveyor	Determines methods of survey to obtain required accuracy; participates, prepares, organizes, and schedules the survey parties. Serves as the principal assistant to the S3 on survey matters. Provides leadership and expertise, and inspects section equipment and vehicles to ensure the proper application of PMCS. Develops training plan to accomplish training objective. Directs collection, evaluation, and dissemination of FA survey information. Coordinates survey operations with other units and maintains survey situation awareness.
IPADS or IPADS-G Team Chief	Supervises and coordinates IPADS or IPADS-G vehicle operations. Computes survey data, plots geographic/UTM grid coordinates, and performs azimuth transfer with IPADS or IPADS-G. Operates IPADS or IPADS-G system; performs calibrations, zero velocity updates, and PMCS on IPADS or IPADS-G. Assists collection, evaluation, and dissemination of survey information. Provides leadership and technical guidance to lower-grade personnel.

Table 1-3. Duties of survey personnel (continued)

Personnel	Duties
FA Surveyor	Assists IPADS or IPADS-G Team Chief with the transfer, strap down, and preparation for IPADS or IPADS-G operations. Operates and performs PMCS on vehicles, radios, weapons, and all survey equipment.
FA—field artillery IPADS—improved position and azimuth determining system IPADS-G—improved position and azimuth determining system-global positioning system PMCS—preventive maintenance checks and services UTM—universal transverse mercator	

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Chapter 2

Survey Planning

Planning for artillery surveys is based primarily on the planned positioning of firing units and target acquisition assets and the commander's accuracy requirements. This allows the commander to mass fires of subordinate units, to store and transfer target locations for future engagements, and to limit vulnerability of firing units.

CONDUCT OF PLANNING

2-1. Surveys are planned to ensure that all required control is provided in the correct place and at the time required. The plan distributes work evenly among teams and eliminates duplicate work. Planning is based on meeting as many survey requirements as possible under the given conditions and always providing the best available survey control to using units. Survey control is critical; the survey plan must reflect the requirement to rapidly extend survey control throughout the AO.

2-2. Survey planning is conducted at all echelons at the same time. Provisions should be made to link together all surveys conducted in the area. The FFA HQ ties together the surveys of the firing and locating elements. The FFA HQ surveyors survey their organic and attached elements and help other units as directed. The degree of accuracy, speed of execution, and priority of work are given in the commander's guidance or are set by the S-3 from the commander's guidance.

2-3. Artillery units at all levels must start survey operations by establishing a common survey control point for initialization using the most accurate method available to the force. They do not wait for higher-echelon survey control to be established in the area. These methods may include using their onboard inertial navigation systems, conventional survey, IPADS or IPADS-G, Dual defense advanced global positioning system receiver (DAGR) Submil-D Kit, or simultaneous observation. Once more accurate survey capabilities are available these locations must be updated. Firing and target-locating units must work from the best available data and improve the data as higher-order survey becomes available.

2-4. Survey sections are organic to the FAB, DIVARTY, and FA battalion, target acquisition platoons. The survey section provides survey control for organic assigned and attached units. The survey section provides common direction, coordinates, and elevation data to all organic, attached, and reinforcing FA battalions, target acquisition assets, and the BCTs mortars as required.

2-5. For the purpose of planning a survey, installations may be separated into groups according to the accuracy of survey required. Requirements and position considerations are shown in table 2-1 on page 2-2.

- **Fourth order.** Fourth-order survey accuracy standard are 4.0 m horizontal circular error probable (CEP), 2.0 meters Vertical Probable Error and no more than 0.6 mil azimuth probable error. To maintain this accuracy IPADS or IPADS-G or Platform are required to perform zero velocity updates every 5 minutes. As a minimum 4 fourth order survey is required for Fires Brigade/Battalion SCP's, and any firing unit firing precision guided munitions.
- **Fifth order.** Fifth-order survey accuracy standard are 7.0 m horizontal CEP, 3.0 meters Vertical Probable Error and no more than 0.4 mil azimuth probable error. To maintain this accuracy IPADS or Platform are required to perform zero velocity updates every 10 minutes. Fifth order survey is the minimum required by firing and target-locating units. Care must be used in selecting a method to establish direction for these installations.
- **Hasty survey.** All firing and target-locating elements requiring survey must be able to use hasty survey techniques to provide the best available survey control rapidly. For detailed information on hasty survey techniques see ATP 3-09.50.

Table 2-1. Survey installation

Type of survey	Installation	Requirement	Remarks
Fourth-order improved position and azimuth determining system (IPADS) must use 5 minute zero-velocity corrections.)	Battalion survey control point (SCP)	Azimuth, coordinates, and elevation.	BN SCP within 2 km of the center of the battalion position area.
	Battery SCP	Azimuth, coordinates, and elevation	SCP within 2 km of the center of the battery position area.
	M119A2 E1/M777A2/Paladin howitzer (if precision munitions are in use)	Coordinates and height to platoon area SCPs. Azimuth from the SCP to an azimuth mark. (Azimuth needed for degraded operations)	Howitzer updated points needed every 16 miles.
Fifth-order IPADS must use 10 minute zero-velocity corrections.)	Battery SCP	Azimuth, coordinates, and height (azimuth not required for MLRS).	SCP within 2 km of the center of the battery position area.
	Paladin howitzer	Coordinates and height to platoon area SCPs. Azimuth from the SCP to an azimuth mark. (Azimuth needed for degraded operations)	Howitzer updated points needed every 16 miles.
	MLRS HIMARS	Coordinates and elevation of the platoon area SCP.	Update points needed every 6 to 8 km. (M270A1 requires update points for the battery center)
	AN/TPQ-37 radar	Azimuth and distance from the OS to the azimuth mark.	Azimuth accuracy ± 0.4 mil PE.
		Coordinates and elevation of the radar position.	
	AN/TPQ-36 radar	Azimuth, distance, and vertical angle from OS to azimuth mark	Azimuth accuracy ± 0.4 mil PE.
		Coordinates and elevation of radar position.	
	AN/TPQ-53 radar	Azimuth and distance from the OS to the azimuth mark.	Azimuth accuracy ± 0.4 mil PE.
		Coordinates and elevation of radar position	
	Lightweight counter mortar radar AN/TPQ 50 series	Azimuth and distance from the OS to the azimuth mark.	Azimuth accuracy ± 0.4 mil PE.
		Coordinates and elevation of radar position.	
	BN—battalion HIMARS—high-mobility artillery rocket system MLRS—multiple launch rocket system OS—orienting station PE—probable error SCP—survey control point		

SURVEY PLANNERS

2-6. Survey planning is performed by many individuals at many levels. Some of these planners are discussed below.

FIELD ARTILLERY BATTALION COMMANDER OR FSO

2-7. The supported commander initiates the requirement for survey planning when he issues guidance to the FA commander or S-3. He does so by stating the scheme of maneuver, rate of movement, anticipated enemy threat, and critical phases of the battle. The FA commander and S-3, analyze the supported commander's guidance to determine the need for passing of target information, first-round fire-for-effect accuracy, and massing of fires. They weigh the analysis against the ability to adjust fires, fire registration missions, and rapidly engage targets from new position areas. The concept for a survey plan to provide common survey control has begun.

2-8. The FA S-3 and FSO then must extract the guidance and information that will allow them to visualize the survey requirements for all fire support (FS) assets. The FSO can gain most of the information by reviewing the scheme of maneuver, rate of movement, effects required on high-payoff targets, and accuracy requirements for TA sensors. They must also determine whether it is more important to have survey at the guns or TA assets first.

2-9. Each commander is responsible for establishing common control throughout their AO. The S-3 and FSO must disseminate to the appropriate artillery battalion headquarters the established accuracy requirements in survey terms. Additional requirements or guidance derived by the S-3 and FSO must also be communicated. This should be done through face-to-face coordination when possible. The Chief Surveyor advises the FSO and or S-3 on his current survey capabilities and limitations.

2-10. The following planning considerations aid the S-3 and FSO in determining survey requirements:

- Select primary, alternate, and supplementary positions areas for the following:
 - Firing unit locations.
 - Target acquisition systems.
- Select times as follows:
 - Time survey is to be completed.
 - Time to staff fieldwork.
 - Time to start reconnaissance.
 - Time to start planning.
- Determine accuracies for the following:
 - Firing unit locations.
 - Target acquisition systems.
 - Mortars (if requested).
- Determine the priorities for each of the following:
 - Field artillery battalions.
 - Target acquisition systems (AN/TPQ-36, -37, -50, -53, and observers).
- Coordinate as follows:
 - To determine location of higher order survey control points (SCPs)
 - To determine when SCPs will be established.
 - To establish liaison with higher, lower, and adjacent units.

TARGET ACQUISITION PLATOON LEADER

2-11. The target acquisition platoon leader is responsible for the survey team of the target acquisition platoon. He is responsible to the S-3 for executing the survey plan to establish common survey control (the common grid) throughout the unit's area. The platoon leader coordinates all artillery survey operations in the supported commander's area of operation to ensure effectiveness and to reduce duplication of effort. The target acquisition platoon leader requests external survey support as required. As the coordinator of

survey resources, the platoon leader advises the commander, S-3, FSO, and staff on all matters pertaining to the following:

- Survey requirements.
- Techniques.
- Capabilities.
- Problem areas.

CHIEF SURVEYOR

2-12. The Chief Surveyor at the FAB, DIVARTY, BCT, and FA battalion is the technical expert on surveying in the unit. His primary duty is to advise the commander, S-3, FSO and target acquisition platoon leader on all aspects of survey operations. He must have wide experience in the employment of FA surveyors in support of all systems requiring survey data. The chief surveyor duties include:

- Brief the staff on survey and reconnaissance matters.
- Coordinates for higher order survey.
- Formulate, implement, and supervise the execution of the survey plan.
- Train surveyors in proper survey procedures.

2-13. The chief surveyor works closely with the target acquisition platoon leader and survey team to facilitate a complete understanding of the survey plan, and that there is effective collection, evaluation, and dissemination of survey data.

2-14. In formulating the survey plan, the survey planner must remember and strive to meet certain essentials. The survey plan must meet the essentials discussed below.

- Provide required control. The plan must provide survey control within the required accuracy to all installations that require survey.
- Provide for checks. Whenever possible, the plan must provide for checks; for example, closed surveys and alternate bases. Each member of the survey team continuously makes checks as a matter of standard practice.
- Be simple. The plan must be understood by all survey personnel. Work that is unnecessary or that exceeds the required accuracy must be avoided.
- Be timely. The plan must be capable of execution in the time allotted.
- Be flexible. The plan must be capable of being changed if the situation warrants.
- Be adaptable. The plan must be adaptable to the following:
 - Terrain.
 - Situation.
 - Personnel available.
 - Weather.
 - Equipment.

FACTORS AFFECTING SURVEY PLANNING

2-15. In formulating the plan by which the survey mission is to be accomplished, the survey planner must consider METT-TC factors. The METT-TC factors cannot be considered independently because each is related to the other.

MISSION

2-16. The tactical mission of the unit determines the time available, the area to be surveyed, the accuracy, and priority of the survey effort. It is the basis of the survey mission and determines the influence other factors have on the survey.

- Starting control. The location of existing survey control or the establishment of control by a higher echelon of survey affects the time required to extend control. Survey operations are concurrent at all echelons. When starting control is not available, the starting data must be

assumed. The necessary survey operations are started immediately. More extensive survey planning is required in areas where survey control is limited.

- Priority. The priority of work assigned is either listed in the mission or commander's guidance or derived from the mission by the S-3. The priority of work affects the order in which the plan is executed or the type of survey performed.
- Number of installations. The number and locations of installations to be surveyed must be considered primarily with respect to time and troops available. The survey operations required to locate a few widely scattered installations often take more time and/or personnel than would be required for many closely grouped installations. In the survey plan, the survey tasks should be allocated so that the various survey teams complete their portion most expeditiously.

ENEMY

2-17. The enemy situation has a strong influence on survey operations, since the disposition of troops may interfere with or restrict the movement of survey personnel and their equipment. Restrictions on communications, such as radio silence and enemy jamming, can greatly reduce the effectiveness of survey teams. The ability of the enemy to interfere with survey operations by denying use of terrain or routes is of prime importance. When survey operations are restricted, the commander should give priority of survey to those units supporting the main attack. FA surveyors must be able to implement suppressive fire immediately if they receive enemy fire. Terrain and cover must be used as much as possible. The unit standard operating procedure (SOP) should provide for actions to be taken by survey teams when mine or improvised explosive device threat is high and for survey teams that come under fire.

TERRAIN AND WEATHER

2-18. The terrain and weather through which survey control must be extended are a primary factor in determining the methods of survey to be used. The survey planner must be so familiar with the effects of terrain and weather on survey operations that he can promptly and properly advise the commander on the time and personnel requirements. Adverse weather greatly reduces the capability of survey teams. Fog, rain, snow, heat, or dust can reduce visibility to the extent that observation through an optical instrument is impossible. Extreme heat or cold can also reduce survey team efficiency and increase the time needed to complete the survey.

TROOPS AND SUPPORT AVAILABLE

2-19. The survey personnel and equipment available to perform the survey mission greatly affect the plan. The status of training determines the methods available and time required to perform survey. The availability and operability of survey equipment dictate the methods used in the plan.

TIME AVAILABLE

2-20. The time available to complete the survey operation is the most critical factor in planning. Survey planners must use the survey techniques necessary to provide the best survey data within the prescribed time. A tradeoff between accuracy and time may have to be made, depending on the tactical situation. The commander makes the decision to allow decreased accuracy before the survey starts or to accept decreased accuracy on completion of the survey.

CIVIL CONSIDERATIONS

2-21. Civil considerations relate to civilian populations, culture, organizations, and leaders within the AO. Commanders consider the natural environment, to include cultural sites, in all operations directly or indirectly affecting civilian populations. Commanders include civilian political, economic, and information matters as well as more immediate civilian activities and attitudes.

2-22. At the operational level, civil considerations include the interaction between military operations and the other instruments of national power. Civil considerations at the tactical level generally focus on the immediate impact of civilians on the current operation; however, they also consider larger, long-term

diplomatic, economic, and informational issues. Civil considerations can tax the resources of tactical commanders while shaping force activities. Civil considerations define missions to support civil authorities.

METHODS OF SURVEY

2-23. In addition to being able to evaluate the factors that will affect the survey, the survey planner must know the methods of survey that might be used and the advantages and disadvantages of each. The method chosen to provide survey control depends on the METT-TC factors. IPADS or IPADS-G survey is the primary means of executing the survey order. Tables 2-2 through 2-5 (pages 2-6 and 2-7) list the different accuracies and requirements for IPADS or IPADS-G Surveys.

Table 2-2. 4th order accuracy 0°-65°

<i>4th Order Accuracies</i>		
<i>0° - 65° N/S Latitude</i>	<i>IPADS-G</i>	<i>IPADS</i>
Initialization Time (GPS available)	0 minutes	10.0 minutes
Initialization Time (GPS unavailable)	10.0 minutes	10.0 minutes
Hot Start (GPS unavailable)	5.0 minutes	5.0 minutes
ZUPT Times (GPS available)	Not Applicable	5.0 minutes
ZUPT Times (GPS unavailable)	5.0 minutes	5.0 minutes
Horizontal Position (CEP)	4.0 meters	4.0 meters
Altitude / Vertical limits	2.0 meters	2.0 meters
Azimuth Error	0.4 mils	0.4 mils
Legend: CEP— circular error probable GPS— global positioning system ZUPT—zero velocity updates		

Table 2-3. 4th order accuracy 65°-75°

<i>4th Order Accuracies</i>		
<i>65°-75° N/S Latitude</i>	<i>IPADS-G</i>	<i>IPADS</i>
Initialization Time (GPS available)	0 minutes	20.0 minutes
Initialization Time (GPS unavailable)	2.0 minutes	2.0 minutes
Hot Start (GPS unavailable)	10.0 minutes	10.0 minutes
ZUPT Times (GPS available)	Not Applicable	5.0 minutes
ZUPT Times (GPS unavailable)	5.0 minutes	5.0 minutes
Horizontal Position (CEP)	4.0 meters	4.0 meters
Altitude / Vertical limits	2.0 meters	2.0 meters
Azimuth Error	0.6 mils	0.6 mils
Legend: CEP— circular error probable GPS— global positioning system ZUPT—zero velocity updates		

Table 2-4. 5th order accuracy 0°-65°

<i>5th Order Accuracies</i>		
<i>0° - 65° N/S Latitude</i>	<i>IPADS-G</i>	<i>IPADS</i>
Initialization Time (GPS available)	0 minutes	Not Applicable
Initialization Time (GPS unavailable)	10.0 minutes	10.0 minutes
Hot Start (GPS unavailable)	5.0 minutes	5.0 minutes
ZUPT Times (GPS available)	Not Applicable	10.0 minutes
ZUPT Times (GPS unavailable)	10.0 minutes	10.0 minutes

Table 2-4. 5th order accuracy 0°-65° (continued)

<i>5th Order Accuracies</i>		
<i>0° - 65° N/S Latitude</i>	<i>IPADS-G</i>	<i>IPADS</i>
Horizontal Position (CEP)	7.0 meters	7.0 meters
Altitude / Vertical limits	3.0 meters	3.0 meters
Azimuth Error	0.4 mils	0.4 mils
Legend: CEP— circular error probable GPS— global positioning system ZUPT—zero velocity updates		

Table 2-5. 5th order accuracy 65°-75°

<i>5th Order Accuracies</i>		
<i>65° - 75° N/S Latitude</i>	<i>IPADS-G</i>	<i>IPADS</i>
Initialization Time (GPS available)	0 minutes	20.0 minutes
Initialization Time (GPS unavailable)	20.0 minutes	20.0 minutes
Hot Start (GPS unavailable)	10.0 minutes	10.0 minutes
ZUPT Times (GPS available)	Not Applicable	10.0 minutes
ZUPT Times (GPS unavailable)	10.0 minutes	10.0 minutes
Horizontal Position (CEP)	7.0 meters	7.0 meters
Altitude / Vertical limits	3.0 meters	3.0 meters
Azimuth Error	0.6 mils	0.6 mils
Legend: CEP— circular error probable GPS— global positioning system ZUPT—zero velocity updates		

STEPS IN SURVEY PLANNING

2-24. The steps in planning a survey are generally the same as the normal small-unit, troop-leading steps.

2-25. accomplish the mission. The lower the echelon, the more simple, direct, and rapid the process. Once the battle starts, orders and responses must be fast, effective, and simple. This requires teamwork. Troop-leading steps should be an instructive and automatic way of thinking for section leaders and commanders. Without detailed instructions, commanders must turn a mission order into actions to support the plan of the next higher commander. Elaborate troop-leading procedures are useless if they slow the response of the force. In addition the planner must integrate risk management into the planning process. For information on risk management see ATP 5-19, ADRP 5-0, and Field Manual (FM) 6-0. The eight troop-leading steps are as follows:

- Receive the mission.
- Issue a warning order.
- Make a tentative plan that will accomplish the mission.
- Start the necessary movement.
- Reconnoiter.
- Complete the plan.
- Issue the order.
- Supervise.

2-26. Troop-leading steps are not rigid. They can be changed to fit the mission and the situation. Often, some steps are conducted at the same time while others are considered continuously throughout the operation. When there is not enough time, certain steps may be left out. The troop-leading steps as they apply to survey operations are discussed below.

RECEIVE THE MISSION

2-27. Leaders receive a mission in either an oral or written operation order (OPORD) or fragmentary order. Upon receiving the order, the leader analyzes the mission and plans the use of available time. The S-3 gives the Chief Surveyor a mission. It may consist of general areas to be surveyed or specific locations for battalion SCPs, platoon area SCPs, mortar positions, and such.

ISSUE A WARNING ORDER

2-28. The leader issues a warning order that gives his subordinates the mission and the time it starts. He issues it early enough for the section to plan and prepare. Normally, warning orders are issued through the chain of command. In that way, all personnel are kept informed of what they must do and why they must do it. The warning order should include the location of a nearby SCP or prominent landmark. Pre-operation checks of vehicles and equipment are completed.

MAKE A TENTATIVE PLAN

2-29. The survey always connects required control with known control. The first step in formulating a survey plan is to gather information on the area, enemy situation, and any usable known control. A map reconnaissance is made to tentatively determine the methods of survey.

Gather Information

2-30. From the commander's briefing, the Chief Surveyor gathers vital information that influences the planning of his survey. This information should pertain to the situation, to include the following:

- Mission of the units.
- Status of registration.
- Time available.
- Zones of fire.
- Friendly positions.
- Routes, communications, minefield, contaminated areas, improvised explosive device hot spots, and restrictions on modes of travel.
- Support to reinforcing units, to allies, or to priority units.

Make a Map Reconnaissance

2-31. After attending the commander's briefing and issuing a warning order to alert his personnel, the survey planner, using any suitable map or map substitute, makes a thorough map reconnaissance. In doing this, he follows a specific procedure to ensure that full consideration is given to all factors. This procedure, in order, is discussed below.

Map-spot Installations

2-32. Known control and those installations requiring survey control are plotted on the map. Restricted areas and other information relative to the AO are also plotted.

Select a tentative plan

2-33. All the factors that affect survey METT-TC are fully considered, methods are chosen, and a tentative plan is made. Particular attention is placed on the accessibility of installations.

Consider Time

2-34. An estimate of the time required to execute the tentative plan is made. If the survey mission cannot be performed within the allotted time, the plan is modified or an appropriate recommendation is made to the commander. The planner may recommend the following:

- Extra personnel are made available.

- Higher support is requested.
- More time is allowed for survey.
- Location of certain installations is delayed.
- Accuracy for certain installations is relaxed.

Determine Critical Areas

2-35. Areas that require detailed ground reconnaissance are identified.

START THE NECESSARY MOVEMENT

2-36. The survey planner must now make good use of the time available so that the section will be in the area to be surveyed at the required time. If the section must move a long distance, it should start the move immediately on the basis of first rough plans.

RECONNOITER

2-37. After the map reconnaissance, the survey planner must make a ground reconnaissance as detailed as time permits. The tentative plan selected during the map study is changed as required by the terrain. Particular emphasis should be placed on critical areas. If necessary, indications are made to other survey planners or IPADS team chiefs at points where tentative plans may need revision or close coordination. A scale sketch of the survey is an easy way to summarize information determined from the ground reconnaissance. Since an IPADS team can provide survey data as it reconnoiters, greater emphasis must be placed on moving efficiently through the area.

COMPLETE THE PLAN

2-38. Reconnaissance may not change the plan, but it certainly adds detail. The plan must be modified to fit all the information gained from the ground reconnaissance.

ISSUE THE ORDER

2-39. A verbal survey order is issued, if possible, from a vantage point overlooking the area to be surveyed. The survey order follows the standard five-paragraph operation order (OPORD) format. Continuing operations may require using a fragmentary order.

SUPERVISE

2-40. A leader must continually supervise the preparation for and execution of the mission. Constant supervision is as important as issuing the order.

THE SURVEY ORDER

2-41. The survey order contains detailed instructions to the survey team not covered by the unit's SOP. It gives general information needed to efficiently accomplish the survey mission. The survey order is written or issued orally. It generally follows the same sequence as the OPORD. Often, because of the tactical situation and wide dispersal of units, parts of this order may be issued by voice, digital means or both.

2-42. The format for a five-paragraph survey order is shown in Figure 2-2 on page 2-10.

Example

1. (U) **Situation.** *The situation paragraph describes the conditions of the operational environment that impact survey tasks in the following subparagraphs. See FM 6-0 for detailed guidance.*
 - a. (U) **Area of Interest.** b. **Area of Operations.** (See OPORD)
 - b. (U) **Enemy Forces.** *Identify enemy forces and appraise their general capabilities. Describe the enemy's disposition, location, strength, and probable courses of action in relation to survey tasks. Identify terrorist threats and adversaries within the AO that may affect survey tasks.*
 - c. (U) **Friendly Forces.** *Briefly identify the missions of friendly forces and the objectives, goals, and missions of civilian organizations that impact survey tasks.*
 - d. (U) **Interagency, Intergovernmental, and Nongovernmental Organizations.** (See OPORD)
 - e. (U) **Civil Considerations.** (See OPORD)
 - f. (U) **Attachments and Detachments.** *This subparagraph lists sections attached for a particular task, such as an infantry squad performing security for the survey team.*
2. (U) **Mission.** *This paragraph is a clear concise statement of the task to be performed by the survey section. It may include implied tasks determined by the survey planner from his mission analysis. Normally it describes who, what (task), when, where, and why (purpose).*
3. (U) **Execution.** *Describes how the survey section intends to accomplish the mission in terms of the commander's intent.*
 - a. (U) **Commander's Intent.** (See OPORD)
 - b. (U) **Concept of Operation.** *This subparagraph briefly describes the survey method to be used. Generally how will the survey be done. The immediate following subparagraphs may be used for specific tasks for any subordinate survey sections or teams. If there are no subordinate survey sections or teams the next subparagraph c. can be used for coordinating instructions.*
 - c. (U) **Coordinating Instructions.** *The last subparagraph contains instructions common to two or more units. These instructions are designed to keep subordinate units working together.*
4. (U) **Sustainment.** *This paragraph lists any logistical considerations that may concern or affect the survey section or team. It lists food, ammunition, POL, location of medics and aid stations, handling of enemy Prisoners of War, and nonorganic transportation. These considerations should only be addressed if they affect the survey being performed. Local SOP items need not be addressed.*
5. (U) **Command and Signal.**
 - a. (U) **Command.** *This subparagraph gives the location of the commander and the succession of command if not listed in the unit SOP.*
 - b. (U) **Control.** *This subparagraph lists the location of command posts and any specific command post that is the primary controlling command post for the survey task.*
 - c. (U) **Signal.** *This subparagraph lists the concept of signal support for the survey tasks. It will also list location and movement of key signal nodes and critical electromagnetic considerations.*

Legend: AO-area of operations FM-field manual OPORD-operations order
POL-petroleum, lubricants, oils SOP-standard operating procedures

Figure 2-2. Five paragraph survey order

2-43. Fragmentary orders include the information in paragraphs 2 and 3 of the survey order and any information that has changed since the last order.

PRINCIPLES OF A SURVEY STANDARD OPERATING PROCEDURE

2-44. A SOP standardizes procedures for those phases of operation that the commander wants to make routine. For an example of a Survey SOP see Appendix A. These procedures are to be followed in the absence of specific instructions. The SOP of a battalion or higher-level headquarters should contain a section on survey. The SOP for each level must conform to the SOP of the next higher level. Therefore, the survey portion of the SOP at each level should include only those survey procedures that the commander wants to make standard throughout his command. Survey items the commander wishes to make standard only for the survey team of their unit should be in the SOP for that particular section. A survey SOP does the following:

- Simplifies the transmission of the survey plan.
- Unifies survey personnel training.
- Promotes teamwork and understanding.
- Expedites survey operations.

SIMPLIFY THE TRANSMISSION OF SURVEY PLANS

2-45. Instructions included in an SOP need not be restated in the survey plan. Many details on operations, measurements, or methods of survey may be outlined in the SOP. This eliminates the need for a lengthy and bulky survey plan or order. However, including instruction in the SOP does not prevent the survey planner from restating these instructions in the survey plan for emphasis.

UNIFY SURVEY PERSONNEL TRAINING

2-46. Establishing standard procedures for survey operations ensures uniform training and minimizes the need for special instructions. By using standard procedures, survey personnel become more proficient in their operations.

PROMOTE TEAMWORK AND UNDERSTANDING

2-47. Standing operating procedures ensure uniform performance of survey operations and minimize the time and effort required for coordination. This is particularly true in those units that use more than one survey team.

EXPEDITE SURVEY OPERATIONS

2-48. When personnel become familiar with and use standard signals, techniques, and procedures, they will do their tasks in minimum time. Furthermore, using standard procedures reduces confusion and eliminates unnecessary survey operations.

2-49. To be effective, a survey SOP must be brief and must conform to established doctrine. If the SOP is too long and detailed, it loses its value as an instrument of ready reference. It must be flexible, since it cannot cover every possible survey situation or method. The SOP should give survey personnel enough latitude to adapt survey requirements to different situations rather than specify various types of problems that may or may not exist in the field. The SOP must conform to the doctrine and policy in the SOP of the higher headquarters so that trained personnel reassigned from one unit to another will have no difficulty or be no less proficient. As a minimum, the SOP for survey operations should contain the information and instructions discussed below.

PRINCIPAL DUTIES OF KEY PERSONNEL

2-50. This survey SOP should define the principal duties of key personnel. The key personnel include the following:

- Chief Surveyor.
- IPADS team chiefs.
- Team members.

ACCEPTABLE METHODS OF SURVEY

2-51. The survey SOP should include the methods of survey acceptable for various survey tasks. The methods will depend on the type of instruments available, IPADS, IPADS-G, time available, and training status of survey personnel.

SUPPLY AND MAINTENANCE INFORMATION

2-52. The survey SOP should include pertinent information on supply procedures, stock levels, and maintenance responsibilities for all survey personnel.

COMMUNICATIONS

2-53. The survey SOP should include information on using radios, telephones, visual signals, and electronic protection procedures.

Chapter 3

Survey Operations

Survey operations must be responsive, accurate, and flexible. The artillery surveyor's primary mission is to provide accurate orientation and determine the coordinates and height of weapons and target-locating systems relative to one another. This is known as establishing a common grid. The task of providing a common grid involves different levels of command and echelons of survey. Beginning at the echelon above brigade, technical engineer specialists (geodetic surveyors) establish third-order or higher SCPs in the corps and division area for the FAB, DIVARTY, and BCTs. FAB, DIVARTY, or BCT surveyors extend control to FA battalion areas, where the battalion surveyors extend control to the weapons and target-locating devices. This chapter discusses the survey operations typical of the following:

- Common grid.
- FA battalion.
- Special environments.

SECTION I – FIELD ARTILLERY BATTALION SURVEY

3-1. The primary mission of the surveyors in a FA battalion is to provide timely survey control and common grid for firing units and target-locating systems within prescribed accuracies. Survey control consists mainly of establishing a line of known direction and determining the locations, both horizontally and vertically, of the weapons and the target-locating systems.

REASONS FOR COMMON GRID

MASS FIRES

3-2. Accurate survey permits rapid and economical massing of fires. For artillery to mass fires accurately without survey requires an observed adjustment of all units on the target or prior registration of all units on a common registration point.

DELIVER SURPRISE OBSERVED FIRES

3-3. If survey is not available and all batteries are required to adjust on a target, the element of surprise is lost. Complete surprise is impossible without survey.

DELIVER EFFECTIVE UNOBSERVED FIRES

3-4. Without survey, consistently effective unobserved fires are possible only if the target has been fired on previously and re-plot data have been computed.

TRANSFER TARGET DATA BETWEEN UNITS

3-5. Transfer of target data between units is possible only when units are located relative to each other and to the target (on a common grid).

VARIATIONS IN STARTING CONTROL

3-6. Starting control for FA survey consists of the coordinates and height of a SCP and a starting azimuth. Although there are several ways in which starting control can be obtained, the best control available for the area should be used to begin a survey. The variations of starting control can be grouped into three general categories:

- Known coordinates, height, and azimuth.
- Assumed coordinates, height and known azimuth.
- Assumed coordinates, height, and azimuth.

KNOWN COORDINATES, HEIGHT, AND AZIMUTH

3-7. Starting control for which the station data are known may be points established by survey done by a higher echelon, or it may be confirmed data established before the start of military operations. Data for stations established by technical engineer specialists, geodetic survey sections, and data for survey control established before the start of military operations are in trigonometric lists prepared and published by the National Geospatial-Intelligence Agency (NGA).

ASSUMED COORDINATES AND HEIGHT AND CORRECT GRID AZIMUTH

3-8. When survey control is not available in the area, the coordinates and height of the starting station must be assumed. Correct grid azimuth can be determined by using the IPADS or IPADS-G. Correct grid azimuth should always be used whenever possible. If both higher and lower survey echelons initiate surveys by using correct grid azimuths, any discrepancy between surveys that is due to assumption of coordinates will be constant for all points located. The approximate coordinates and height of the starting point can be determined from a large-scale map and should closely approximate the correct coordinates and height to facilitate operations. Starting data determined from a map must always be considered as assumed data.

ASSUMED COORDINATES, HEIGHT, AND ASSUMED AZIMUTH

3-9. Assumed azimuth should be used for a starting azimuth only when azimuth cannot be determined from the IPADS, astronomic observation computation, or a published trigonometric list. The assumed azimuth should approximate the correct grid azimuth as closely as possible. The approximate grid azimuth can be determined by using a declinated compass or scaling from a large-scale map (map spot). If either a higher or lower survey echelon or both initiate survey operations with assumed azimuths, differences of varying magnitude will exist between the coordinates of points located by their surveys. This variation complicates the problem of conversion to common control. For this reason, an assumed azimuth should never be used if the correct azimuth can be determined.

CONVERSION TO COMMON GRID

3-10. A battalion SCP is a point provided by a higher survey echelon for initiating survey control for the battalion. More than one of these points may be required for a battalion. SCPs on the grid of the next higher echelon may be available in the form of one or more trigonometric points in the vicinity of the battalion installations. When available, trigonometric points from NGA or other published trigonometric lists should be used as the basis for all echelons of survey operations. When one or more SCPs have been established by the next higher echelon, these SCPs should be used as the basis for battalion survey operations. In either situation, the common grid is established.

3-11. Unless the tactical situation causes the commander to decide otherwise, battalion (battery) data are converted to the grid of the next higher echelon when data differ by 2 mils or more in azimuth, 10 meters or more in radial error, or 2 meters or more in height. If the next higher echelon converts its survey control to a different grid, the battalion must also convert to that grid. The problem of converting data to a common grid is greatly simplified if survey personnel use the correct grid azimuth to initiate survey operations. Accurate azimuth can be determined by IPADS or IPADS-G.

3-12. The mission of the subordinate unit requires it to initiate survey operations without waiting for survey control to be established by a higher echelon. Thus, a battalion assigned or attached to a FAB, DIVARTY, or BCT may have to operate first on the grid established by the battalion (battalion grid) and finally on the grid established by geodetic higher order survey section. When survey at one or more echelons is based on assumed data, data established by the lower echelon should be converted to the grid established by the higher echelon. An exception to this rule would be when prescribed accuracies are met or when the tactical situation, time constraints, or SOP causes the commander to decide otherwise

3-13. Whenever survey operations are started with an assumed azimuth, regardless of whether the coordinates and height are known or assumed, the coordinates of each station and the azimuths determined will be in error. To convert the assumed data to correct grid data, all azimuths and coordinates determined in the scheme must be corrected.

3-14. When using the forward observer system (FOS) device to convert assumed azimuth or coordinates to common control, use the following procedures:

- Display the SURVEY MODE MENU.
- Select the TRANSFORMATION MENU.
- Press the <A> key to select COORDINATE CONVERSION. Observe the COORDINATE CONVERSION SUMMARY LIST. Press the <Y> key and observe the TRANSFORMATION MENU. **STOP.**
- To print a survey form (DA Form 7368-R, *Computation—Conversion UTM to GEO Coordinate, GEO to UTM Coordinate, Zone-to-Zone Transformation*) of an existing record, press the <F> key.
- Select the letter key for the desired records. One of the following is printed depending on the type of coordinate conversion in the record:
 - Universal Transverse Mercator (UTM) to Geographic (GEO) Coordinate.
 - GEO to UTM.
 - Zone-to-Zone Transformation.

POSITION AREA SURVEY REQUIREMENTS

3-15. Survey control is required in the position area of each firing battery of a FA battalion. The FA battalion survey teams using the IPADS or IPADS-G. Position area survey requirements are identical for any type of artillery battery (see figure 3-1). Requirements for position area survey are described in paragraphs 3-17 through 3-23.

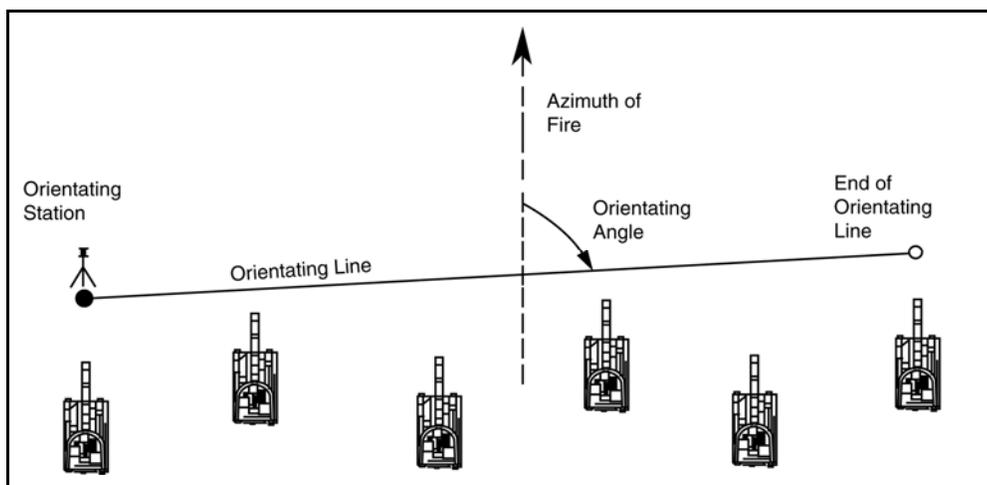


Figure 3-1. Position area survey

BATTALION AND BATTERY SCPs

3-16. As mentioned earlier, survey control for artillery units may be available in the form of SCPs established by technical engineer specialist geodetic surveyors or trigonometric lists containing data for stations located near the unit. The locations of SCPs established by the BCTs FA battalion survey teams must allow for the survey capability of the battalion. An SCP must be provided within 2 kilometers of the center of the battalion position area if the IPADS or IPADS-G is the primary method of survey. The BCT Chief Surveyor may task organic FA battalions to provide survey control for supporting units located in the battalion AO.

FIRING BATTERY POSITIONS

3-17. Survey requirements in each firing battery position are described below.

- Battery SCPs. Will provide coordinates and height for weapon systems position updates. Azimuth will be determined from Orienting Station.
- Orienting station (OS). The OS is a station used by the firing battery or platoon personnel to orient the weapons. The coordinates and height of the OS and a line of known direction are required. The position of the OS is usually selected by the battery commander or fires battery platoon leader, but it can be selected by the survey personnel. The frequent moves and the many positions required will not always allow the battery commander and/or platoon leader to select all OSs. The relative locations of the OS and end of orienting line (EOL) usually are addressed in the unit survey SOP.
- EOL. The EOL is a survey station used as an azimuth mark for the OS. The EOL must be located so that it is visible and at least 100 meters from the OS.
- Orienting line (OL). An OL is a line of known direction materialized on the ground in each position area. It is used as a reference direction for orienting instruments and for laying weapons for direction. When using IPADS or IPADS-G to establish the OL, the two-position mark is the preferred method. If optical transfer is used by achieving auto-reflection, a one-position angle must be measured.

FIELD ARTILLERY RADAR LOCATIONS

3-18. If a WLR section is attached to a FA battalion, the coordinates and the height of the radar position (near stake) and a line of known direction to an azimuth mark (far stake) are required. The distance and vertical angle to an azimuth mark is also required. The battalion survey team is responsible for determining this data. Usually, the FAB or DIVARTY WLRs will be located near one of the FA battalions. FABs and DIVARTY may task the nearest FA battalion to provide survey control. The radars require coordinates and height of the radar position and distance and direction to an azimuth mark.

3-19. . The IPADS or IPADS-G is the primary means of obtaining survey control for the radars. When the IPADS or IPADS-G is not available before the radar section occupies the radar site, the radar section will conduct a hasty survey. The hasty survey will provide the data for initializing the radar. If the IPADS or IPADS-G team arrives after the hasty survey has been completed, the data determined by the IPADS or IPADS-G survey will be entered into the radar computer instead of the hasty survey data. Azimuth required by the WLR radars must be accurate within 0.4 mil. The position accuracy required is 10 meters. The vertical interval accuracy is 10 meters for the AN/TPQ-36, AN/TPQ-50, AN/TPQ-53, and 3 meters for the AN/TPQ-37. However, the weapon location accuracy of the WLRs is greatly enhanced by keeping the vertical interval accuracy within 3 meters. This accuracy is within the capabilities of the IPADS survey.

ALTERNATE, SUPPLEMENTARY, AND OFFSET POSITIONS

3-20. Survey of alternate, supplementary, and offset positions should be performed as soon as survey operations for primary positions are completed. Survey requirements for alternate positions are the same as those for primary positions.

MULTIPLE LAUNCH ROCKET SYSTEM (MLRS) SURVEY

3-21. The survey mission in multiple launch rocket system (MLRS) is to provide timely survey control within prescribed accuracies. Numerous alternate position areas are essential for survival, and all require the same survey as the primary position area. Each system has individual requirements that vary slightly from other FA systems. These differences are due to equipment design, number of launchers, and auxiliary equipment requiring survey control.

POSITION NAVIGATION UNIT (PNU)

3-22. The position navigation unit (PNU) provides launcher position and navigation data. During fire missions, the PNU provides the fire control system (FCS) with location, attitude, and launcher rate data for use in computing ballistics and aiming the launcher module (LM). The PNU contains an embedded GPS receiver to enhance its inertial performance and provide effective land navigation for the launcher. The reference package of the PNU is capable of alignment on the move, a process that takes approximately 15 minutes as long as the vehicle remains in motion. Stationary alignment time can be as long as 5 minutes or as short as 2 minutes and 30 seconds, depending on initialization data and conditions. The position determining system (PDS) requires manual updating only in the event that GPS is not available to the system. GPS enables effective land navigation of the launcher in the absence of SCP information. In the absence of GPS information, the PNU provides free inertial navigation or navigation with the aid of existing odometer encoder inputs.

SURVEY METHODS

3-23. Survey personnel must begin survey operations as soon as the requirement for survey is identified. The goal is to establish survey control prior to occupation by delivery and/or acquisition platforms. In a GPS permissive environment only a few initialization SCPs across the AO are critical and SCPs in position areas for artillery (PAA) will not be an urgent priority. However, operations in a GPS denied/degraded environment will require establishing survey prior to occupation. FA surveyors must provide the most accurate survey data possible within the constraints of the battlefield. In a GPS denied/degraded environment, the commander may have to accept survey accuracies that incur risk (increased error). Field artillerymen and leaders must advise the commander of the effect of inaccuracies regarding fire support—for example, in a GPS denied/degraded environment where conventional survey means may be required and survey closure error is excessive, the ability of a fire support unit to achieve desired effects on a target may require adjustment of fires to account for non-standard conditions, adding to the total mission time. Survey control can be determined by hasty survey techniques found in ATP 3-09.50.

MLRS OR HIMARS ELEMENT

3-24. The MLRS is a fully tracked, highly mobile, rapid-fire, free-flight rocket system that is designed to complement cannon artillery and supplement other fire support systems. The high-mobility artillery rocket system (HIMARS) is the wheeled variant of the MLRS. FABs and DIVARTYs may be assigned or attached MLRS or HIMARS battalions as needed. MLRS and HIMARS batteries are organized so that each is a relatively self-sufficient unit. Each MLRS and HIMARS firing battery has two firing platoons with three launchers per platoon. Each MLRS M270A1 launcher and HIMARS is equipped with a stabilization reference package and position-determining system (SRP/PDS), which is an onboard navigational system. The SRP/PDS provides direction, elevation, location, and launcher can't angle data to the fire control system. Once updated at a SCP, the SRP/PDS continuously carries accurate location data that are used by the fire control system to compute fire missions. The survey team must provide update points for the SRP/PDS.

SURVEY REQUIREMENTS

3-25. The battery operations officer directs and monitors survey operations. The primary responsibility of the IPADS or IPADS-G team is to establish SCPs throughout primary, future, and alternate locations. Each platoon could occupy from three to six new positions per day (see figure 3-2 on page 3-6).

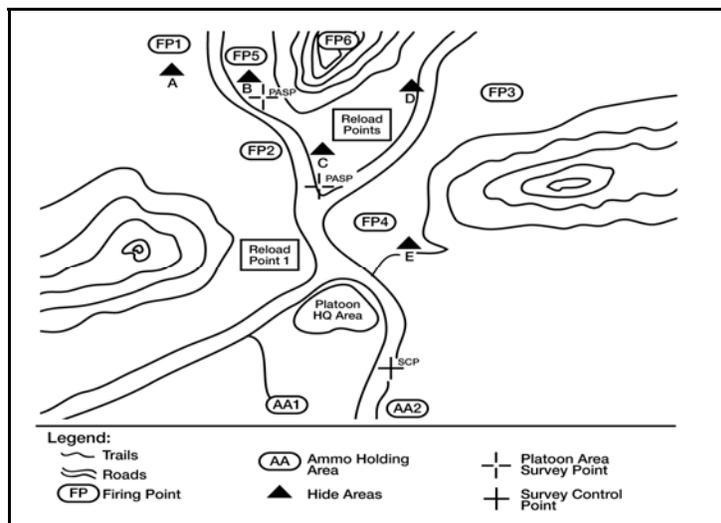


Figure 3-2. Typical MLRS firing platoon position area

3-26. SCPs are used to initialize, update, and calibrate the SRP/PDS aboard the launcher. These SCPs are established with the IPADS or IPADS-G by using 10-minute zero velocity updates (ZUPT) corrections. Directional control is not required for the MLRS and HIMARS. At least one SCP must be available in each of the three firing platoon positions.

3-27. Although cover and concealment are considerations in platoon area survey point selection, utility should be the primary consideration. The platoon area survey point must be readily accessible so that the driver can stop the launcher next to the SCP without a ground guide or excessive maneuvering.

3-28. In the motor park area, each launcher should have an individual SCP for initialization. This option will enable the launcher to leave the motor park area in a HOT status and be able to accept fire missions immediately.

3-29. The launcher crew calibrates the SRP/PDS whenever the launcher carrier track system is replaced or repaired. Calibration must also be performed when there is a significant change in the terrain of the operating area. Three SCPs located 4 to 6 kilometers apart are required for conducting calibration. The launcher must be calibrated every 30 days, after position determining system (PDS) maintenance, and after major suspension or track drive maintenance.

ALTERNATIVE SURVEY CONTROL

3-30. If the IPADS or IPADS-G becomes inoperative, the battery commander must ensure that the survey mission is continued. In this situation, survey control should be obtained from other FA units operating in the area or may be established by using hasty survey techniques. The IPADS or IPADS-G team can continue the mission using the AN/PSN-11 (precise lightweight global positioning system receiver [PLGR]) or AN/PSN-13 DAGR) to establish coordinates at the firing point. (For guidance on using the PLGR or DAGR, see chapter 9.) When location data are determined by hasty survey or map reading skills, the distance traveled by the MLRS between update points cannot exceed 6 kilometers. The unit must train and rehearse these techniques at every opportunity, both in the field and in garrison, to ensure that personnel have the skills needed to consistently obtain accurate results. It must be understood that these alternative methods are to be used only in emergency situations.

3-31. Maintain maps and files of survey data for the battalion AO, and coordinate survey activities with higher, lower, and adjacent headquarters.

M777 SURVEY

3-32. The digital fire control system integrates modular components on the M777A2 howitzer. With its navigation subcomponents: The Inertial Navigation Unit (INU), Motion Velocity Sensor, Mission Support Computer and Dual DAGR GPS the digital fire control system provides:

- Gun location.
- Pointing.
- Navigation.
- Digital communications.
- Emplacement and displacement aid capability.

3-33. The INU located in the right gun carriage assembly (over the right wheel when howitzer is emplaced) provides weapons position, location, and current pointing data to the Mission Support computer. Using both a DAGR (in the Communications location assembly) and a vehicle motion velocity (located on the right wheel of the howitzer) it maintains navigation data. The INU determines weapons location in terms of Easting, Northing, and Altitude (meters), and cannon pointing information in terms of quadrant elevation and azimuth.

PALADIN SURVEY

NAVIGATION SYSTEM WITH MODULAR AZIMUTH POSITIONING SYSTEM

3-34. The modular azimuth positioning system (MAPS) is made up of modular components combined in different configurations to provide survey and orientation information needs of a particular system. In the Paladin application, major components of MAPS consist of the dynamic reference unit-hybrid, vehicle motion sensor, and the GPS DAGR.

3-35. The dynamic reference unit-hybrid is mounted on the right trunnion of the Paladin armament system. Operating in conjunction with PLGR, the dynamic reference unit-hybrid contains all necessary sensor electronics, processing, and input-output circuitry to perform survey and orientation functions and interface with other MAPS components. The dynamic reference unit-hybrid performs the following functions:

- Provides vehicle position from a known starting point in terms of universal transverse mercator coordinates of easting, northing, and altitude.
- Provides vehicle orientation in terms of azimuth from grid north.
- Compensates for weapon pitch and cant.
- Supplies angular velocity rates.
- Provides weapon elevation, grid azimuth, azimuth rate, elevation rate, travel local grid azimuth reference, and travel local elevation reference.

Note. A best practice is for the section chief to copy down all position and direction data for his weapon system before he shuts down the computer. This enables the section chief to establish his own SCP to initialize his system when he powers the computer back up.

PALADIN ELEMENT

3-36. The Paladin is the M109A6 self-propelled howitzer equipped with a MAPS. With MAPS, the Paladin has more flexibility and requires fewer crewmembers and less equipment. The Paladin battery normally operates in a two-platoon configuration (three howitzers per platoon). A Paladin platoon requires a position area on the order of 2,000 by 1,000 meters and it uses all of that terrain during normal operations. Limitations of the onboard navigational system restrict the howitzer displacement distance. The Paladin must be updated every 16 miles or 26 kilometers to ensure that it meets position accuracy requirements.

SURVEY REQUIREMENTS

3-37. If the Paladin battalion is to accomplish its mission effectively, survey operations must be continuous and carefully coordinated. The battalion S3 and Chief Surveyor must use their limited survey assets wisely. The primary responsibility of the IPADS or IPADS-G team is to establish update points along the routes of march and one update point per weapon system to ensure that no Paladin has to travel more than 16 miles or 26 kilometers without updating. If the battalion has set up a rearm, refuel, resupply, and survey point, update points should be set up next to the fuel trucks so the howitzers can perform an update while refueling. If no rearm, refuel, resupply, and survey point is set up, establish update points, spaced 50 to 100 meters apart, near the release point of a tactical road march. These points should be easily identifiable and accessible without detouring far from the route of march and without clogging traffic along the route of march. This will allow the entire platoon to update at once, so they will not hold up the rest of the battalion.

ALTERNATIVE SURVEY CONTROL

3-38. If the IPADS or IPADS-G becomes inoperative, the Chief Surveyor must ensure that the survey mission continues. In this situation, survey control should be obtained from other FA units operating in the area or may be established by using hasty survey techniques. The IPADS or IPADS-G team can continue the mission by using survey methods that can be performed by two men with a theodolite and the handheld terminal unit (HTU) (FOS device). Refer to Chapter 7 for hasty survey techniques. Battery personnel must help the IPADS or IPADS-G team in the survey effort by using the AN/PSN-11 PLGR or AN/PSN 13 DAGR to provide the best available update points possible until the IPADS or IPADS-G is operating again. Hasty survey methods or a Precise Positioning System (PPS) GPS receiver can also be used by the howitzer crew as a last resort.

DESCRIPTION OF THE GUN LAYING AND POSITIONING SYSTEM

3-39. The gun laying and positioning system (GLPS) supplements the M2A2 aiming circle, and will be the primary instrument used to orient howitzers in cannon units not equipped with digitized weapon systems. When used in conjunction with the PLGR, the GLPS will determine grid location, establish directional control, and allow the operator to transfer directional control to the individual howitzers using standard laying commands. Additionally, the GLPS eye-safe laser range finder eliminates the need to measure sub tenses to determine the distance to the howitzer. The system is man-portable and tripod-mounted. It can be emplaced and used much the same as the M2A2 aiming circle, but without the need for external survey support.

3-40. GLPS is not a survey instrument and doesn't provide common survey across the area of operations. It only provides local common survey (for example, if you lay a gun and then move the GLPS to another location to lay another gun, the guns are not on common survey).

3-41. Technical data on GLPS capabilities are shown in the table 3-1. Battery leadership must be proficient in the setup and orientation procedures for the GLPS as listed in the equipment operator's manual. An independent check of the GLPS orientation must be made before using it to lay the howitzers.

Table 3-1. Gun laying and positioning system technical data

<i>Gyroscope</i>	
Accuracy of orientation	±0.2 mils probable error (PE) for latitudes 0° to 70° North or South. ±0.3 mil PE for latitudes above 70° to 75° North or South.
<i>Theodolite</i>	
Telescope magnification	10X
Graduation	0.1 mils
Resolution of horizontal and vertical circles	0.1 mils
<i>Laser Range Finder</i>	
Accuracy	± meters
Range	30 meters to 2,000 meters

Table 3-1. Gun laying and positioning system technical data (continued)

Global Positioning System Accuracy	
Positioning accuracy	10 meters circular error probable (CEP) (horizontal) 10 meters PE (altitude)

TARGET ACQUISITION

3-42. Common datum or common survey is critical for successful employment of TA WLR assets. The specific survey data required for each TA WLR system is described as follows:

- AN/TPQ-36:
 - Grid zone.
 - Site location (UTM coordinates within 10 meters CEP).
 - Distance from near stake (radar location) to far stake (orienting point). This distance should be at least 250 meters. The minimum distance is 100 meters. However, the further out the distance the better the accuracy that the system will report.
 - Azimuth from near stake to far stake (0.4 mil PE).
 - Vertical angle from near stake to far stake (0.5 mil PE).
 - Altitude of the near stake (10 meters PE).
- AN/TPQ-37:
 - Grid zone.
 - Site location (UTM coordinates within 10 meters CEP).
 - Distance from near stake (radar location) to far stake (orienting point). This distance should be at least 250 meters. The minimum distance is 100 meters. However, the further the distance the better the accuracy that the system will report.
 - Azimuth from near stake to far stake (0.4 mil PE).
 - Altitude of the near stake (3 meters PE).
- AN/TPQ-53:
 - Grid zone.
 - Site location (UTM coordinates within 10 meters CEP).
 - Distance from near stake (radar location) to far stake (orienting point). This distance should be at least 250 meters. The minimum distance is 100 meters. However, the further out the distance the better the accuracy that the system will report.
 - Azimuth from near stake to far stake (0.4 mil probable error (PE)).
 - Vertical angle from near stake to far stake (0.5 mil PE).
 - Altitude of the near stake (10 meters PE).
- AN/TPQ-50:
 - Grid zone.
 - Site location (UTM coordinates within 10 meters CEP).
 - Distance from near stake (radar location) to far stake (orienting point). This distance should be at least 250 meters. The minimum distance is 100 meters. However, the further out the distance the better the accuracy that the system will report.
 - Azimuth from near stake to far stake (0.4 mil probable error (PE)).
 - Vertical angle from near stake to far stake (0.5 mil PE).
 - Altitude of the near stake (10 meters PE).

MODULAR AZIMUTH POSITIONING SYSTEM

3-43. The AN/TPQ-36(V)8 and AN/TPQ-37(V)8 radars are equipped with the Modular Azimuth Positioning System (MAPS). MAPS provides required survey for these systems. However, MAPS requires external survey support to provide the initialization data and update points required for operation. MAPS

initialization requires the use of an initial survey control point of 5th order or higher. Before MAPS can be initialized, the antenna group must be parked over the survey control point. Once initialization begins it takes between 9 and 15 minutes to complete. Once the initialization data is stored, the antenna group can be moved to a different location in preparation for operations. The MAPS can be turned off after initialization and as long as the antenna group is not moved it will maintain all data. MAPS must be turned on and operational before the antenna group can be moved.

GLOBAL POSITION SYSTEM/ INTERNAL NAVIGATION UNIT (GPS/INU)

3-44. The AN/TPQ-50 and A/TPQ-53 are equipped with a global position system and internal navigation unit (GPS/INU). GPS/INU provides required survey data for the radars systems. It also provides a directional azimuth to orient the Radar systems, and pitch and roll to ensure the systems are within the required leveling tolerances.

SECTION II – MAINTENANCE OF SURVEY INFORMATION

FIELD ARTILLERY BRIGADE, DIVARTY, AND BRIGADE COMBAT TEAM CHIEF SURVEYOR

3-45. The FAB, DIVARTY, and BCT Chief Surveyors are the principal advisor to the FAB, DIVARTY, BCT commander, S-3, and staff on survey matters. The Chief Surveyor works out of the main command post and helps plan and coordinate for support of the FAB, DIVARTY, and BCT survey plans.

3-46. Survey planning begins with understanding the commander's intent and receiving the S-3 and FSO's guidance. During planning, full consideration must be given to the commander's concept, priorities, tactical situation, survey control available, desired accuracy, number of installations, and METT-TC factors. This information can be translated into survey requirements for the target acquisition sensors and the designated attack systems, which must be on a common grid by the time required. Aggressive survey planning that answers the requirements of plan, prepare, execute and assess is essential to ensure mission success.

3-47. The survey mission requirements are:

- Ensure common grid throughout the area of operations. This should be based on the grid provided by geodetic surveyors if available.
- Coordinate survey operations with higher, lower, and adjacent units.
- Establish survey priority on the basis of the commander's intent.
- Request, external survey support and/or information from the engineer geodetic survey element.
- Disseminate survey information to its organic units.
- Gather, evaluate, and compile survey control established by its organic units.
- Maintain maps and overlays of completed surveys, surveys in progress, and planned surveys.
- Provide starting survey control data to its organic units and tie-in point data between adjacent units.
- Advise and help the FA battalions target acquisition platoon to plan, conduct, and evaluate survey training.
- Select sites for declination stations.
- Plan and provide survey control to other users when required.
- Direct and coordinate recovery of existing SCPs.

COLLECTION OF SURVEY INFORMATION

3-48. Information collected by the operations cell includes NGA trigonometric lists, and all reports by the survey teams of the FAB, DIVARTY, and FA battalion.

NGA TRIGONOMETRIC LISTS

3-49. The FAB, DIVARTY, and BCT operations cell obtains NGA trigonometric lists as part of the initial map issue to the unit. The operations cell retains one copy of each trigonometric list as a reference record. Trigonometric lists are considered allied support material to the map supply and are requisitioned through S-2 channels. The areas of current operations and prospective interest are the basis of map supply.

REPORTS BY DIVISION/CORPS

3-50. In static situations, the corps or division may periodically publish consolidated lists of fourth-order SCPs established by the geodetic survey and design team and survey teams from all survey teams in the corps and division area of operations.

SURVEY TEAM REPORTS

3-51. The survey teams report their progress daily to the operations cell. Reports should include DA Form 5075, *Artillery Survey Control Point*, on all 4th order surveys performed. The Chief Surveyor and members of the fires cell (FC) check and evaluate the data and check the required information on DA Form 5075. (See figures 3-3 and 3-4 on page 3-13) This form is completed in duplicate for each fourth-order SCP. One copy of the form is provided to the fires cell, and one copy is filed as a reference record in the operations cell.

FIELD ARTILLERY BATTALION SURVEY REPORTS

3-52. The FA battalion survey teams periodically submit survey information to the FAB, DIVARTY and BCT operations cell on DA Form 5075. Copies are retained as reference records. Only survey control that the FAB, DIVARTY, or BCT SOP or OPORD has directed the FA battalions to establish are reported. The FAB, DIVARTY, or BCT Chief Surveyor designates the points to be established by battalions when the situation is such that the establishing these control points would contribute materially to the expeditious delivery of fires. These SCPs are of particular value in cases in which FA battalions exchange position areas or when counterattack plans are implemented and an abundance of survey control is required in a general area to be occupied by the supporting FA battalions. They are designated with a specific purpose in mind and then only when it is impractical to provide fourth-order SCPs.

MAINTENANCE OF SURVEY INFORMATION

3-53. The operations cell must maintain the information it has collected in a usable form. A survey information database or map with overlays and a survey information file are prepared to allow information to be used.

INFORMATION MAP WITH OVERLAYS

3-54. The operations cell maintains information showing all SCPs in the division area and adjacent brigade areas located to fourth-order accuracy or higher. This may be displayed by a digital data base or display, or by a map and overlay for backup situations. In addition, digital databases, or overlays to the map show the locations of artillery units, possible position areas, surveys in progress, proposed surveys, and other information required by the unit SOP. These databases, maps, and overlays should show the following information:

- Survey control points in black.
- Completed surveys in brown.
- TAB installations in blue.
- Proposed surveys in green.
- Present (solid-line symbols) and proposed (broken-line symbols) artillery positions in the operations area in brown.
- The friendly situation and the enemy situation when it might affect the planning or performance of survey in the area of operations.

INFORMATION FILE

3-55. The operations cell maintains a survey information file of trigonometric lists and extracts of trigonometric lists prepared and issued by NGA and the Corps of Engineers. A record is maintained of field notes and computations on control points established by the supporting FAB, DIVARTY, and BCT FA battalion survey teams. The operations cell submits periodic reports on surveys in progress to adjacent units and any other artillery units operating in the area.

ADVANCED FIELD ARTILLERY TACTICAL DATA SYSTEM SURVEY CONTROL POINT DATABASE

3-56. The operations cell must ensure that known control points are entered into the Advanced Field Artillery Tactical Data System SCP database. SCPs in the division area of interest and in the supported unit areas of influence should be entered and updated. The SCP database must be kept current to decrease the possibility of duplicate surveys and to rapidly exchange survey data automatically.

DA FORM 5075

3-57. DA Form 5075 is used to quickly identify SCPs. Figures 3-3 and 3-4 (page 3-13) show the use of DA Form 5075. The front of the form (figure 3-3) provides blocks for the following:

- Control point name and number.
- Map sheet and series number.
- Grid and geographic coordinates.
- Altitude.
- UTM zone and UTM square.
- Marking method.
- Accuracy of the data.
- Notes.
- Location diagram.

3-58. The back of the form (figure 3-4) provides blocks for the following:

- Description of reference points.
- Sketch of reference points.
- Distance to reference points.
- Grid bearing or azimuth to reference point.
- Methods used in determining horizontal, vertical, and azimuth control.
- Verification information (unit, preparer, checker, date, and notebook reference).

ARTILLERY SURVEY CONTROL POINT			
For use of this form, see ATP 3-09.02; the proponent agency is TRADOC.			
UTM ZONE 14S	UTM SQUARE NP	STATION NAME MLRS 1	ACCURACY
		STATION NUMBER 46	E + N 1:5,000
		MAP SERIES SHEET NO 6253 II	AZIMUTH 1:3,000
HOW MARKED <i>DISK MARKED "MLRS" IN NW CORNER OF A 12.2 X 4.5 METER CONCRETE SLAB</i>	E 538548.11	N 3834364.24	ALTITUDE 396.07 METERS
	LONGITUDE 98° 34' 46"	LATITUDE 34° 39' 08"	
NOTES	LOCATION DIAGRAM <p>WARNING THERE ARE DIFFERENT WAYS OF WRITING THE NUMBERS 17 AND 17.</p>		

DA FORM 5075, JAN 2016

PREVIOUS EDITIONS MAY BE USED UNTIL EXHAUSTED.

APD LC v1.00

Figure 3-3. DA Form 5075 (front)

DESCRIPTION	SKETCH	DISTANCE	GRID BEARING/AZIMUTH
STATION IS A DISK STAMPED "JOHN" SET IN CONCRETE AT OP BLACKHORSE, KNOWN AS JOHN RANGE CONTROL TOWER.		3,216.85 METERS	MILS 4,877.689 DEGREES GRADS
STATION IS A 1/8 - INCH STEEL ROD IN THE CENTER OF A METAL CLOVER LEAF. A METAL QUAD MARKER IS ERECTED OVER THE STATION.		1,224.26 METERS	MILS 0195.151 DEGREES GRADS
STATION IS AN IRON ROD IN CONCRETE, 738 METERS NE OF STATION MLRS 1. A QUAD MARKER IS ERECTED OVER THE STATION.		3,541.40 METERS	MILS 1,275.069 DEGREES GRADS
STATION IS A DISK STAMPED "TOM" SET IN CONCRETE AT OP LITTLE ROCK, 349 METERS SE OF STATION MLRS 1. MARKED WITH RED AND WHITE 4-FOOT STAKE.		349.51 METERS	MILS 2,485.661 DEGREES GRADS
STATION IS A DISK STAMPED "JED" SET IN CONCRETE AT EDGE OF DIRT ROAD, 500 METERS SW OF STATION MLRS 1.		299.89 METERS	MILS 3,302.105 DEGREES GRADS
METHOD OF DETERMINATION		UNIT HQ BATTERY, 3/35 FA	
HORIZONTAL	TRAVERSE	PREPARED	SGT DOE
VERTICAL	TRAVERSE	CHECKED	SSG DOE
AZIMUTH/ORIENTATION	TRAVERSE	DATE	29 DEC 15
NOTEBOOK REFERENCE		BOOK 1 OF 4 3/35 FIELD ARTILLERY	

REVERSE OF DA FORM 5075, JAN 2016

APD LC v1.00

Figure 3-4. DA Form 5075 (back)

EVALUATION OF SURVEY INFORMATION

3-59. The appropriate level Chief Surveyor must check the field records and computations of the target acquisition platoon survey teams. A survey team operating in the field maintains a field notebook containing a complete record of all fieldwork performed and all DA forms on which computations are performed. On completion of the survey, the field notebook, computation forms, and results of the survey are forwarded to the Chief Surveyor for checking, adjusting, and recording.

3-60. The evaluation process is designed to verify the validity of the survey consists of procedure checks, computation comparison checks, closure checks, and map verification:

- Procedure check. All computations and values recorded in the field notebook are checked to ensure that proper procedures, specifications, and techniques were used to complete the survey fieldwork to the required accuracy.
- Computation comparison check. The computations performed by the computers are compared to ensure that both sets of computations agree.
- Closure check. A check is made to ensure that the survey has been properly closed within fourth-order accuracy.
- Map verification. If the survey data passes the procedure check, computation check, and closure check, the data are plotted on the largest-scale map available to check both the validity of the survey and the accuracy of the map. If the map plots verify the recorder's field notebook description, the survey is accepted. If the map plots do not verify the recorder's field notebook description, the data are subjected to a complete computation check. If necessary, additional fieldwork is prescribed to determine whether the map or the survey is in error. Any map errors detected by survey personnel performing fieldwork should be noted in the remarks column of the field notebook and reported to higher headquarters through S-2 channels.

DISSEMINATION OF SURVEY INFORMATION

3-61. Timely dissemination of survey information is as important as maintaining a complete and accurate survey information file. The operations cell maintains survey information maps and overlays to aid in the rapid dissemination of survey information to units and to aid the S-3 in preparing the survey plan.

3-62. Target acquisition platoon surveyors or their representative should contact or visit the operations cell often to keep abreast of survey plans and to obtain survey control (trigonometric lists) available in their prospective areas of interest.

3-63. The Chief Surveyor should visit the target acquisition platoon often to coordinate and discuss survey operations and requirements. During these visits, he should ensure that the surveyors are aware of available control.

3-64. Survey data can be stored and rapidly transmitted by using digital systems such as an Advanced Field Artillery Tactical Data System. The unit SOP will dictate the procedures used to access, store, update, and disseminate survey information between echelons.

3-65. Survey information may be disseminated by radio or telephone. However, security requirements must be observed. Radio or telephone communication is the least desirable method of disseminating survey information because of possible errors in transmitting and because of problems in orally describing the survey station sketches shown on DA Form 5075.

3-66. Survey information usually is not disseminated until it has been evaluated and adjusted. During fast-moving situations in areas where limited survey control is available, there may be exceptions. In this case, the Chief Surveyor disseminating the survey data will ensure that the battalion commanders are informed that the data provided is unchecked and unadjusted. When the survey data is turned in to the operations cell, the Chief Surveyor will report which data he has disseminated and to whom. The operations will then ensure that the user gets the adjusted data when they become available.

SECTION III – SURVEY IN SPECIAL ENVIRONMENTS

3-67. Survey operations must proceed regardless of environmental factors, such as climate and terrain. Therefore, the type of environment must be considered. This section discusses some of the problems that may affect surveyors in arctic, desert, jungle, and urban areas.

ARCTIC AREAS

SURVEY OPERATIONS

3-68. Normally, peacetime surveys are planned to take advantage of the warmer months of the year to avoid working under the varying terrain and climate conditions found in the upper latitudes. In wartime, however, survey operations are executed when and where needed and cannot wait for ideal climate conditions. The summer season has the advantage of better visibility, greater body comfort, and fewer equipment malfunctions. The winter season reduces transportation difficulties in river, lake, and tundra regions. Survey control can be extended easily along riverbanks; over the nearly level, treeless plains of the arctic tundra; or across large bodies of water. When committing survey teams to field operations in arctic regions or under arctic conditions that are seasonal in the middle latitudes, commanders must consider the effects of ice movement, snowfall, prevailing wind, light refraction, and other peculiarities. The proper use of authorized cold weather equipment and field expedients will overcome most problems caused by the cold. For detailed information on cold weather operations see ATTP 3-97-11.

IPADS OR IPADS-G OPERATION

3-69. Operation of IPADS or IPADS-G in ambient temperatures above 115°F may cause the internal battery computer unit (BCU) battery temperature to approach or exceed 150°F.

CAUTION

IPADS or IPADS-G batteries contain an internal thermal cutoff switch to protect them from extreme heat. If the internal battery temperature approaches 150°F, the BCU may not provide backup battery power for IPADS or IPADS-G operation.

WARNING

Contact with power supply fins may cause skin burns at high ambient temperatures. Lead-acid batteries that are not fully charged may freeze and burst. Handle batteries as prescribed in TM 9-6140-200-13.

3-70. IPADS or IPADS-G can be operated for long periods of time on vehicle battery power. If it is necessary to extend a mission after operating IPADS or IPADS-G at temperatures of 115°F or above, do not turn the vehicle off or turn IPADS or IPADS-G direct current (DC) INPUT power off before performing a one-position mark. The hot start initialization procedure can be used to reinitialize IPADS or IPADS-G if necessary.

3-71. If a vehicle-to-vehicle transfer is required for an IPADS or IPADS-G that has been operated for long periods of time at temperatures of 115°F or above, perform a one-position mark before switching over to backup battery power. The hot start initialization procedure can be used to reinitialize IPADS or IPADS-G if necessary.

OTHER FIELD OPERATIONS

3-72. Survey accuracy depends largely on factors that can be controlled in the field by the IPADS or IPADS-G survey team. These include instrument handling, equipment care, and aids to maintaining body comfort. Surveying in the arctic or under arctic conditions requires a lot of professional judgment and common sense. All survey methods may be employed subject to terrain and weather conditions in the area of operation. Warm-up time for electronic equipment will be increased.

3-73. Setting up instruments under bad weather conditions, especially in snow, requires the use of field expedients. Brief setups in snow can be accomplished by firming up a snow base. Tamping will suffice for routine operations. Other processes are:

- Clear away the snow to reach the frozen but solid earth.
- Drive stakes to form a trivet-like base for tripod shoes.
- Use long tripod legs for setting up in deep snow.
- Use sharply pointed tripod shoes to facilitate setting upon icy surfaces.
- Protect the instrument from wind or accurate readings will be difficult.

3-74. Proper daily care ensures against equipment failure and delays in the field. Extreme changes in temperature may induce internal stresses within an instrument. Instruments should be kept outside overnight or in unheated shelters for short periods of nonuse. When transporting instruments in the field, arrange for the instrument to be carried outside the vehicle or in an unheated cargo compartment. Tripods also should be left outside when not in use. The FOS device temperature range (operating): +25°F to +120°F, temperature range (non-operating): -40°F to +150°F.

3-75. Body comfort depends mainly on the protection offered by issue clothing. The Chief Surveyor or Team Chief can improve conditions by directing the digging of pits, erecting windshields, or building up snow banks to reduce the intensity of exposure over extended periods. Utility stoves should be used for heating nourishing liquids and keeping the fingers warm. An instrument can be modified by providing enlarged nonmetallic operating knobs or by wrapping standard knobs with adhesive tape. This facilitates manipulation of the instrument and helps keep the fingers from being injured. Head and hand coverings become a problem for the instrument operator and the recorder. Layer gloves and layer head coverings provide a practical combination of warmth and maneuverability. An easily removed hood over an ear-covering headpiece is practical for most conditions. Safety precautions are:

- Do not touch metal with any part of the bare skin.
- Use equipment furnished for protection of the eyes against wind and glare.
- Always use the buddy system in surveying. Do not go out alone.
- Always carry a first aid kit.
- Practice personal hygiene as covered in ATTP 3-97.11.

SURVEY CONTROL

3-76. In most arctic areas, especially on the tundra or in heavily forested regions and away from centers of civilization, pre-established control will be minimal. Survey control that does exist will be difficult to locate in areas of heavy snowfall and high winds. Geodetic survey support is essential to establish the common grid. Map spotting, when maps are available, are almost impossible because of the lack of definable natural and manmade objects. The most probable solution for the extension of survey control (if geodetic survey support cannot be provided) is for the survey planner to assume position control, use the IPADS or IPADS-G and astronomic observation for direction, and start the common grid there. Each installation or unit will then convert to common control as it enters the appropriate survey net.

DESERT AREAS

3-77. FA survey in a desert environment lends itself to some major problems in equipment, methods, and operations. Problems not experienced in other environments are prevalent during desert operations. Initially, desert operations seem to be perfect for survey with long lines of sight, and cloudless skies for

celestial observations. However, the desert environment can cause unique problems for the surveyor. Some of the problems encountered are described below.

EQUIPMENT

3-78. Optical instruments operated in extreme heat can have some major interior and exterior physical problems. Experience has shown that at 100°F, the survey instrument leveling vials increase about 2 graduations past the true center. Therefore, at 120°F, the instrument operator may not be able to level the instrument because of bubble expansion. To counter this, instruments should always be shaded. The direct rays of the sun can and will cause optical distortion and internal stress. Before moving to a desert environment, operators and supervisors must ensure that proper maintenance is performed and lubricants are applied to and maintained in the instruments. The scoring effects of sand and grit on the instrument optics require that the instrument lens covers be in place when the instruments are not being used. The major problems in desert operations are caused by heat waves. Distances between stations are severely limited because of heat wave distortions. Consistent readings at occupied stations are nearly impossible to achieve. Operator eye fatigue is common and necessitates frequent operator changes. Because of heat wave distortion, IPADS or IPADS-G operations requiring optical transfer should be avoided.

SURVEY CONTROL

3-79. Survey control in the desert is very fleeting in nature. The lack of definable natural and manmade objects increases the problem of permanent control. Geodetic surveyors must make every effort to provide starting control for the FAB, DIVARTY, or BCT survey teams. Established survey control dates from the desert colonial periods and, although scarce, it is accurate. However, control that can be identified and located one day may be obscured by sand the next. If these control points are constructed of anything valuable (for example, metallic substances of any kind), local civilians will dig up and carry off the station markers. In establishing control, efforts must be made to camouflage or immobilize control points. Using the existing road networks and road junctions is another way of ensuring that control is available when it is required. Burned-out armored vehicles and destroyed fortifications also can be used as control points. When operating in the desert, the surveyor should ensure that all control possible within the zone of operations is recovered and verified. It should be understood that control in the desert is, at best, only temporary in nature. For more information on desert operations see FM 90-3.

JUNGLE AREAS

SURVEY OPERATIONS

3-80. Survey operations in the jungle pose many problems not encountered in other environments. Some of these are the foreboding appearance of the jungle, the oppressive humidity and heat, the unfamiliar noises, and the loneliness one feels in the jungle. In addition to the physical and psychological effects of working in the jungle, the FA surveyor will be aware immediately of the lack of adequate maps. The maps that are available often are inaccurate except for locations of coastlines and principal rivers. For a more detailed discussion of jungle operations, refer to FM 90-5.

SURVEY CONTROL

3-81. Because of the inaccessibility of jungle areas and since adequate maps do not exist for most areas, establishing survey control and the common grid is a primary consideration of the commander.

3-82. The extension of survey control should not depend on pre-established control, which in most jungle areas is minimal and at best difficult to recover and identify. One solution is for the survey planner, using available maps or map products, to assume control; use the IPADS or IPADS-G, for direction; and to initiate the common grid. Each unit will convert to common control when it ties into the survey control net. Map spotting with available maps or photomaps may have to suffice for position control at firing unit locations.

3-83. Normally, FA firing positions are in natural clearings. This usually will permit a position area survey to tie in the firing batteries relative to each other. Direction can be obtained as described above. One possible solution for the extension of the common grid is using gridded mosaics or other photomap products.

URBAN AREAS

3-84. In most military operations, the type of terrain is a prime factor in planning, coordinating, and executing a unit mission. This is especially true for survey operations conducted in and around villages, towns, cities, and other built-up areas. The presence of buildings and manmade changes to the landscape greatly affect survey operations and must be considered during IPADS or IPADS-G operations.

3-85. The tactical situation is a strong influence on survey operations in built-up areas. The enemy can be well hidden by using roofs and upper stories of buildings, sewer systems, subways, and other underground structures. Enemy obstacles (barricades, improvised explosive devices, booby traps, and minefields) may deny the use of certain terrain needed as routes for extension of survey control. Communication between survey assets may be hampered by the limited range of frequency modulated radios within built-up areas.

3-86. Line-of-sight limitations in urban areas and the possibility of widespread weapon positions will increase the number of survey stations. Required OPs must be located on rooftops, towers, or other high structures. Also, more OPs may be needed to observe all areas of concern and to ensure accurate target locations.

3-87. Targets of opportunity generally will be exposed for brief periods. Also, political and tactical considerations will demand pinpoint accuracy in locating and destroying targets. Destroying key facilities and creating severe obstacles to friendly troops must be weighed. For a detailed discussion of urban operations, see FM 3-06.

Chapter 4

Field Notes

The field notes of any survey are the only original record of the survey that the survey party has once it leaves the field. Therefore, the field notebook must contain a complete record of all measurements made or determined during the progress of the survey. It should include complete sketches, descriptions, and remarks, when necessary, to clarify the notes. The best survey fieldwork is of no value to the using unit if the notes are not accurate, legible, and complete in every detail.

FIELD NOTEBOOK

4-1. The field notebook (DA Form 4446, *Level, Transit, and General Survey Record Book*) is a hardback, permanently bound book for recording all survey data determined in the field. On the flyleaf inside the front of the book are instructions to the finder for the return of the book if it is lost. Also on the flyleaf are spaces for the identification of the notebook (see figure 4-1). Each set of two facing pages constitutes one numbered page. The page number appears in the upper right corner. The first two facing pages are reserved for the index of the contents of the notebook. The index should be kept current at all times.

POSTMASTER

Below label may be used for mailing this book to the addressee. Postage guaranteed.

POSTAGE AND FEES PAID
DEPARTMENT OF THE ARMY
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WASHINGTON, D.C. 20315
OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, \$300

COMMANDER
1st BN, 30 TH FA
FT. SILL, OK. 73503

U.S. GOVERNMENT PRINTING OFFICE: 19-1097-2

DEPARTMENT OF THE ARMY

CORPS OF ENGINEERS

**LEVEL, TRANSIT, AND GENERAL SURVEY
RECORD BOOK**

BEST RANGE
LOCALITY

TRAINING
PROJECT

BOOK 1 OF 1

T-16 THEODOLITES
INSTRUMENT

SFC JONES
CHIEF OF PARTY

IMPORTANT

On the opposite page, print the address to which this book is to be returned, if lost.

Figure 4-1. Example of data on flyleaf of a field notebook

DATA RECORDED

4-2. Recorded field notes consist of a combination of tabulated data, sketches, and descriptions. The total record of any survey in the field notebook should provide a clear and concise picture of the survey

performed. This information will include descriptions of the starting and closing stations, a description of any principal station established, the area or locality in which the work is performed, the purpose of the survey, and general remarks on weather, terrain, or other conditions that may be factors in evaluating the results. The information in the field notes must be complete enough that anyone not familiar with that particular survey operation can take the notebook, return to the locality, and recover or reconstruct any portion of the survey.

4-3. Data are recorded in the field notebook in tabulated columns according to a prescribed plan. Enough spaces are provided to permit entry of mean values as they are determined by the recorder.

4-4. Sketches must be made when needed. For example, if the description of an SCP in the trigonometric list is vague, incorrect, or missing or if maps of the area contain errors, a sketch is required. Each sketch should be drawn to an approximate scale and include a grid north (GN) line. Important details of the sketch may be exaggerated for clarity. Sketches should show distances to at least two reference marks from any principal station that might be buried underground. Reference marks should be permanent in nature. If permanent reference marks are not available, the survey party should emplace semi-permanent marks. Sketches also are used when necessary to indicate heights of survey signals and other points when vertical angles are observed to other than instrument height. A small protractor, which can also be used as a straightedge, should be used as an aid in making sketches. Each sketch should be legible and should be drawn large enough to ensure that it can be understood. Each station shown on the sketch should be identified.

4-5. A description should be used to supplement the information shown in the sketch. Remarks may be made to clarify measurements, weather, terrain, and observing conditions. The remarks should include any other factors that might be of any value in the evaluation of the survey. Approved abbreviations and conventional symbols will be used on sketches and in descriptions.

RECORDING

4-6. Each numbered page of the field notebook provides space for recording information pertinent to the survey. The type of survey and the date are entered at the top of the left side of the page. Weather conditions (two variables that identify visibility and temperature), the type and serial number of the instrument, and the names of the party personnel are entered across the top of the right side of the first page of each survey. The rest of the pages are used for recording survey data (instrument readings, mean angles, and distances) for designating the survey stations; for recording telescope positions or number of repetitions measured; and for recording remarks, sketches, and descriptions. The team chief will check data entered on each page and initial each numbered page before leaving the field. (If an incorrect angle or distance is discovered, it can be re-measured before the party leaves the area.) The instrument operator also should check recorded values for each occupied station before taking down the instrument.

4-7. All entries in the field notebook will be printed in capital block letters and in a neat and legible manner. Always use a sharpened pencil with lead soft enough to be readily seen but hard enough to be smear proof (3H or harder). Entries will **never** be made in ink. The recorder goes with the instrument operator and records the data in the field notebook as they are announced to him. He then reads data back to the instrument operator to ensure his entry is correct. Field data entries are recorded directly in the field notebook and not on scraps of paper for later transfer. As the entries are made, the recorder computes and records mean values and, for ease of identification, encircles the data that will be used to compute the survey. The recorder will immediately notify the instrument operator of any incorrect angle before the instrument is moved from the station. Station descriptions, sketches, and remarks are entered in the notebook before the survey party moves to the next station and must be complete enough to permit reestablishment. Only the data for that specific survey will be recorded on the page. Data pertaining to surveys other than the one in progress will be recorded on other pages.

4-8. Erasures are not permitted in the field notebook. If an incorrect entry is made, it is corrected by drawing a single line through the incorrect data and entering the correct data directly above the incorrect data. When a page is filled with data, sketches, or remarks that will not be used because of a change in plans, the page is crossed out by drawing diagonal lines between opposite corners of each side of the page and printing the word *VOID* in large letters across each side of the page (see figure 4-2 on page 4-4).

TYPES OF FIELD NOTES

4-9. Procedures covering all situations cannot be prescribed; therefore, the examples in figure 4-2 (on page 4-4) should be used as a guide in developing suitable techniques. IPADS or IPADS-G data will also be recorded in DA Form 4446. In the heading, enter the designation of the type of survey performed (IPADS or IPADS-G survey). The date will be the actual date of the IPADS or IPADS-G survey. In the heading of the adjoining page, show the IPADS or IPADS-G serial number (electrical mounting base), the spheroid number, and the total mission time. Across from these three items, enter the names of the IPADS or IPADS-G operator, assistant operator, and the ZUPT time used to conduct the mission. Label the columns below the heading, from left to right, as follows:

- STA—to identify the updated or marked stations.
- Identification number (ID NO)—to identify the storage position in the IPADS computer corresponding to the updated or marked stations (IPADS can store data for more than 360 positions.).
- Position, azimuth, elevation (PAE)—to identify the function performed at each position.
- U/A—to identify unadjusted or adjusted data.
- EASTING—to identify the UTM grid zone and casting grid of the position.
- NORTHING—to identify the northing grid of the position.
- EL—to identify the elevation of the position.
- TAZ-GAZ—to identify the true azimuth and grid azimuth of a plumb bob two-position azimuth mark.
- DISTANCE—to identify the distance (in meters) from the last marked position, when required, or the distance measured in an optical measurement.
- MALFUNCTION—to identify any malfunctions during the survey mission.

Note. Use the next recording page for recording horizontal angles, grid azimuth, and offset distances for all optics measurements performed during the survey. The rest of the page will be used for remarks.

SECURITY OF FIELD NOTES

4-10. A field survey notebook is as valuable to the enemy as a captured map. The notebook would enable the enemy to locate battery centers, observation posts (OP), and other military assets (radars, mortars, and such). For this reason, every effort must be made to safeguard the notebook.

4-11. Figure 4-2 (on page 4-4 through 4-7) are examples of common types of field notes kept by the recorder.

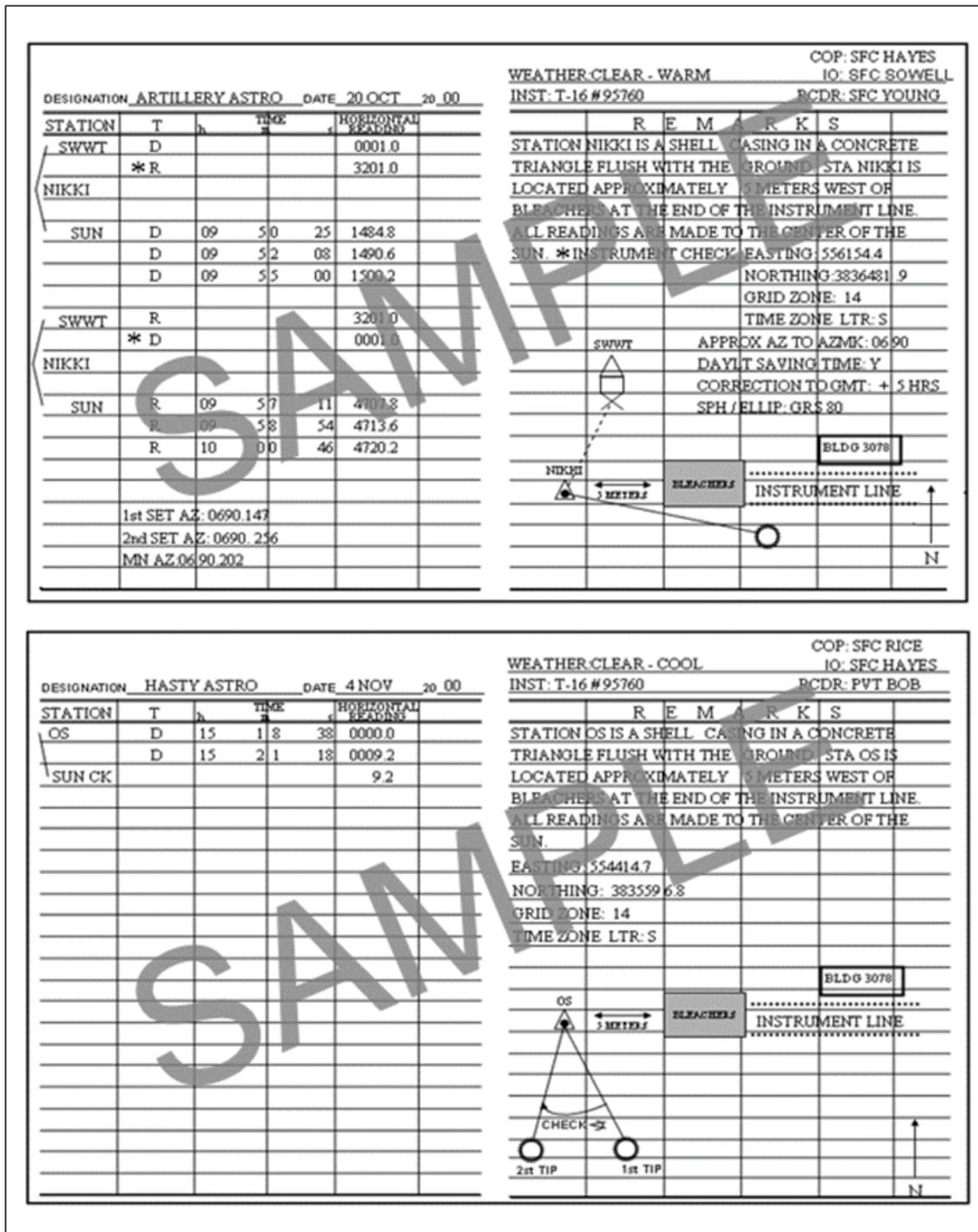


Figure 4-2. Example field notebook pages (continued)

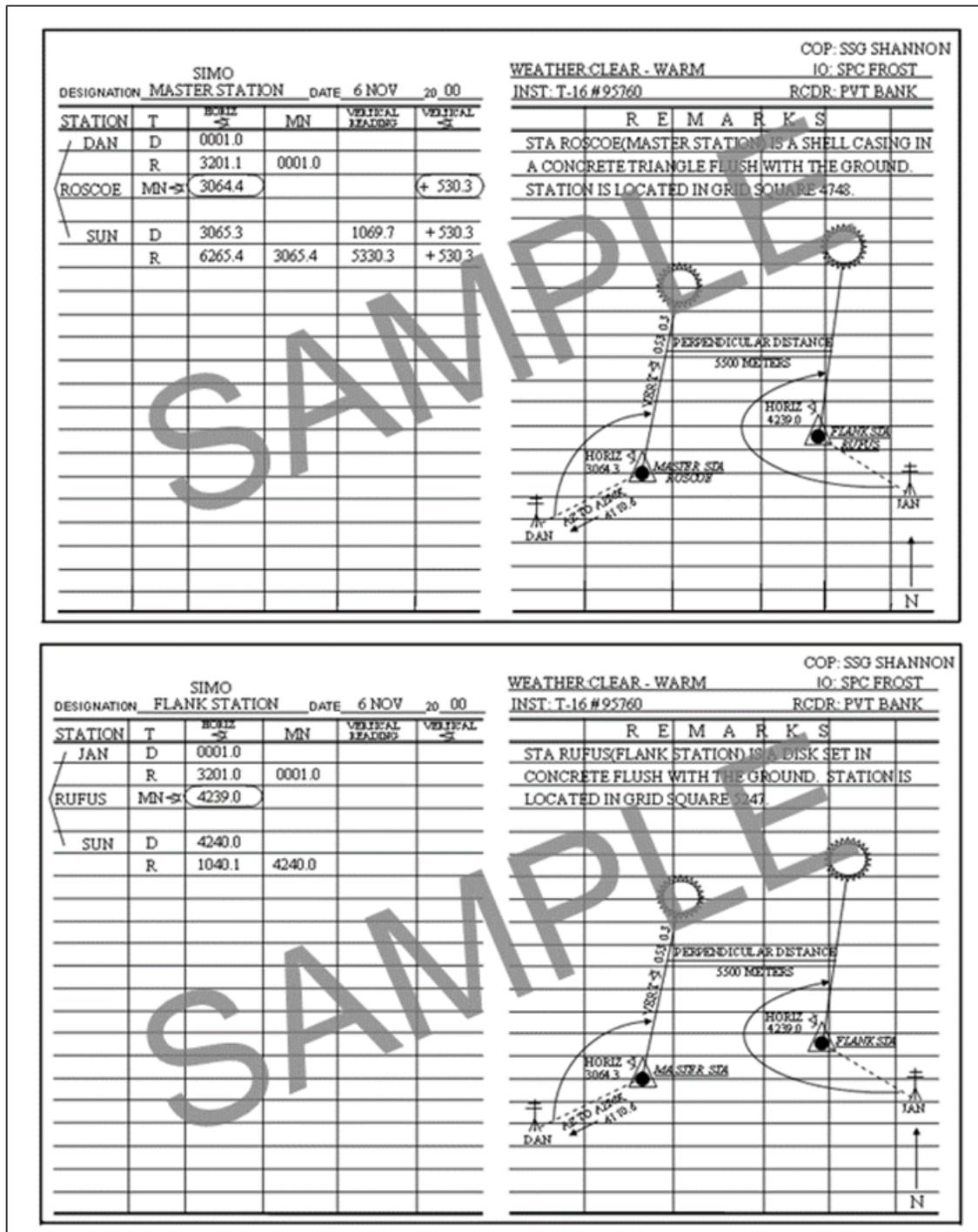


Figure 4-2. Example field notebook pages (continued)

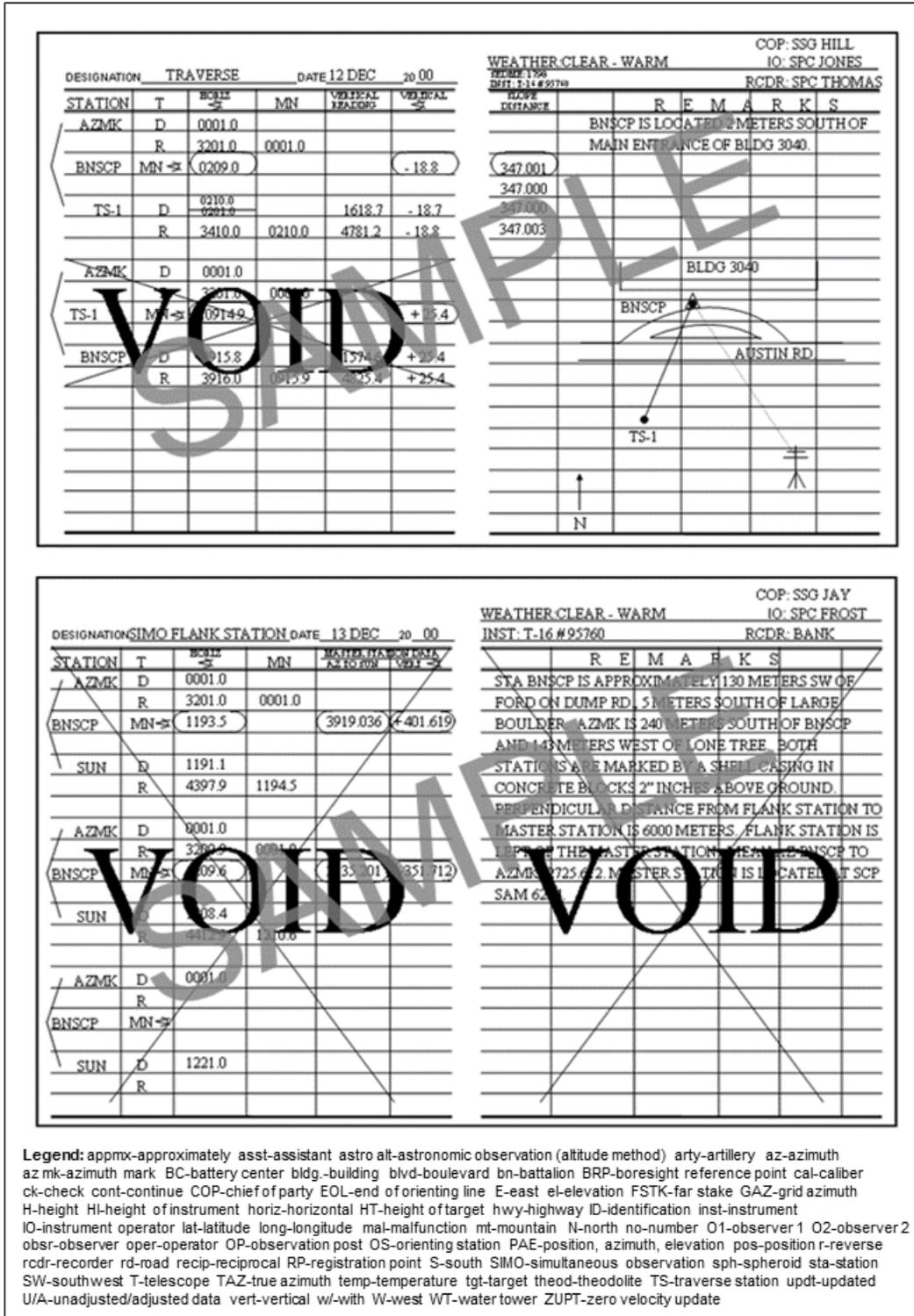


Figure 4-2. Example field notebook pages (continued)

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Chapter 5

Angle Determination

An FA survey operation consists of many tasks. One task is to measure horizontal and vertical angles. FA surveyors use the NIKON NE-102, 0.02/0.05 mil Theodolite to accomplish this task.

NIKON NE-102 - LOCATION AND DESCRIPTION OF CONTROLS

5-1. . The instrument used by FA Surveyors for angle measurements is the 0.05/0.02 mil Theodolite. This instrument is used for measuring horizontal and vertical angles for fourth-order, and fifth-order survey operations. For a description and location of controls see figures 5-1 and 5-2 (on pages 5-2 and 5-3).

- Carrying Handle – used to lift and replace theodolite from and back into carrying case.
- Display and Keyboard – Do Not use organic solvents (such as paint thinner or ether) to clean the non-metallic parts such as the keyboards, and the painted or printed surfaces. Solvents will discolor the surfaces or remove printed characters. Clean only with a soft cloth or tissue slightly moistened with water or a mild detergent.
- Power Switch – Turns display on and off.
- Optical Plumb – The optical plumb image is erect with a 3X magnification power. The field of view is 5°, with a focusing range of 0.5m to infinity.
- Tribrach Leveling Screws – Used for precise vertical alignment of the instrument’s vertical axis.
- Optical Sights – Used to “rough” sight instrument on target. Optical sights are located on the top and bottom of the telescope.
- Objective Lens – Lens image is erect. Magnification is 30X, with a field of view of 2.3m at 100m. The minimum focusing distance is 0.7m.
- Circular Level – Used to “rough” level the instrument. Level sensitivity for the Circular Level is 2mm.
- Tribrach Leveling Screws – Used for precise vertical alignment of the instrument’s vertical axis.



Figure 5-1. NE-102 Location and controls (front view)

- Diopter Ring – Used to bring the reticle crosshairs into fine focus.
- Battery Mounting Button – Press Battery Mounting Button down to remove/reattach battery pack.
- Battery Pack- Battery Pack contains 6, 1.5V AA Batteries. Operating time is approximately 22 hours of continuous use.
- Vertical Clamp – Used to lock vertical fast motion. Vertical Clamp must be locked prior to using the Vertical Tangent Screw.
- Vertical Tangent Screw – allows for fine movement of vertical motion. Last motion should always be made in a clockwise motion.
- Horizontal Clamp - Used to lock horizontal fast motion. Horizontal Clamp must be locked prior to using the Horizontal Tangent Screw.
- Horizontal Tangent Screw - allows for fine movement of horizontal motion. Last motion should always be made in a clockwise motion.

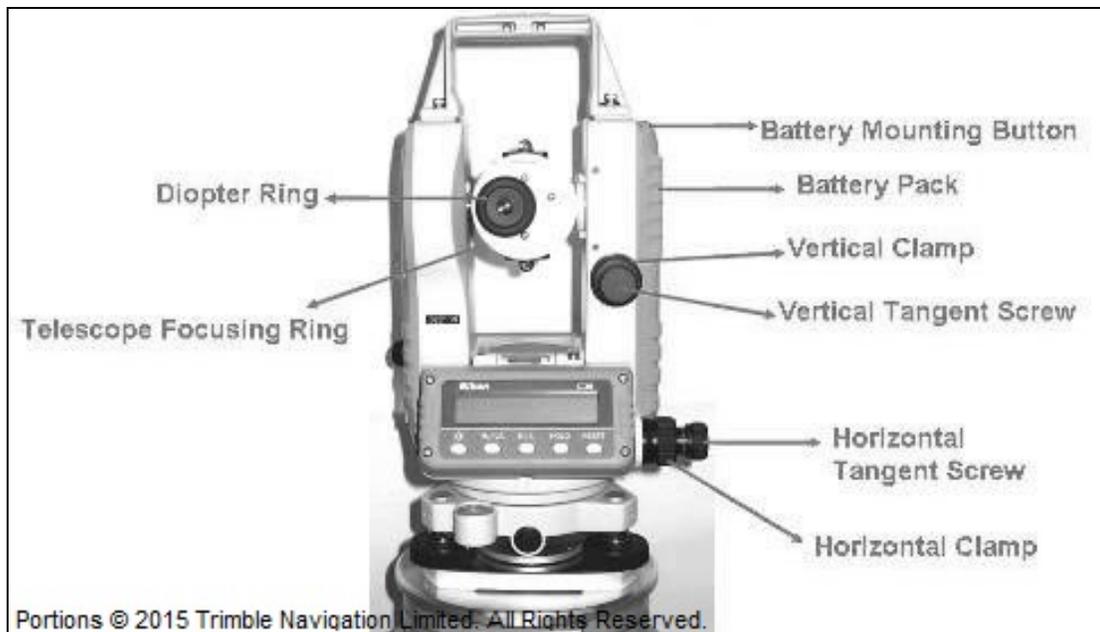


Figure 5-2. NE-102 Location and controls (rear view)

- Vertical Angle Display – Displays vertical angle in degrees, GONS (Northern European graduation equivalent to 1/400th of a circle) or mils.
- Horizontal Angle Display – Displays horizontal Angle in degrees, GONS or mils.
- Battery Capacity Level – When all three black bars are displayed battery is at full operational power. As battery discharges bars will go to two, then one. When “low” appears you have 30 minutes of battery power left. When “Help” is displayed, access is disabled, operations stop, the display locks, and approximately 5 minutes later the power automatically shuts off.
- Telescope Reticle Light and liquid crystal display (LCD) Backlight Key – Pressing this key illuminates the reticle crosshairs and the LCD. Illumination switches off automatically approximately 1 minute after being enabled, or can be manually turned off by pressing key again.
- Vertical Angle Priority Display Switch-over Key – Switches vertical angle display to grade reading by percentage, and then to the display of horizontal angle only.
- Horizontal Angle Reading Direction Display Switch-over Key – Switches the reading direction of horizontal angle, clockwise reading “HA” and counterclockwise reading “HL”. This key will not be used for artillery survey purposes.
- Horizontal Scale Hold/Horizontal Angle Summary Key – The Hold Key holds current horizontal angle reading, even when sighting direction is changed. Enables the summing of repeated horizontal angle measurements and during Initial Start Up procedures used for saving selections.
- Horizontal Angle Reset Key–The Rest Key resets horizontal angle to zero. During Initial Start Up procedures used for changing selections.

5-2. See figure 5-3 for an overview of the NE102 display operations (on page 5-4).

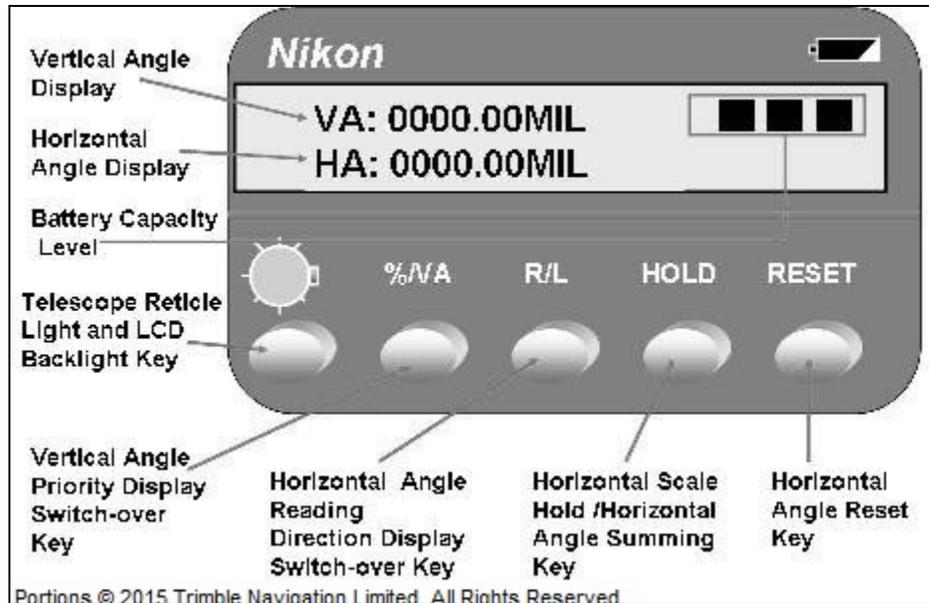


Figure 5-3. NE-102 Display operations key

SETUP PROCEDURES

5-3. The first step is to emplace the tripod over the station point. Open the legs of the tripod sufficiently enough for the instrument to be stable and ensure the station point is located directly beneath the center hole in the tripod head. A good way to ensure the tripod is at the correct height is to extend the legs to chest height. Press the tripods feet or ferrules firmly into the ground leveling the top of the tripod head then firmly fasten the clamp screws on the tripods legs.

5-4. Once the tripod is securely emplaced, use the carrying handle to remove the NE102 from its case and emplace the instrument to the tripod using the instrument clamp screw on the tripod. Insert the instrument clamp screw into the center hole of the instrument's base plate and tighten firmly.

5-5. There are two ways to align the instrument precisely over the station mark. One is to use a plumb bob and the other is performed using the optical plumb.

5-6. To center and precisely align the instrument's central axis over the station point hang a plumb bob on the hook of the instrument's clamp screw. Adjust the length of the plumb bob line so that the tip of the plumb bob is approximately level with the station point. Slightly loosen the clamp screw and while supporting the outer side of the leveling base with both hands carefully slide the instrument on the tripods head until the tip of the plumb bob coincides with the center of the station point.

5-7. To use the instrument's optical plumb place the instrument on the tripod head and insert the instrument clamp screw into the center hole of the instruments base plate and tighten securely. Looking through the optical plummet, align the station point image with the center mark of the reticle by turning the leveling screws. While supporting the tripod head with one hand, loosen the tripod legs and adjust the length of each leg to center the air bubble in the circular level. Once the bubble is centered tighten the tripod leg clamps. Then use the plate level to level the instrument. Look through the optical plummet and ensure the station mark is still centered in the reticle mark. If a slight displacement is detected, loosen the clamp screw and adjust the position by moving the instrument laterally (not rotationally) on the tripod head, Confirm precise alignment by viewing from two directions at right angles to each other.

WARNING

Never look at the sun through the telescope. Doing so may cause loss of eyesight.

5-8. To perform diopter adjustment, direct the telescope towards a blank area. While looking through the eyepiece, rotate the diopter ring to bring the reticle crosshair into sharp focus.

5-9. To eliminate parallax (the apparent displacement of an observed object due to the difference between two points of view) rotate the focusing ring to bring the target image into focus on the reticle crosshair. Move your eye vertically and horizontally to see if the target image moves in relation to the reticle crosshairs. If the target image does not move, there is no parallax. If the image does move, rotate the telescope focusing ring to eliminate the parallax.

INITIAL SETTING PROCEDURES

5-10. Prior to using the NIKON NE-102 theodolite for artillery survey procedures, the factory default settings must be changed.

5-11. To conduct a proper turn on sequence press the power switch while simultaneously holding down the reset key (see figure 5-4). Release the power switch prior to releasing the reset key. The LCD will light up for approximately 1 second, and then the screen will show the Version Number Display, followed by a display of the first item which is “Minimum Angle Unit Selection”.



Figure 5-4. NE-102 Turn on procedure

5-12. The following options are available for minimum angle selection. For 4th order survey 0.02 mil and 5th order survey 0.05 mil (see figure 5-5 on page 5-6). The value headed with the highlighted black square is the current selection. To change the setting, depress the RESET key and the position of the highlighted black square will be switched over. Once the selection is made, depress the HOLD key to fix the setting and proceed to the next setting item.

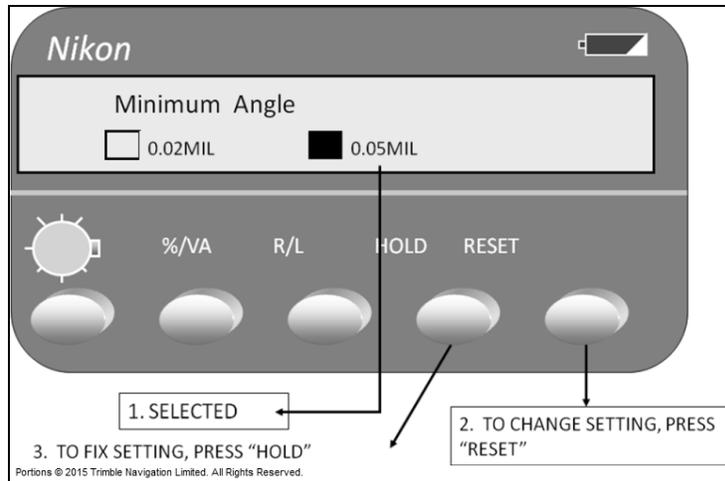


Figure 5-5. Minimum angle selection

5-13. The next setting item is the VERTICAL 0° orientation selection (see figure 5-6). For all artillery survey you must select Z-0. This will ensure that the horizon line is 1600 mils and 4800 mils, with the zenith as 0 mils. To change the setting, depress the RESET key and the position of the highlighted black square will be switched over. Once the selection is made depress the HOLD key to fix the setting and proceed to the next setting item.

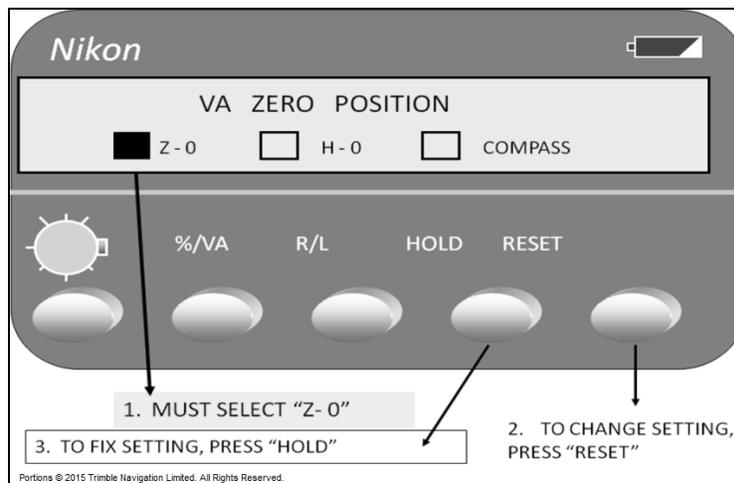


Figure 5-6. Vertical 0° orientation selection

5-14. The next step is the ANGLE UNIT SELECTION (see figure 5-7 on page 5-7). The 3 options are Degree (360), GON (400), and MIL (6400). To change the setting, depress the RESET key and the position of the highlighted black square will be switched over. Select MIL and depress the HOLD key to fix the setting.

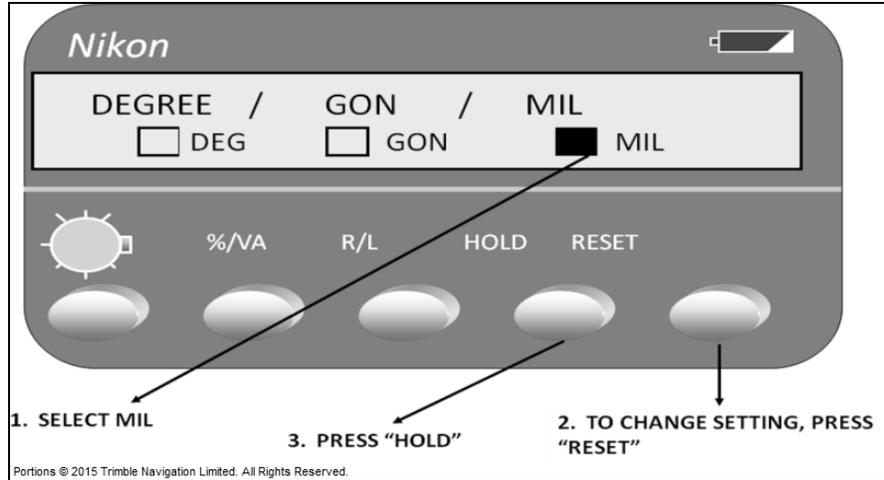


Figure 5-7. Angle unit selection.

5-15. After the ANGLE UNIT is selected the next step is to set the AUTOMATIC POWER CUT-OFF selection (see figure 5-8). The 3 available options are OFF (which disables automatic cut-off for continuous operation), selecting 10' will automatically shut the instrument off if left unattended for 10 minutes, selecting 30' will automatically shut the instrument off if left unattended for 30 minutes. A buzzer will sound 5 times, a minute before the power cuts off. Unattended means, no key operation, or no changes in horizontal or vertical angles. To change the setting, depress the RESET key and the position of the highlighted black square will be switched over, depress the HOLD key to fix the setting and proceed to the next setting.

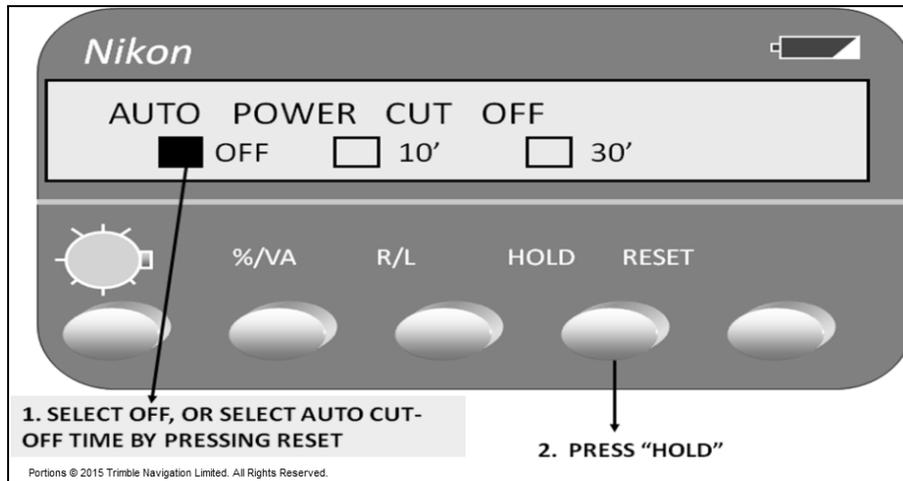


Figure 5-8. Automatic power cut off

5-16. The final step in the Initial Setting sequence is the TILT Telescope setting (see figure 5-9 on page 5-8). Be careful not to insert your finger between the telescope and the instrument trunion when rotating the telescope. Using the vertical clamp screw, loosen the telescope and rotate slowly till the instrument beeps once. The LCD will then revert to the initial start-up screen.

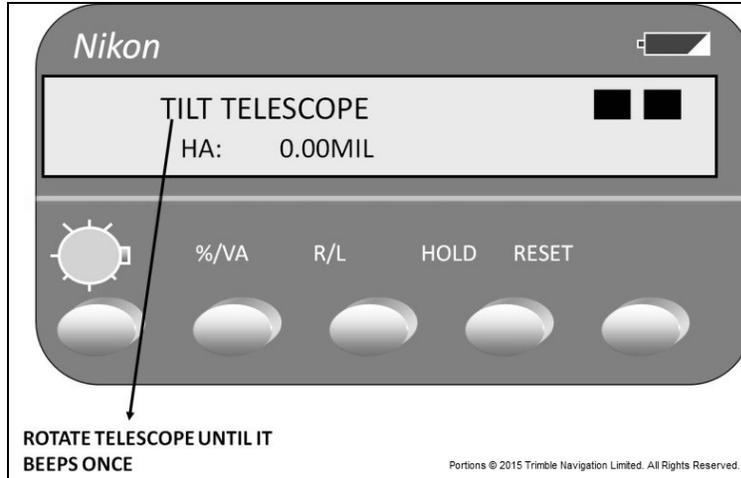


Figure 5-9. Tilt telescope

5-17. At this point the instrument is ready for angle measurement operations (see figure 5-10).

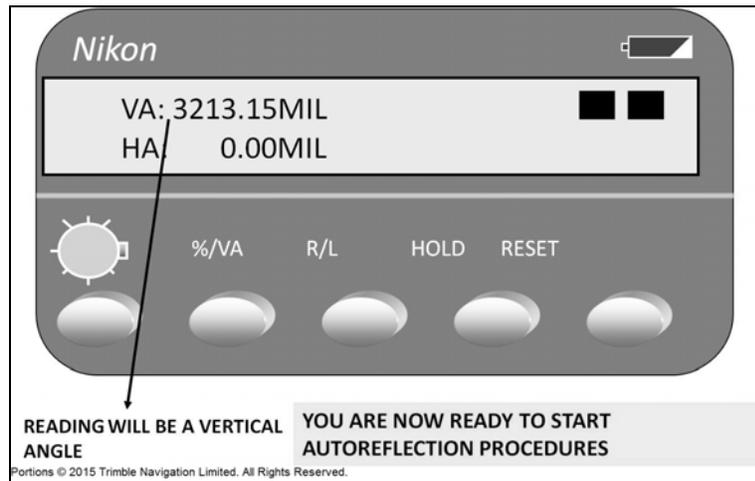


Figure 5-10. Vertical angle reading

VERTICAL ANGLE MEASUREMENTS

5-18. With the instrument set-up over a point ensure the instrument is level and optically plumbed. Ensure the telescope is in the direct mode (the telescope eyepiece will be on the left side, see figure 5-11 on page 5-9) and achieve autoreflection.

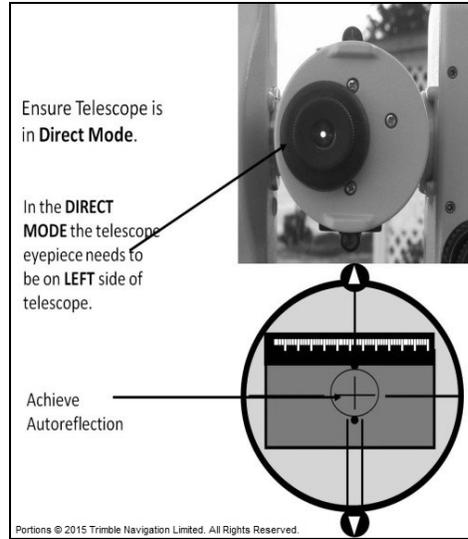


Figure 5-11. Telescope direct mode

5-19. After achieving autoreflection, read the vertical angle which is annotated by VA on the display (see figure 5-12). Record the Direct Vertical Reading in the Recorder's Notebook in the Vertical Reading column in the D row which stands for Direct Mode.

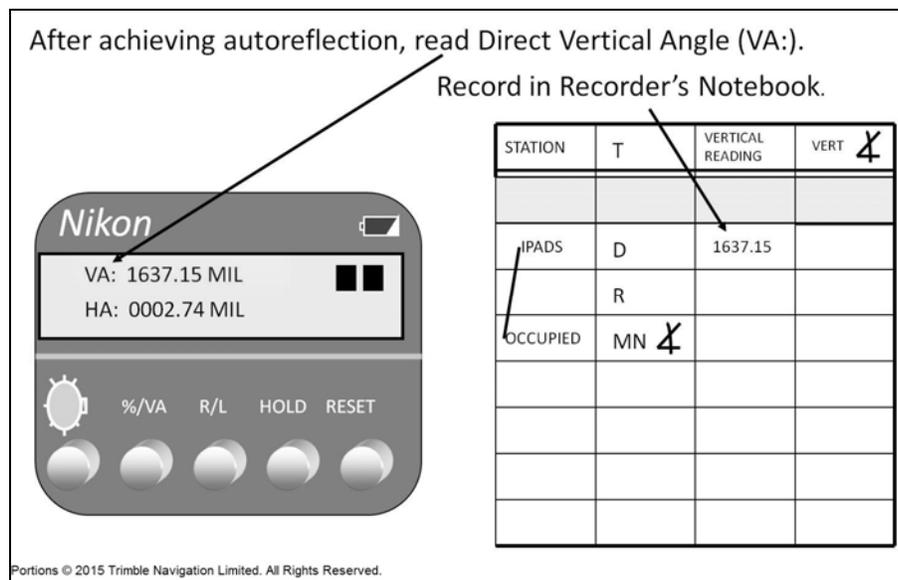


Figure 5-12. Vertical angle recording

5-20. The next step is to take a reverse vertical angle reading (see figure 5-13 on page 5-10). Be careful not to insert your finger between the telescope and the instrument trunion while rotating the telescope. Plunge the telescope in the reverse mode the eyepiece will be on the right side of the telescope. With the telescope in the reverse mode achieve autoreflection.

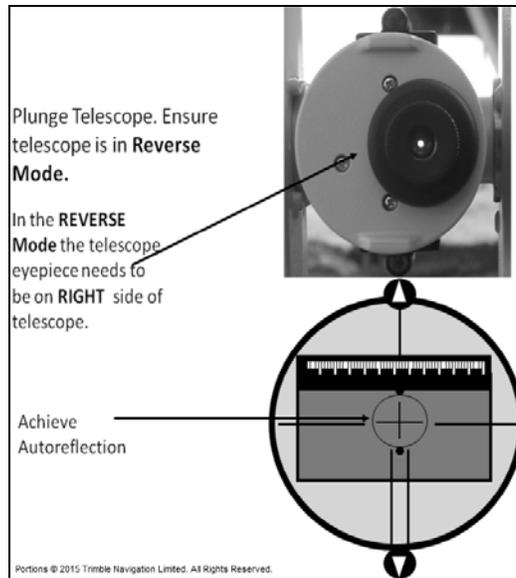


Figure 5-13. Telescope reverse mode

5-21. After achieving autoreflection, read the Reverse Vertical Angle which is annotated by VA on the display (see figure 5-14). Record the Reverse Vertical Reading in the Recorder’s Notebook in the Vertical Reading Column which is the R row which stands for Reverse Mode.

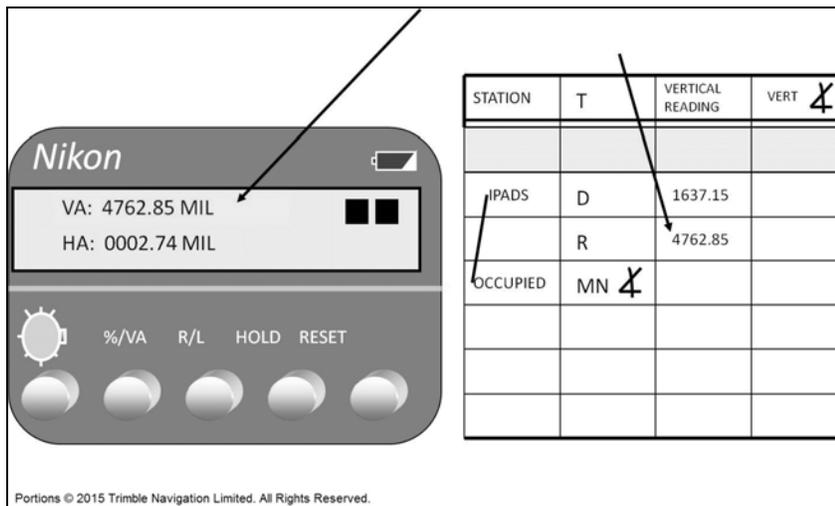


Figure 5-14. Reverse vertical angle recording

5-22. The next step is to mean the vertical angle reading (see figure 5-15 on page 5-11). To figure out the Direct Vertical Angle use the Direct Vertical Reading. If the reading is greater than 1600, subtract 1600 from the vertical reading and record in the Vertical Angle column in the D row. The vertical angle will be in the 2nd Quadrant, therefore, the vertical angle is negative. If the reading is less than 1600, subtract the reading from 1600. The vertical angle will be in the 1st Quadrant therefore the vertical angle is positive. To figure out the Reverse Vertical Angle, use the Reverse Vertical Reading. If the reading is greater than 4800, subtract 4800 from the Vertical Reading and enter the value in the Vertical Angle column in the R row. The vertical angle will be in the 4th Quadrant, therefore, the Vertical Angle is positive. If the reading is less than 4800, subtract the reading from 4800. The Vertical Angle will be in the 3rd Quadrant, therefore, the Vertical Angle is negative. Take the 2 values in the Vertical Angle column, add them together, then divide by 2. This value is the mean Vertical Angle. Record the value in the Vertical Angle column, in the Mean Angle row. Ensure you use the positive or negative symbol.

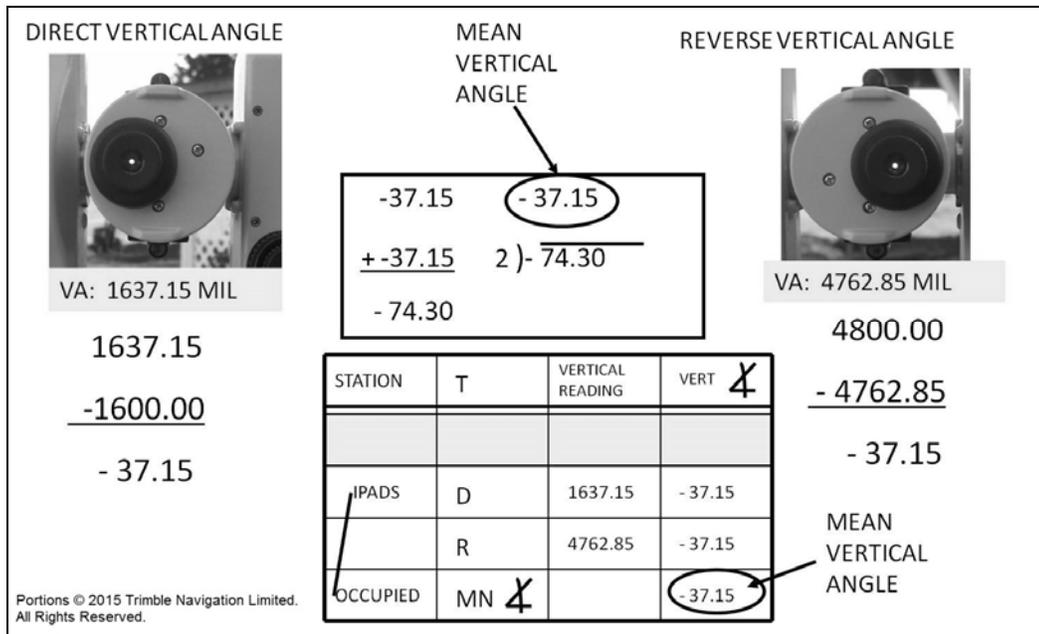


Figure 5-15. Vertical angle mean

SCALING DISTANCES

5-23. After achieving autoreflexion, use the horizontal tangent screw to set the left stadia line on zero on the distance scale of the porro prism (see figure 5-16). If the right stadia line is on the scale, read the number off the scale where the stadia line crosses it. In this example the reading is 8.2 meters. Record the distance in the recorder’s notebook in the Distance column.

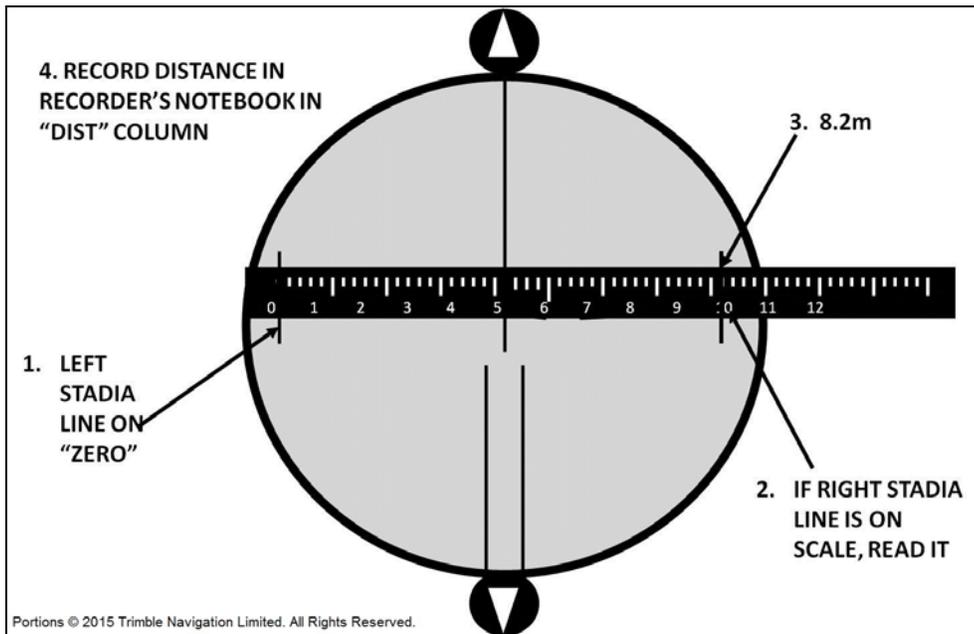


Figure 5-16. Scaling distance stadia line on scale

5-24. If the right stadia line is off the scale, (see figure 5-17) read the scale where the center vertical cross hair crosses the scale. The reading is then doubled and the total is the distance in meters. In this example 6.4 plus 6.4 is 12.8 meters. Record the distance in the recorder's notebook in the Distance column.

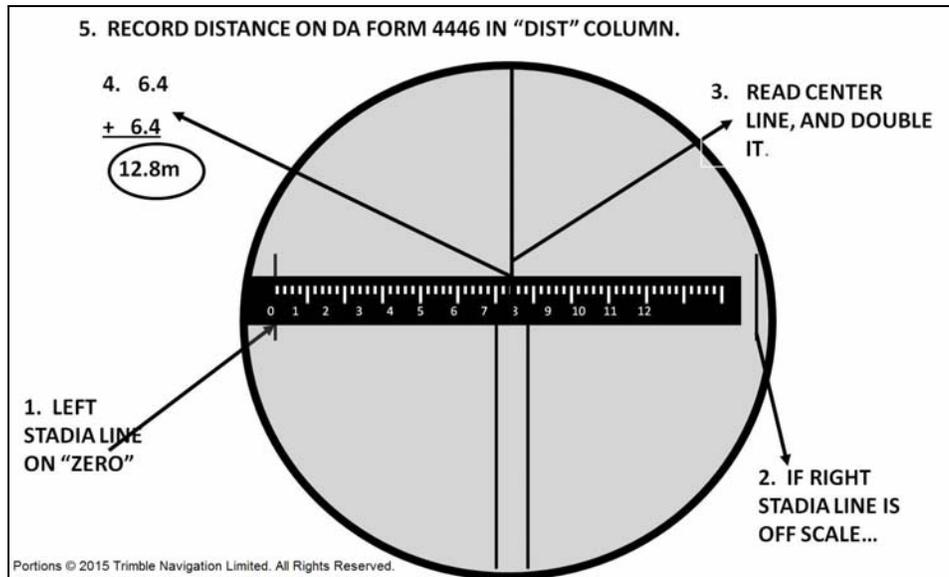


Figure 5-17. Scaling distance stadia line off scale

HORIZONTAL ANGLE MEASUREMENTS

5-25. Prior to beginning to turn horizontal angles, an initial circle setting of 0001.0 must be set on the Horizontal Scale on the display (see figure 5-18). To accomplish this, rotate the instrument slowly in a clockwise direction until the Horizontal Reading HA is close to 0001.0 mils. Use the horizontal clamp to lock the instrument in place. Use the Horizontal Tangent screw to set the Horizontal Reading to 0001.0 mils. Once this is accomplished press the hold button to lock the setting in place.

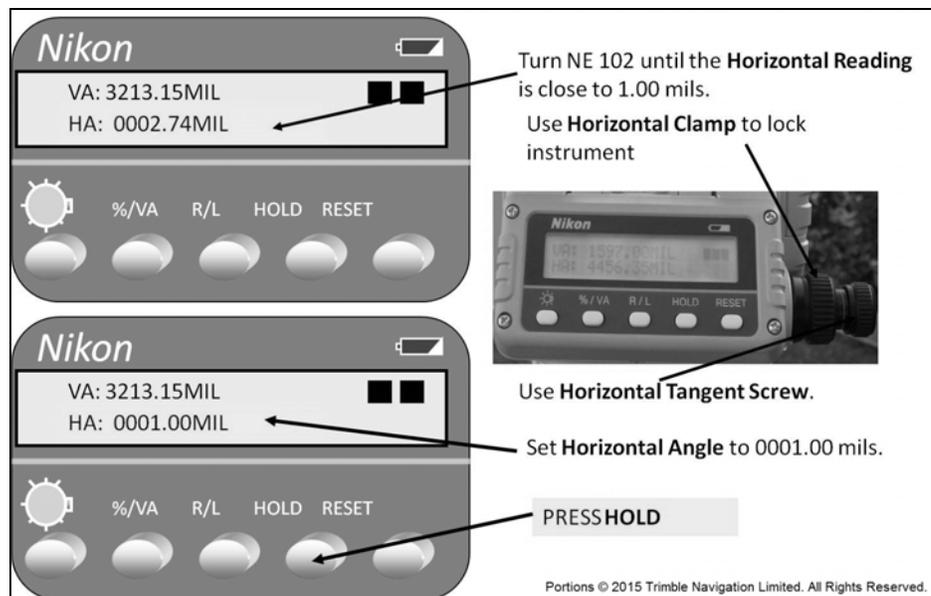


Figure 5-18. Initial circle setting

5-26. While ensuring the telescope is in the direct mode with the eyepiece on the left side achieve autoreflection on the porro prism of the IPADS (see figure 5-19).The IPADS is the rear station. Record the initial setting of 0001.0 in the Recorder's Notebook under the Horizontal Angle column, in the IPADS D direct row.

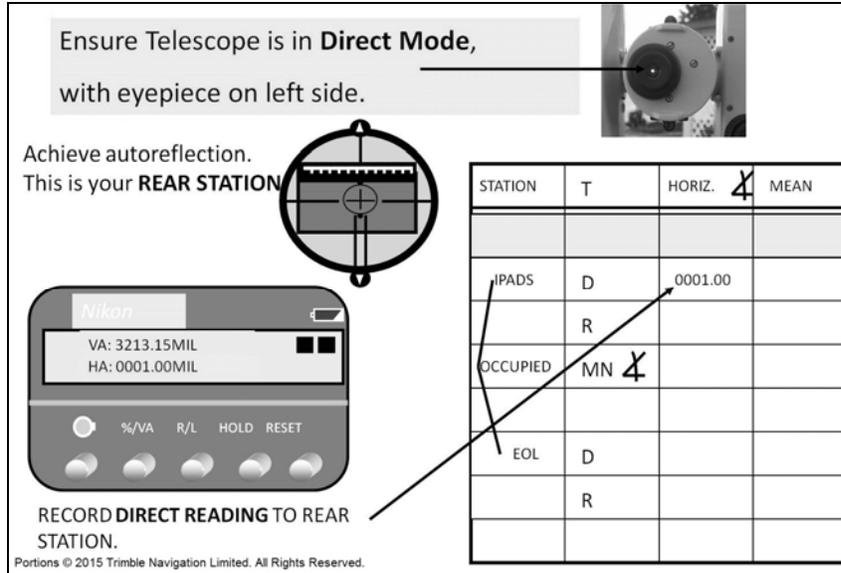


Figure 5-19. Autoreflection rear station

5-27. Press Hold to release the scale and rotate the instrument in a clockwise direction and sight in on the lowest visible point of the forward station. Read the Horizontal Angle and record in the Recorder's Notebook in the Horizontal Angle column of the Forward Station D row (see figure 5-20).

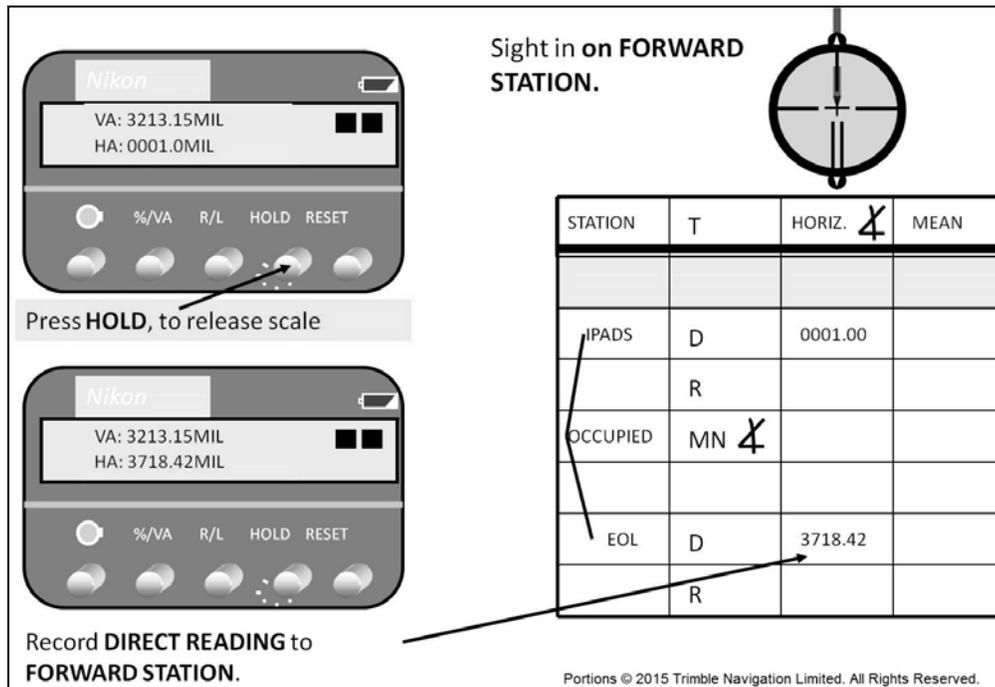


Figure 5-20. Forward station direct horizontal angle reading

5-28. Plunge the telescope to the reverse mode and ensure that the eyepiece is on the right side of the instrument. Sight in on the forward station to the lowest visible point. Read the reverse horizontal angle to the forward station and record in the recorder's notebook in the horizontal angle column R row (see figure 5-21).

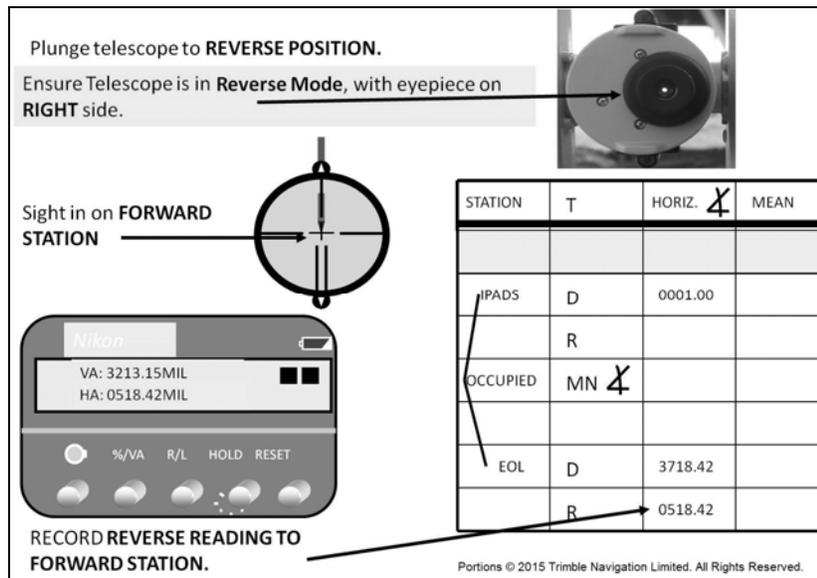


Figure 5-21. Forward station reverse horizontal angle reading

5-29. Turn the telescope to the rear station and achieve autoreflection. Read the reverse horizontal angle to the rear station and record in the recorder's notebook in the horizontal angle column of the R row (see figure 5-22).

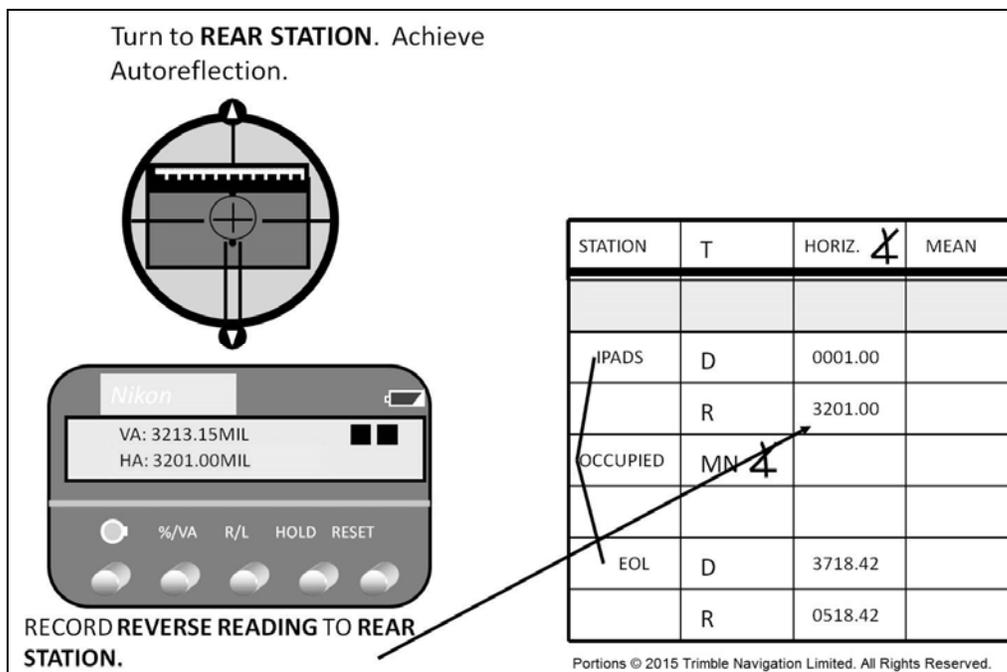


Figure 5-22. Rear station reverse horizontal angle reading

5-30. The next step is to mean the horizontal readings and achieve a mean horizontal angle. Make the reverse reading look like the forward reading by adding or subtracting 3200. Add the two results together

and divide by 2, the resulting mean reading will be recorded in the mean column in the R row. Mean the Direct and Reverse readings to the Rear Station. Make the reverse reading look like the forward reading by adding or subtracting 3200 add the 2 results together and divide by 2. The resulting mean reading will be recorded in the mean column in the R row (see figure 5-23).

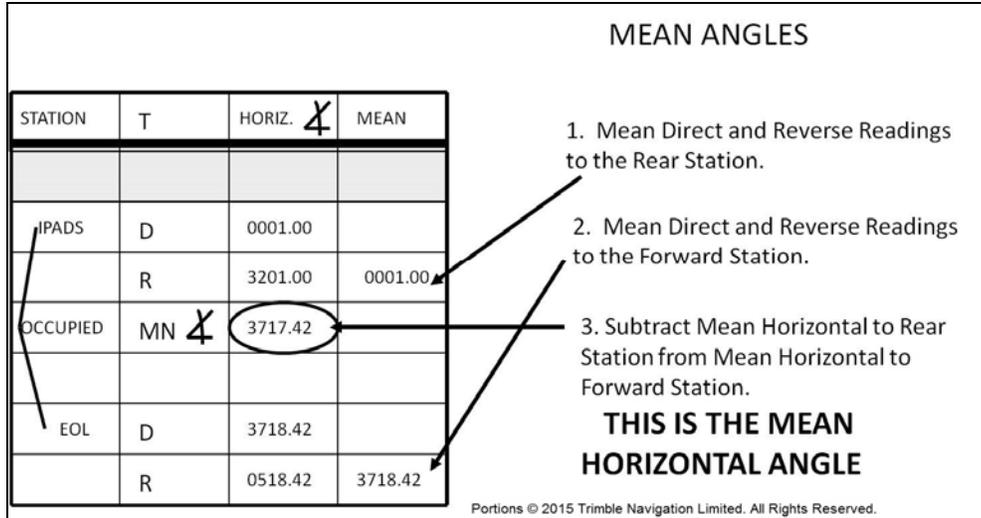


Figure 5-23. Mean horizontal angle

TURNING MULTIPLE HORIZONTAL ANGLES

5-31. Prior to beginning to turn multiple horizontal angles the initial circle setting of 0001.0 must be obtained as described in paragraph 5-24 and figure 5-18 (on page 5-12).

5-32. While ensuring the telescope is in the direct mode with the eyepiece on the left side achieve autoreflection on the porro prism of the IPADS (see Figure 5-19).The IPADS is the rear station. Record the initial setting of 0001.0 in the Recorder’s Notebook under the Horizontal Angle column, in the IPADS D direct row.

5-33. Press Hold to release the scale and rotate the instrument in a clockwise direction and sight in on the lowest visible point of the forward station. Read the Horizontal Angle and record in the Recorder’s Notebook in the Horizontal Angle column of the 1st Forward Station D row (see figure 5-24).

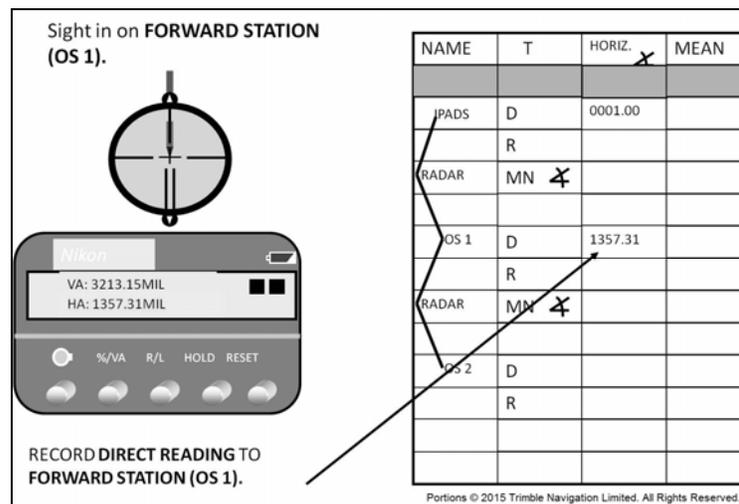


Figure 5-24. Direct reading forward station 1

5-34. Rotate the instrument in a clockwise direction and sight in on the lowest visible point of the 2nd forward station. Read the Horizontal Reading HA and record in the recorder's notebook in the Horizontal column of the 2nd Forward station D row (see figure 5-25).

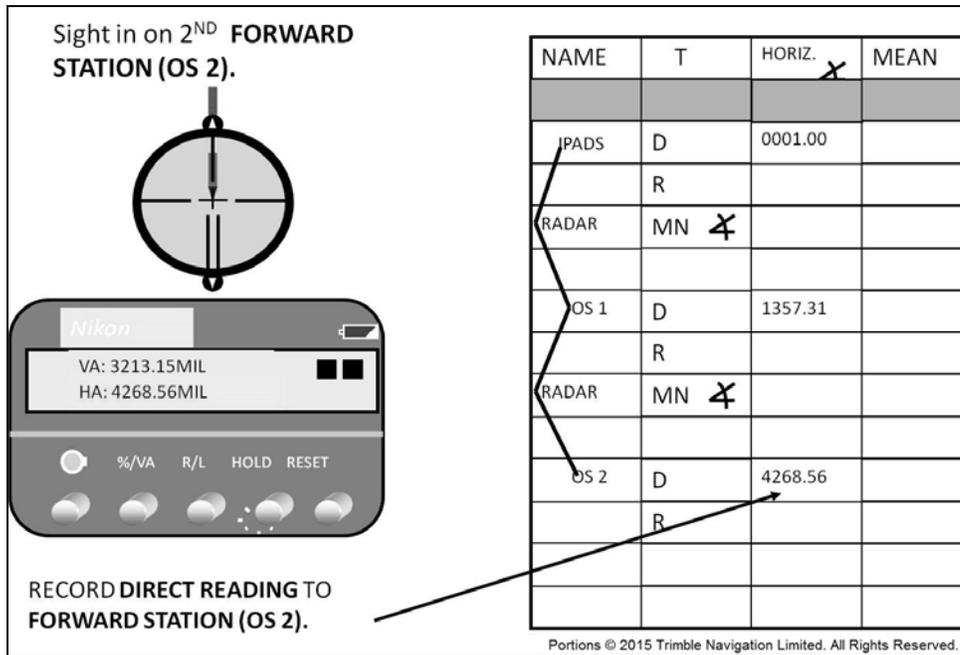


Figure 5-25. Direct reading forward station 2

5-35. Plunge the telescope to the reverse position and ensure the telescope eyepiece is on the right side of the telescope. Sight in on the 2nd forward station to the lowest visible point and read the reverse horizontal angle. Record the reading in the Horizontal Angle column R row (see figure 5-26).

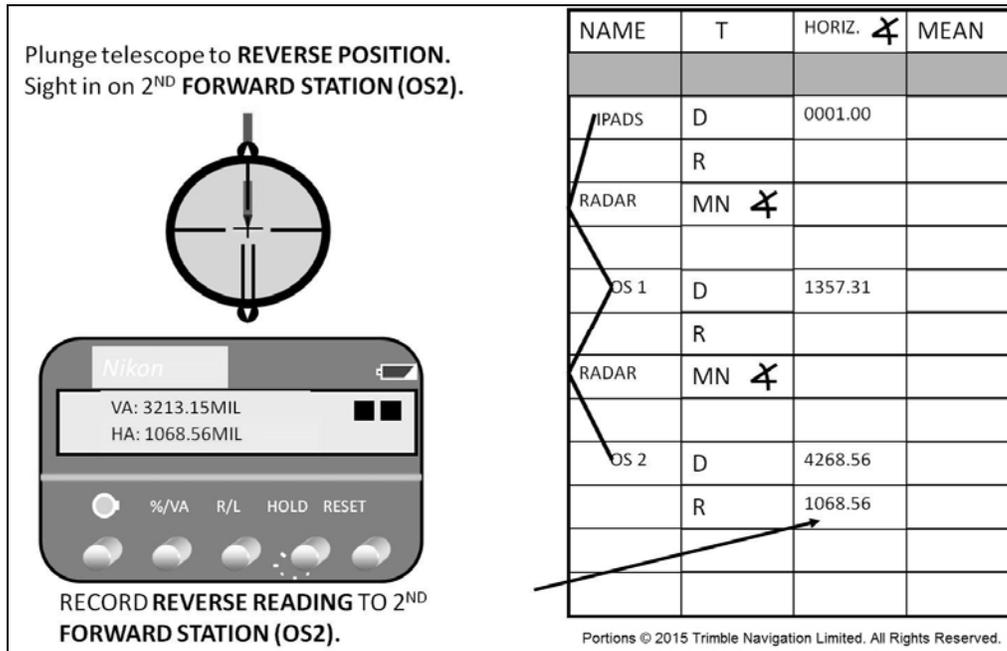


Figure 5-26. Reverse reading forward station 2

5-36. While turning the instrument in a clockwise direction sight in on the 1st Forward Station to the lowest visible point. Read the reverse horizontal angle and record in the Horizontal Angle column R row (see figure 5-27).

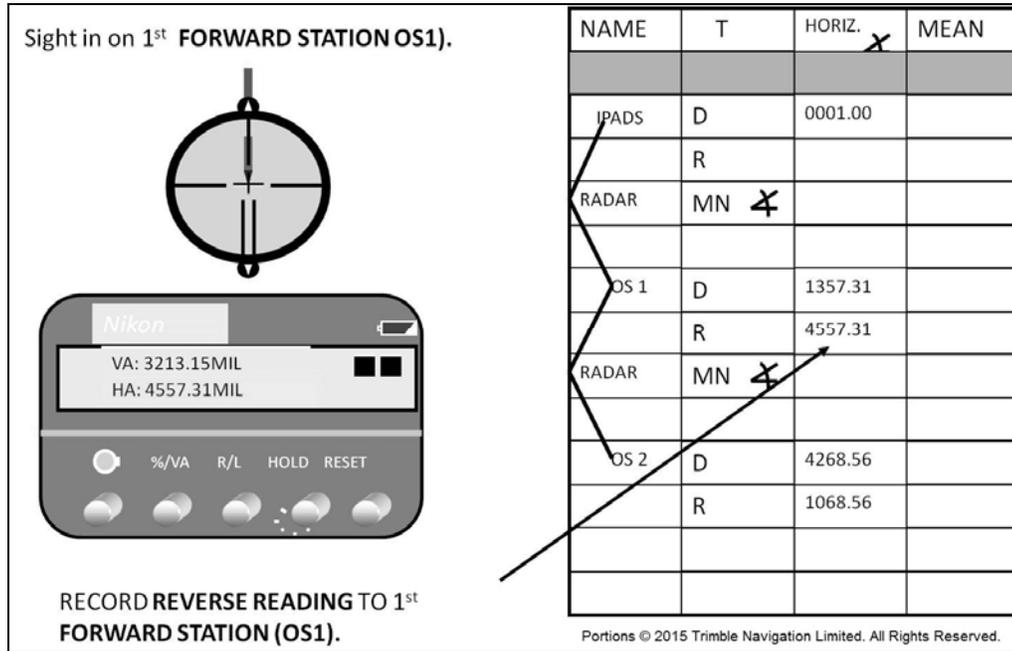


Figure 5-27. Reverse reading forward station 1

5-37. While turning the instrument in a clockwise direction sight in on the IPADS or IPADS-G porro prism and achieve optical transfer. .Read the reverse horizontal angle and record in the Horizontal Angle column R row (see figure 5-28).

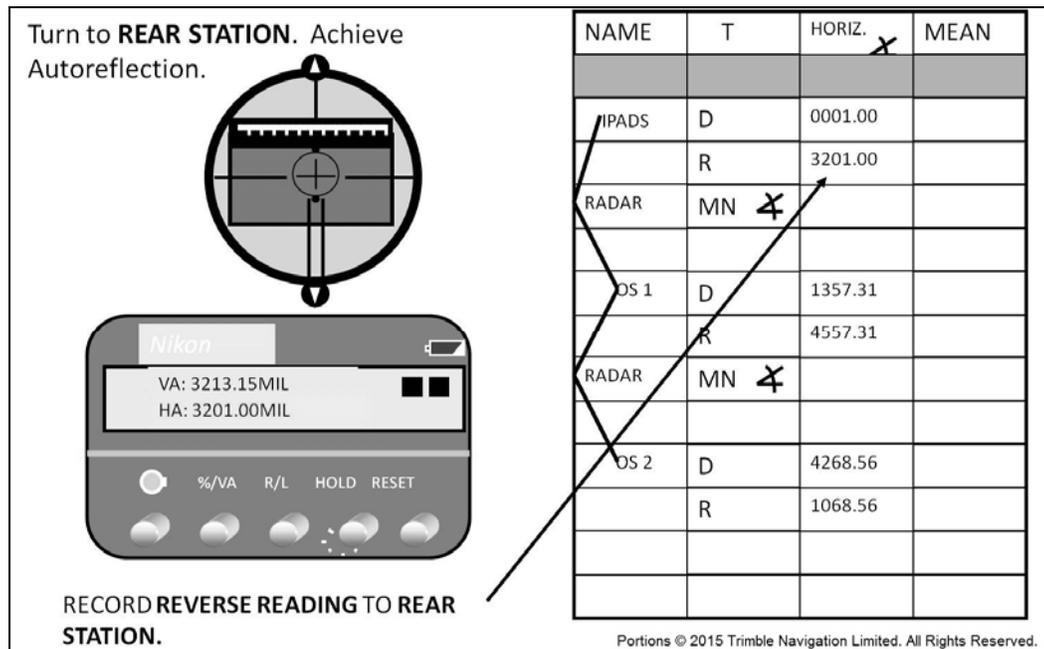


Figure 5-28. Reverse reading rear station

5-38. The final step is to mean the horizontal readings and achieve a mean horizontal angle. Mean the direct and reverse reading to the Rear Station. Make the reverse reading look like the forward reading by adding or subtracting 3200. Add the 2 results together and then divide by 2. The resulting mean reading is recorded in the mean column R row. Mean the direct and reverse readings to the 1st forward station. Make the reverse reading look like the forward reading by adding or subtracting 3200. Add the two results together and divide by 2. The resulting mean reading is recorded in the mean column R row. Mean the direct and reverse readings to the 2nd forward station. Make the reverse reading look like the forward reading by adding or subtracting 3200. Add the two results together and divide by 2. The resulting mean reading is recorded in the mean column R row. Subtract the mean reading to the rear station from the mean reading of the 1st Forward station record the Mean Horizontal Angle in the Horizontal Angle Column in the mean angle row. Subtract the mean reading to the Rear Station from the mean reading to the 2nd Forward station record the Mean Horizontal Angle in the Horizontal Angle Column in the mean angle row (see figure 5-29).

NAME	T	HORIZ. X	MEAN
IPADS	D	0001.00	
	R	3201.00	0001.00
RADAR	MN X	1356.31	
OS 1	D	1357.31	
	R	4557.31	1357.31
RADAR	MN X	4267.56	
OS 2	D	4268.56	
	R	1068.56	4268.56

1. Mean Direct and Reverse Readings to the Rear Station.

2. Mean Direct and Reverse Readings to Forward Station Number 1 (OS1).

3. Mean Direct and Reverse Readings to Forward Station Number 2 (OS2).

4. Subtract Mean Horizontal to Rear Station from Mean Horizontal to Forward Station 1. **THIS IS THE MEAN HORIZONTAL ANGLE TO OS 1.**

5. Subtract Mean Horizontal to Rear Station from Mean Horizontal to Forward Station 2. **THIS IS THE MEAN HORIZONTAL ANGLE TO OS 2**

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Figure 5-29. Mean horizontal angles

Chapter 6

Survey Computer Systems

The forward observer system (FOS) gives FA forward observers the capability to direct and coordinate FA, mortar, close air support, and helicopter munitions onto targets. The FOS gives commanders, fire support officers, fire support teams, and forward observer and survey teams the capability to plan collective actions through maneuver and artillery graphic map displays. It provides storage of survey calculations and control points by FA surveyors.

SECTION I – OVERVIEW

6-1. The handheld terminal unit (HTU) is part of the common hardware program, and therefore, software for other military systems can be loaded on the HTU. For example, Battery Computer System (BCS) software has been hosted to the HTU. The software loaded on the internal hard drive controls the functions available to an HTU operator. When the FOS software is loaded on the HTU, the operator can function as a forward observer, fire support team (FIST), fire support officer, commander, or a surveyor.

HANDHELD TERMINAL UNIT SYSTEM SPECIFICATIONS

6-2. The four areas of the HTU system specifications:

- Physical specifications.
- Environmental specifications.
- Functional specifications.
- Electrical specifications.

PHYSICAL SPECIFICATIONS

Handheld Terminal Unit Front View

6-3. The front of the HTU has four main areas (see figure 6-1 on page 6-2).

- Display panel.
- Indicator lights.
- Pointing devices.
- Keyboard.

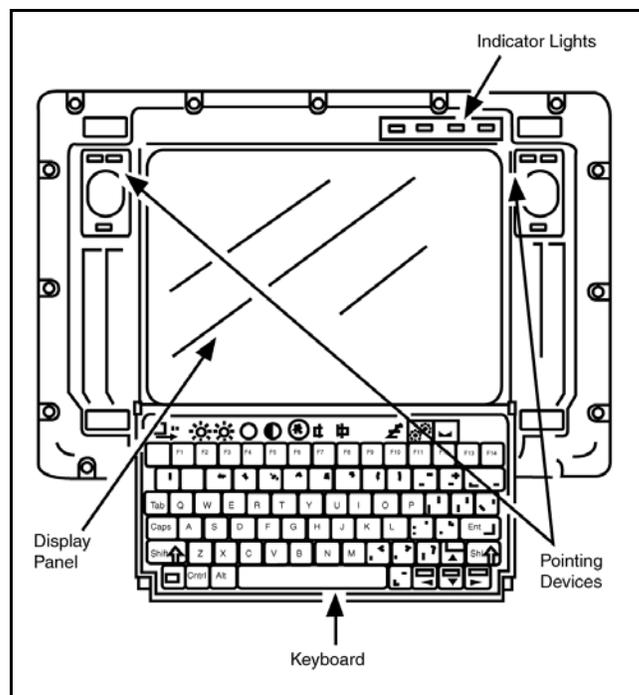


Figure 6-1. Forward observer system (FOS) physical specifications—front view

Handheld Terminal Unit Left Side

6-4. The left side of the HTU has seven ports and two binding posts. All ports are operational, but four ports will probably not be used for 13T FOS operations in the field (J3, J4, J5, and J7). The J2 port will be used only if an external alternating current (AC) or DC power source and adapter are used to power the HTU. The ports functions are briefly described below (see figure 6-2 on page 6-3):

- E1 and E2—dual binding posts used to establish single-channel communications using field wire.
- J1—dual channel modem port—used for connecting to one or two radios using a single or branched radio cable. It also can be used for other communication devices such as the Enhanced Position Location Reporting System. For Bradley fire support team vehicle operations, the J1 port will be used as the data connection to the Bradley FIST lightweight computer unit (LCU).
- J2—external power port—used for powering the HTU using 110/220V AC power or 28V DC vehicular battery. Both the AC and DC external power sources require special adapters and cables to convert the power for use by the HTU.
- J3—external keyboard or mouse—may not be used in the field, but is operational.
- J4—external video graphics array (VGA) monitor—may not be used in the field, but is operational.
- J5—RS-232 serial port (COM 1)—may not be used in the field but is operational.
- J6—parallel printer port—used to connect HTU to V2 LCU dot matrix printer (PN: 50786) using a new printer parallel cable.
- J7—RS-232 serial port (COM 2)—used for connecting the HTU to a ground/vehicular laser locator designator (G/VLLD) for 13F.

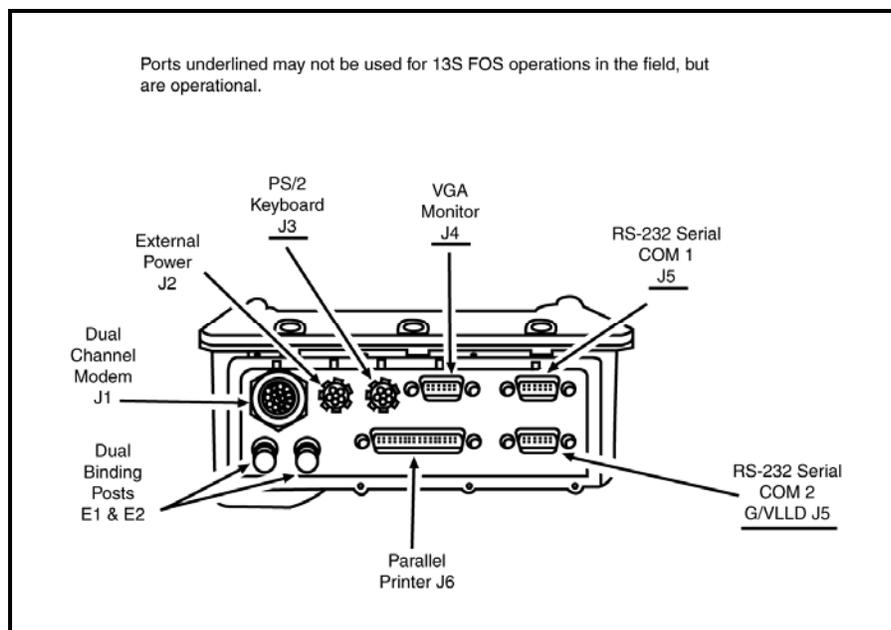


Figure 6-2. Forward observer system (FOS) physical specifications—left side

Handheld Terminal Unit Right Side

6-5. The right side of the HTU has two personal computer memory card international association (PCMCIA) slots and the cap for the battery or power stick compartment. The internal lithium battery is inserted into the battery compartment. For dismantled operations, the lithium battery will be used as the power source for the HTU. This compartment can also be used for the power stick that allows the HTU to receive power via a cable from the power stick to a vehicular battery (see figure 6-3 on page 6-4).

6-6. The HTU has two PCMCIA slots under the faceplate secured by six screws.

6-7. There are different kinds of personal computer (PC) cards (also called PCMCIA cards) that can be inserted in these slots. Examples include hard disk drives, fax/modems, Ethernet, compact disc read-only memory connectors, and voice recognition PC cards.

6-8. Some of these are for future capabilities, but one will be fielded with the FOS. A PC card that contains a hard disk drive will be used to transfer the FOS software to the internal hard disk drive of the HTU. The PC card drive can be 260 megabyte (MB), 340MB, or 520MB.

6-9. A PC card drive in one of the PCMCIA slots can also be used to run the FOS instead of running it from the internal HTU hard drive. The removable PC card drive must be inserted into the PCMCIA slot farthest from the battery. It would only be used in emergency situations.

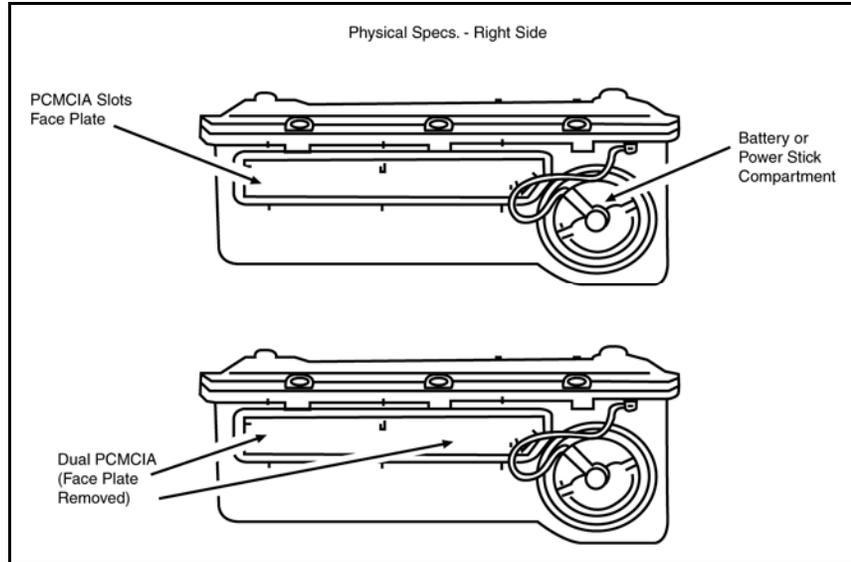


Figure 6-3. Forward observer system (FOS) physical specifications—right side

ENVIRONMENTAL SPECIFICATIONS

6-10. Some of the environmental specifications of the HTU are described below. (For more information see paragraph 1-12b in TB 11-7021-228-10-1).

- The operating temperature range: +25 to +120 degrees Fahrenheit. The original specifications from Litton state the range will be -25 to +120. However, subsequently it has been learned that from -15 to +20 degrees Fahrenheit, the screen becomes sluggish and may freeze up. Basic input/output system (BIOS) 1.22+ has been built to automatically turn on the HTU heaters when the temperature is below 25 to warm the HTU components to operating temperature.
- Storage nonoperating temperature range: < -40 and >150 degrees Fahrenheit.
- Altitude (operating): 15,000 feet.
- Altitude (nonoperating): 40,000 feet.
- Humidity (operating): 5 percent to 95 percent.
- Sand and dust: The HTU can withstand effects of 20 mph sand and dust for 30 minutes.
- Orientation: operates in any orientation.

FUNCTIONAL SPECIFICATIONS

6-11. The functional specifications of the HTU are:

- Speed: 133 megahertz (MHz) (since the motherboard is a 25 MHz board, the HTU runs at approximately 75-100 MHz).
- Processor: AMD 5 x 86 central processing unit (CPU).
- Memory: 32 megabytes (MB) random access memory (RAM).
- Operating System (OS): SCO (Santa Cruz Operations) Unix V5.0.2 used when running the FOS software.
- Keyboard Backlight: Keyboard can be backlit in red and changed to a low/high setting.
- Display: 4-Color VGA liquid crystal display (LCD) monitor.
- Data Storage: 260, 340, or 520 MB internal PCMCIA Type III Hard Disk Drive (HDD). (Currently, the internal hard disk drive is 260MB.)
 - Stores Unix OS, FOS software, and data entered by operator.
 - Stores data automatically every 30 seconds—no operator action needed to save data.

- Screen Brightness and Contrast. Brightness controls adjust a backlight outlining the display screen.
- Contrast controls adjust the color and intensity of the text and background.

ELECTRICAL SPECIFICATIONS

6-12. The electrical specifications of the HTU are:

- The internal lithium battery (BA 5600/U) is inserted into the battery compartment. It powers the HTU during dismantled operations.
- The power stick can be used in place of the lithium battery. The power stick converts 12V or 24-32V DC power from a vehicular battery to the 9-12V DC power used by the HTU.
- The external AC or DC power can also be supplied using cables that connect to the J2 port on the HTU. When the J2 port is used, special types of adapters and cables are required. AC power from an electrical outlet can be 110/220V AC. DC power from a vehicular battery can be 12V DC or 24-32V DC.

HANDHELD TERMINAL UNIT POWER MANAGEMENT

6-13. Power management is a new feature when the FOS software is running on the HTU. The purpose of power management is to extend the life of the lithium battery.

6-14. Power management will cause the HTU to “sleep” after 4 minutes of inactivity. Inactivity is defined as no messages received by the HTU and no keys pressed by the operator.

6-15. The HTU will “wake” when the operator presses a key or a message is received. To wake the HTU, the first key press must be firm and held down for about one second. As a suggestion, wake the HTU by pressing the Enter or W (for wake) key. However, most of the keys will wake the HTU. After the HTU wakes up, the next key press will perform the function of the key pressed.

6-16. Maximum power management will give 18 to 20 hours of operation before the battery dies. It will be enabled automatically by the FOS software. The indicators are—

- The green POWER light will slowly blink on and off.
- The screen will go blank.
- The screen brightness light (if on) will go off, and most internal components (such as the internal hard drive and CPU) will shut down.

6-17. Minimum power management will give 10 to 12 hours of operation before the battery dies. It is manually enabled by you. The minimum power management replaces maximum power management when an entry of 1 to 999 minutes is made in the LOOP TEST field in the SETUP display.

6-18. The HTU does not go into maximum power management because you have instructed the HTU to automatically send a test message to confirm communications are still established between your FOS and other FOSs. Therefore, the internal components of the HTU never shut down.

6-19. To conserve the battery, the LOOP TEST should be disabled (enter 0). You can set the LOOP TEST to 999 if you are not powering the HTU with the internal battery and do not have a need for the HTU to go to sleep. This will prevent the screen from going blank. The indicators are—

- The display backlight (if on) will go off, but the green POWER light will not blink and the screen will not go blank.
- The CPU and hard drive will slow down.

Note. For some HTUs, the screen will go blank even when the LOOP TEST has an entry greater than 0. The POWER light does not blink. This hybrid power-management mode occurs only when using AC power and an adapter. It is unlikely that the HTU will be powered by AC power in the field. If you are using AC power in the classroom, and do not want the student's HTU screens to go blank, go into page 2 of the complimentary metal-oxide semiconductor screen (press CTRL + ALT + ESC keys during boot up). Change the power management setting to "AC DISABLED." Enter 999 in the LOOP TEST field in SETUP.

6-20. The setting for power management must be set to "ENABLED" and LOOP TEST must be set to 0 when the class is completed to enable the HTUs to go into maximum power management when using a battery. Without power management, the internal battery will last 4 to 6 hours.

PREPARATION FOR OPERATION

6-21. Before placing the FOS device into operation as a communications device, system operation parameters need to be established. These parameters are entered through the INITIALIZATION MENU selection (option J) from the MODE MEDE. INITIALIZATION MENU consists of the following screens: Required: SETUP, NET STATUS, MEMBER DATA, and MAP MODIFICATION DATA. Optional: MEMBER MONITOR, URN, SELF-LOCATION, SURVEY FORM HEADER DATA, and MESSAGE LEGALITY TABLE SETUP.

6-22. The SETUP, NET STATUS, MEMBER DATA, and MAP MODIFICATION are the minimum number of screens that must be completed when you first initialize the FOS. The FOS is not operational until the four required screens have data.

6-23. Local address and observer number information can be found in the current signal operating instructions (SOI). To ensure communications with other elements, member data (address, observer number, and device type) must be entered. Member data can be entered by selecting MEMBER DATA (option D) from the INITIALIZATION MENU. (See TB 11-7021-228-10-1 for detailed information on entering member data. Local SOPs will dictate the elements that will be entered into the member data table.)

SECTION II – COMMUNICATIONS PROCESSING

6-24. The FOS provides data communications over a wide range of military communications equipment and communications security devices. This section explains how to establish communication.

6-25. The FOS SETUP file requires the FOS observer number, FOS address, unit name, and the unit reference number (URN). The operator must also enter the date, time, and the time zone. (Refer to procedure 2-4 in TB 11-7021-228-10-1 for more information.)

6-26. After entering the FOS setup information, the operator may enter up to four nets. Four nets are available if an external tactical communications interface module (TCIM) is connected to the LCU. The NET STATUS screen will display four nets only when the external TCIM has small computer system interface (SCSI) address set to 5. (Set the address before the external TCIM is turned on. Turn on the TCIM before the LCU boots up.) Only two nets are available for the HTU. The net list is displayed on the NET STATUS LIST. This list shows which net(s) are currently in an activated status. Information for the individual net is entered on the NET STATUS display. The NET STATUS display is accessed by selecting a blank or existing record from the NET STATUS LIST. If the entry in the CONNECTION field on the NET STATUS display is changed, a new set of default entries is displayed in the remaining fields. Enter all necessary information. Then observe the prompts at the bottom of the screen. The prompt, <D/A>=DE/ACTIVATE NET, initiates a command for terminating or activating the net. Press the A key to load net parameters into the modem, enabling communications for that net. Press the D key to terminate communications for that net. (Refer to procedure 2-5 in TB 11-7021-228-10-1 for more information.)

6-27. There is no requirement to enter a URN and unit identification (ID) for each nonmember when the FOS is being initialized. However, the operator must enter the information before transmitting or receiving

a message containing a field for a nonmember's unit ID. (An example of a unit ID is the NAME field on the SPRT UNIT message: “_1/A/1_5_”. An example of a URN is “03100121.”) A message cannot be transmitted unless a URN is entered for your FOS, your member, and the nonmember whose unit ID will be in a field of the message. (The nonmember's URN is entered on URN/UNIT NAME CORRELATION screen.) Before a message is transmitted, the FOS first looks in the MEMBER DATA file to check if there is an associated URN for the unit named in a unit ID field. If not, the FOS checks the URN file for an associated URN for the unit in a unit ID field. There are two exceptions to the requirement to enter a URN before transmitting. For a SPRT UNIT message, the FOS does **not** require a URN if the entry in the FRIENDLY field is NO. However, the NAME field must have an entry for the non-friendly unit's ID. This unit ID is transmitted instead of the URN. (If the entry in the FRIENDLY field is YES, a URN must be entered for the member or nonmember whose unit ID is in the NAME field before the SPRT UNIT message can be transmitted.) The second exception is for a SPRT GEOM message describing a fire support coordination measure. The FOS transmits the unit ID entered in the fire support coordinator (FSCoord) field instead of the URN. To enter a URN for a nonmember, display the INITIALIZATION menu and then the URN FILE SUMMARY screen. This display can list URN data for up to 300 nonmembers. The operator may page up or down through the pages of the summary to select an existing record for view or edit. The operator may purge the entire URN file. Selecting a record displays the URN/UNIT NAME CORRELATION screen. From this display, the operator may enter or delete the URN data for the nonmember. (See paragraph 1-19b and procedure 2-8 in TB 11-7021-228-10-1 for more information.)

6-28. Information in the MEMBER DATA file impacts how the FOS communicates with individual members. The required entries include the member address, device type, unit name, and the URN. Other fields on the MEMBER DATA displays are required based upon the operator's entry in the CONNECTION and PROTOCOL fields in the NET STATUS display. In addition, the entry in the DEVICE field determines what messages are legal for transmission and receipt from this member.

Note. The MEMBER DATA display is also used to establish the member for relay. Member routing and the method of updating the FOS database by messages from the member are also established with the MEMBER DATA display. (Refer to procedure 2-6 in TB 11-7021-228-10-1 for more information.)

SECTION III – FORWARD OBSERVER SYSTEM SURVEY

FORWARD OBSERVER SYSTEM SURVEY

6-29. The FOS provides the capability to compute survey data for hasty survey techniques for planning and coordination. When in the FOS survey operational mode, the operator may perform survey point (SP) processing, survey calculations, and transformations or conversions. The operator may also perform math calculations from the survey calculator. The FOS also supports the printing of various survey forms used in processing data. Forms can be printed by the HTU using the HTU printer. When in the fire support or commander operational mode, the operator can only receive SPRT PNT messages and store the SPs or SCPs in the database. The points can then be reviewed, transmitted, printed, or deleted. The fire support officer or commander can also conduct a search of the points.

SURVEY CALCULATOR

6-30. The FOS survey calculator is available by pressing the **F9** key when the SURVEY MODE MENU or a survey calculation screen is displayed. The FOS survey calculator consists of two types of calculators. They are the survey calculator display and the survey formula calculator display.

6-31. The survey calculator display provides normal calculator functions. The survey formula calculator display provides specialized survey algorithms. The operator may switch between calculators by paging up or down. If the survey calculator was accessed from a survey calculation display, the operator may export the calculated value to the calculation display. An error message is generated when legal range limits are exceeded. For all calculator functions, ERROR is displayed in the VALUE field when required fields are

not present. ERROR is also displayed when the calculated result is too large for the VALUE field or when a mathematical error is encountered. (An example would be when the operator attempts to divide by zero.)

SURVEY FORMULAS

6-32. When the operator accesses the survey formula calculator display, seven survey formulas are available. They are radial error, accuracy ratio, mean value, traverse adjustment, mil relation, comparative accuracy, and law of sines. To process a calculation, the operator presses the **Shift** and **Colon** <:> keys. The calculated result is placed in the VALUE field.

CALCULATOR FUNCTIONS

6-33. The calculator functions available on the survey calculator display are similar to those of a normal handheld calculator. When working from the calculator display, the operator may clear the current entry in the VALUE field by pressing the <X> key once. Pressing the <X> key twice consecutively will clear the accumulator. The following calculator functions are accessible from this display.

Mathematical Operation

6-34. The mathematical operation performs addition, subtraction, multiplication, and division. When one of these operations is invoked, the entry displayed in the VALUE field is assimilated into the accumulator. The pending operation is then changed to the mathematical operation selected.

Trigonometric

6-35. The SIN, COS, and TAN operations are performed when the operator presses the <S>, <C>, <T> keys respectively. The inverse (INV) operations are performed by pressing the <I> key, then the <S>, <C>, or <T> keys. The VALUE field is then changed to the result of the selected operation. The pending operation remains unchanged.

Square Root

6-36. Pressing the <Q> key calculates the square root of the entry displayed in the VALUE field. The result is then displayed in the VALUE field. The pending operation is unchanged.

Exponential Log

6-37. Pressing the <L> key calculates the exponential log of the number displayed in the VALUE field. The result is then displayed in this field. The pending operation is unchanged.

Natural Log

6-38. Pressing the <N> key calculates the natural log of the number displayed in the VALUE field. The result is then displayed in this field. The pending operation is unchanged.

PRINTING SURVEY FORMS

6-39. The FOS has the capability to print DA forms for calculations, conversions, and transformations. The print form capability is available from the SURVEY MODE MENU or from a survey calculation. The appropriate form header information—entered by the operator on the SURVEY FORM HEADER DATA display—is also included on the form. Selecting the PRINT FORMS function on the MODE MENU allows the operator to print a blank form of any calculation or transformation. The calculations are azimuth/distance, traverse, traverse closure, triangulation, triangulation closure, resection, altitude method, hasty astronomic, star ID, Polaris tabular, grid convergence, trigonometric traverse, intersection, and artillery astronomic. The transformations are coordinate conversions, UTM datums, Gauss-Kruger (GK) datums, and user-defined datums.

SURVEY POINT PROCESSING

6-40. In the SURVEY or fire support officer and commander operational modes, the FOS will store a maximum of 360 SPs in the SP file. To view the current number of points on file, display the FILE SUMMARY from the SURVEY MODE MENU (<F> key). The SURVEY POINTS OPTIONS MENU provides access to the SPs list and the SPs search request options.

Note. The SP file contains both SPs and SCPs. The operator has the option to specify one or both types of points when conducting a search of the SP file.

SURVEY POINTS LIST

6-41. The SURVEY POINTS LIST is an index listing of all SPs and SCPs currently on file. The index gives the point name, coordinates, and type of point. The operator may select an existing record. The operator may also create a new point by selecting a blank record from the list. Whenever a point record is selected from the list, a SURV PNT message format is displayed. The SURV PNT message may be edited by the survey operator. The fire support officer or commander can review the message in a read-only mode.

6-42. Both the survey and fire support officer or commander can transmit or delete the message. When selecting the edit mode, the operator may enter new or update previous data in the message. When exiting the SURV PNT message, the FOS checks the type of grid coordinates in the message. If UTM grid coordinates are present, they are converted to geographic coordinates. If geographic coordinates are present, they are converted to UTM grid coordinates. The file is updated with both sets of coordinates. When transmit is selected, the SURV PNT message is routed to the transmit queue for transmission.

6-43. The option to delete a survey point must be confirmed by the operator. If the point to be deleted is not a SCP, a pre-composed FREETEXT message is displayed. The message indicates the survey point has been deleted. The operator may transmit the message. No FREETEXT message is displayed when deleting a SCP.

Note. If a FREETEXT message containing the text SURV PNT ??????? DELETED BY MEMBER? is received, the operator may delete the point by pressing the <U> key. The action will result in a confirmation message. If intent to delete is confirmed, the SP is deleted from the SP file.

SURVEY POINTS SEARCH REQUEST (SURVEY FIRE SUPPORT OFFICER AND COMMANDER)

6-44. Selecting this option displays the SURV SRCH screen. Entries made on the SURV SRCH display define the criteria used to search the SP file. These entries are:

- Full Search. If the command is FULL, a SURV PNT message is generated for each point in the SP file which matches the search criteria.
- Count Search. If the search command is COUNT, a SURV LIST message is displayed indicating the number of points meeting the search criteria.
- List Search. If the search command is LIST, a SURV LIST message(s) is generated. The message contains the points meeting the search criteria. The survey point name, coordinates, and SP or SCP indicator are displayed for each point. The operator may select a point from the SURV LIST screen to edit or delete from the list. In addition, the SURV LIST message may be transmitted or deleted. If transmit is selected, the message is sent to the single message transmit queue. If deleting the SURV LIST message, the operator is prompted to confirm the action.

6-45. The SURV SRCH display allows the operator to search his own or a member's survey point file for SPs, SCPs, or both using one of six search types:

- Thrust Search. Selecting the thrust search type displays the fields for the coordinates of two points and two widths. The thrust line is defined as the line that connects the two points. DIST 1 defines the width of the search area to the left of the thrust line. DIST 2 defines the width of the search area to the right of the thrust line.

- Circular Search. Selecting the circular search type displays the fields for a center point and radius. The search area is defined by the circle described by this center point and radius.
- Rectangular Search. Selecting the rectangular search type displays the fields for the opposite corners of the search area rectangle. The rectangle is completed such that two sides are parallel to the Northing Axis, and two sides are parallel to the Easting Axis.
- Four Points Search. Selecting the four points search type displays the fields for the coordinates of four points. The search area is defined as the area inside the four points.
- Single Point Search. Selecting the single point search type displays the fields for the names of four survey point names. The survey point file is searched for the point name(s) entered in these fields.
- All Points Search. All points in the survey point file are included in the search operation.

INITIATING THE SURVEY SEARCH

6-46. Two prompts appear at the bottom of the SURV SRCH screen. These prompts allow the operator to initiate the search of the survey point file or clear the SURV SRCH display of all entries. With all required search data entered, the operator toggles off the edit mode. Then the operator presses the <I> key to initiate the search command.

SURVEY SEARCH DESTINATION

6-47. If a destination is entered in the SURV SRCH message, the resulting messages are entered in the appropriate bulk transmit queue for transmission. If destination was not entered, the resulting messages are accessible by pressing the **Page Up** and **Page Down** keys or the **F11** and **F12** keys.

Note. A received SURV SRCH message does not automatically result in the FOS performing the requested search. The operator may elect to save the SURV SEARCH message or initiate the search request. If the search is initiated, the message(s) generated from the search is formatted and sent to the bulk transmit queue for transmission. If the specified search command was LIST or COUNT, the SURV LIST message(s) is transmitted. If the command entered was FULL, then a SURV PNT message(s) is transmitted.

SURVEY CALCULATION FUNCTIONS

6-48. For the survey operational mode only, the FOS provides the capability to perform various types of survey calculations. These options are accessed through the survey calculations menu. The calculation functions available to the operator are azimuth/distance, traverse, triangulation, resection, altitude method, hasty astronomic, star ID, Polaris tabular method, grid convergence, trigonometric traverse, intersection, and artillery astronomic.

CALCULATION SUMMARY LIST DISPLAYS

6-49. Selecting a calculation function from the survey calculations menu displays the associated summary list for that option. From this list, the operator may select a record for review and edit. Or, the operator may create a new record by selecting a blank record from the list. Depending on the type of summary list displayed, other screen prompts are provided. These are prompts to delete all records from the list, print forms, and display additional lists or information.

CALCULATION AND SOLUTION DISPLAYS

6-50. When a listed record without a solution is selected from the summary list, only the calculation record is displayed. If the selected record has a calculated solution, the solution record is displayed. Depending on the type of calculation or solution record displayed, one or more screen prompts are provided. For calculation displays, prompts to calculate a solution, access the survey point file, delete the record, and initiate a search for specified sets of survey points may be included on the calculation screen.

For solution displays, prompts to calculate accuracy ratios, delete the record, show input data, and scan other calculation solution records are included on the solution screen.

SURVEY TRANSFORMATION AND CONVERSION FUNCTIONS

6-51. For the survey operational mode only, the survey transformation and conversion function allows the operator to perform various types of coordinate conversions and datum-to-datum transformations. The options are selected from the transformation menu:

- Coordinate Conversion. Three types of coordinate conversion may be performed by the FOS. They are GEO to UTM coordinate, UTM to GEO coordinate, and Zone-to-Zone transformation.
- UTM/GEO Listed Datum Transformation. Four types of UTM/GEO datum transformations may be performed by the FOS. They are UTM to UTM, UTM to GEO, GEO to UTM, and GEO to GEO.
- Gauss-Kruger Datum Transformation. Four types of Gauss-Kruger datum transformations may be performed by the FOS. They are Krassovsky to UTM, UTM to Krassovsky, Bessel to UTM, and UTM to Bessel.
- User-Defined Datum Transformation. Three types of user-defined datum transformations may be performed by the FOS. They are User Defined to User Defined, User Defined to Listed, and Listed to User Defined.
- Summary List. When one of the above options is selected from the transformation menu, the associated summary list is displayed. From this list, the operator may select a record for review and edit, create a new record by selecting a blank record, or delete all records from the list. Additional screen prompts may be provided to print forms and to display additional lists or information.
- Coordinate Conversion, Transformation, and Solution Displays. When a listed record without a solution is selected from the summary list, only the associated record is displayed. If the selected record has a calculated solution, the solution record is displayed. Depending on the type of record or solution displayed, one or more screen prompts may be provided. For record displays, prompts to calculate a solution, access the survey point file, and delete the record are included on the screen. For solution displays, prompts to delete the record, show input data, add the calculated survey point to the survey point file, and scan other solution records are included on the solution screen.

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Chapter 7

Survey Methods

This chapter discusses the various methods that will be used to provide survey control to requiring units.

IMPROVED POSITION AND AZIMUTH DETERMINING SYSTEM- GLOBAL POSITIONING SYSTEM

7-1. The IPADS or IPADS-G is the primary means for providing survey control. Instructions for use of the systems are located in TM 9-6675-349-13&P and chapter 8 of this publication.

GLOBAL POSITIONING SYSTEM

7-2. The NAVSTAR Global Positioning System is a space based navigation and positioning system that provides accurate, three-dimensional position and velocity information, and time.

7-3. The space segment is made up of 30-32 NAVSTAR satellites that orbits the earth twice in a day. These satellites are deployed in six orbital planes and are configured so that four or more satellites will be in view at all times. This arrangement allows for 24-hour, three-dimensional, worldwide coverage. As with the stars, the satellites rise above the horizon about 4 minutes earlier than the previous day.

7-4. The control segment consists of five passive-tracking monitoring stations, active-tracking ground antennas, and the master control station. These tracking stations, located around the world, are capable of monitoring the satellite navigation messages and time signals better than 90 percent of the time. This information is relayed to the master control station, which has the capability to effect any needed corrections to the satellite timing and navigation messages.

7-5. The user segment consists of navigation receivers designed for marine, aircraft, handheld or vehicle use. The receivers must have electrical line-of-site with the satellites to receive and decode the satellite signals. The internal computer uses the satellite data to generate a precise time, velocity, and three-dimensional (3D) position data. The receiver must track four satellites to obtain a 3D position, and three satellites will yield a two-dimensional (2D) position. Current position coordinates and height are obtained from a 3D position and only current coordinates are obtained from a 2D position. The receiver needs only one satellite for precise time.

GLOBAL POSITIONING SYSTEM METHOD

7-6. The AN/PSN-13(13A) DAGR is the receiver used by the FA Surveyor. The DAGR allows the surveyor to initiate surveys when existing survey control is not available. It allows more accuracy than assumed data or a map spot. When the DAGR is loaded with the correct encryption keys the required accuracy of 10 meters CEP is met. Notice that the 10 meter CEP does not meet the requirements for 5th order survey. If this method is utilized then a more accurate method of survey needs to be prioritized in the survey plan. Position data should always be checked by another independent means; for example a second receiver, an accurate map spot or the correct coordinates on the IPADS or IPADS-G. The DAGR could determine height relative to either the horizontal datum ellipsoid (ellipsoid height) or mean sea level (elevation). The DAGR is not to be used to determine an orientation azimuth unless utilizing Dual DAGR Kit, Sub-MIL Azimuth Determination Dual DAGR Receiver NSN 5985-01-549-7219) system used by the USMC.

HANDHELD TERMINAL UNIT

7-7. The most important information the surveyor provides to both firing and target acquisition units is azimuth. If the surveyor has an HTU and a trigonometric list of survey control points he can perform a simple computation to determine accurate azimuth. Program A (Survey Calculations) on the HTU will compute an accurate azimuth and distance between two 4th Order or higher survey control points with only the easting and northing coordinates of the two points. You cannot compute azimuth and distance between two points established with the IPADS, or GPS. For use of this equipment refer to TM 11-7021-225-12&P.

ASTRONOMIC OBSERVATIONS

7-8. As stated above, the most important information the surveyor provides to both firing and target acquisition units is azimuth. If the IPADS or IPADS-G is non-mission capable or unavailable the surveyor must maintain the ability to provide this critical information to all who require it. An IPADS or IPADS-G Team with a GPS, Theodolite, and a HTU (FOS device) can perform an astronomic observation to provide an accurate azimuth.

PURPOSE OF ASTRONOMIC OBSERVATIONS

7-9. Astronomic observations can be used for, but are not limited to, the following survey operations:

- Checking the azimuth of any line in a survey.
- Providing orienting azimuths for cannons and associated fire control equipment.
- Determining azimuths for the declination of aiming circles.
- Providing orienting azimuths for radars and OPs.

METHODS OF DETERMINING AZIMUTH

7-10. The artillery surveyor uses three basic methods to determine azimuth by astronomic observation. The three methods are artillery astronomic observation, hasty astronomic observation, and simultaneous observation. All three methods require a horizontal angle from an azimuth mark to the observed body in order to compute the astronomic azimuth on the ground.

FIELD REQUIREMENTS FOR ASTRONOMIC OBSERVATIONS

7-11. Each of the three methods of determining azimuth by astronomic observation requires the measurement of the horizontal angle (see figure 7-1 on page 7-3), from the azimuth mark to the celestial body. Except for the method of sighting on the celestial body, horizontal and vertical angles are measured the same.

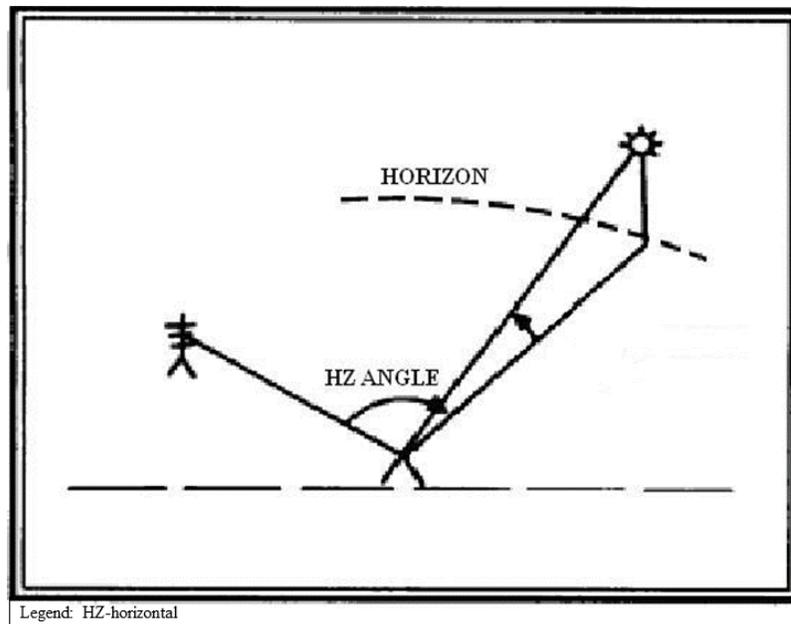


Figure 7-1. Measuring horizontal and vertical angled from azimuth mark to celestial body

7-12. In all astronomic observations, the instrument must be perfectly level with reference to the most sensitive bubble the instrument has. An appreciable error, which cannot be eliminated by direct and reverse pointing, is introduced into the measurement of a horizontal angle between two objects of considerable difference in elevation if the vertical axis of the instrument is not vertical.

Field Data Requirements

7-13. The field data requirements for survey are listed below:

- UTM coordinates (easting and northing) map-spotted to within 150 meters.
- Horizontal reading from the desired azimuth mark to the celestial body.
- Approximate azimuth to the desired azimuth mark. A magnetic or map-spotted azimuth will suffice.
- Date of observation.
- Time of observation.
 - Sun (accurate to 1 second).
 - Star (accurate to 1 second).
 - Polaris (accurate to 10 seconds).
- Special requirements are:
 - The sun should not be observed within 1 hour local apparent time of the observer's meridian. This is because there is no valid solution when angle t is less than 15° (1 hour).
 - For best results, stars should be below 800 mils in altitude.

Note. The restriction has been placed on vertical angles over 800 mils because of the error introduced into the horizontal angle measurement when the instrument has not been leveled perfectly. The error in the horizontal angle is equal to the tangent of the altitude of the celestial body multiplied by the error in leveling the plate of the instrument.

Time Requirements

7-14. The primary means for achieving a correct time should be a GPS or DAGR device with a current crypto key loaded and a time figure of merit of 3. However; any good watch with a sweep second hand is

adequate for timekeeping, if a correction is carried. For astronomic observation, a good watch is one that gains or loses a constant amount of time over a given period. The timekeeper should not try to set his watch to the exact time, but he must ensure that the second hand is in the vicinity of 12 when the minute hand is on a minute mark. (This will preclude a 30-second error.) The timekeeper will determine the amount his watch is in error and note the correction, with the proper +/-, in the remarks section of the recorded field notes.

Sighting Techniques (Obtaining A Correct Sight-Picture)

CAUTION

The sun must never be viewed through the telescope without a sun filter. The filter should be inspected before use to ensure that the coated surface is free from scratches or other defects. Serious eye damage will result if proper precautions are not taken. If the sun filter has been damaged or lost, a solar observation may be completed by use of the card method. The image of the sun is projected onto a card held 3 to 6 inches behind the eyepiece and the telescope is focused so that the cross hairs are clearly defined.

7-15. When the sun is being observed, special sighting techniques are required to resolve its center because of the size and brilliance of the sun. Since the angular diameter of the sun is about 9.5 mils of arc, an accurate sight-picture cannot be achieved without the use of special aids and/or techniques.

7-16. One of the special sighting aids is the solar circle etched on the reticle of the observing instrument. Most theodolites have the solar circle etched on the reticle (see Figure 5-2). No special sighting technique is required with these instruments, but the sun must be centered in the circle. The sun will not always fit exactly into the circle. However, the amount of overlap, or spacing, will not affect the final result.

7-17. A correct sight-picture on a star is made in the same manner as sighting in on the sun, except that at the instant TIP is announced the cross hairs should bisect the star.

Note: When using the Artillery Astronomic Method of observation, the instrument operator takes three direct readings to the celestial body, and then plunges the telescope, and sights back on the azimuth mark. A second set should be taken with three readings in the reverse position as a check on the instrument and operator. As a rejection criterion, the closing readings on the azimuth mark should agree with the initial circle setting by the known spread of the instrument. In addition, the mean of the two sets of readings should agree with both sets within prescribed accuracies.

Note: When the observer is observing the stars it is advantageous for him to have the telescope blacked out until the star is identified. When the star has been identified, the telescope light rheostat is turned up so that as many stars as possible, other than the desired one, will be obliterated by the light in the telescope.

Recording and Meaning Data

7-18. The format for recording field data and determining the mean angles is generally the same as that for other angle measurements. Sun observations are recorded in the same manner as star observations, Figures 4-5 through 4-8, are examples of how data is recorded in a field notebook for astronomic observations.

Artillery Astronomic Using the Sun

7-19. In the artillery astronomic method of determining azimuth; two sides of the Pole-Zenith Star triangle, the polar distance and colatitude, and one angle are used to solve for the azimuth angle. This computation is

based on the time of the observation. The problem of determining azimuth consists of taking a horizontal reading at the observer's station between the mark and sun, the azimuth of which can be computed. The simple operation of subtracting this horizontal angle from the computed azimuth of the sun gives the desired azimuth to the mark.

Artillery Astronomic Observation Using a Star

7-20. The artillery astronomic method can be used with observations on Polaris or on east-west stars. Used with Polaris, this method yields the most accurate azimuths. When the artillery astronomic method is used with east-west stars, the requirement for accurate time is a disadvantage, but the method can be used when no stars meet the position requirements for the altitude method. Computation of artillery astronomic star is the same as the computations for artillery astronomic sun. The only differences are steps 9 and 9a of the form. Step 9 will be answered N (no). Step 9a asks for the star number which can be found on the reverse of the computation form.

Procedures for Performing an Artillery Astronomic Observation

7-21. The instrument operator sets up his instrument as prescribed in Chapter 3. With the instrument telescope in the direct position, he points the telescope at the azimuth mark. After the initial circle setting has been recorded in the recorder's book, the instrument operator and recorder perform these steps:

- The instrument operator places the sun filter on the telescope and turns the instrument until the sun is near the center of the solar circle. He announces TRACKING.
- On the instrument operator's announcement of TRACKING, the recorder begins keeping time without lifting his eyes from the GPS or watch. At the instrument operator's announcement of TIP, the recorder notes the exact uncorrected and records it in the field notebook.
- The instrument operator reads the horizontal circle reading and announces it to the recorder.
- The instrument operator and recorder repeat steps 6, 7, and 8 two more times.
- Once 3 horizontal angles have been measured the instrument operator will plunge the scope and close out on the rear station (Azimuth mark).

SIMULTANEOUS OBSERVATIONS

7-22. Simultaneous observations of a celestial body provide a quick method of transmitting direction over great distances without time-consuming computations. This method is ideally suited to the needs of the artillery since many units can be placed on common directional control in a very short period of time. Because of the great distance of celestial bodies from the earth, the azimuths to a celestial body at any instant from two or more close points on the earth are approximately parallel. The difference in the azimuth is caused by the fact that the azimuths at different points are measured with respect to different horizontal planes.

PROCEDURES FOR SIMULTANEOUS OBSERVATIONS

7-23. Flank stations are established at points where azimuth is required. A master station is established at a point from which the grid azimuth to an azimuth mark is known or has been computed (see figure 7-2 on page 7-6), an assumed azimuth may be used. Both the flank and master stations should be points that are easily identified on a map and provide the best possible communications.

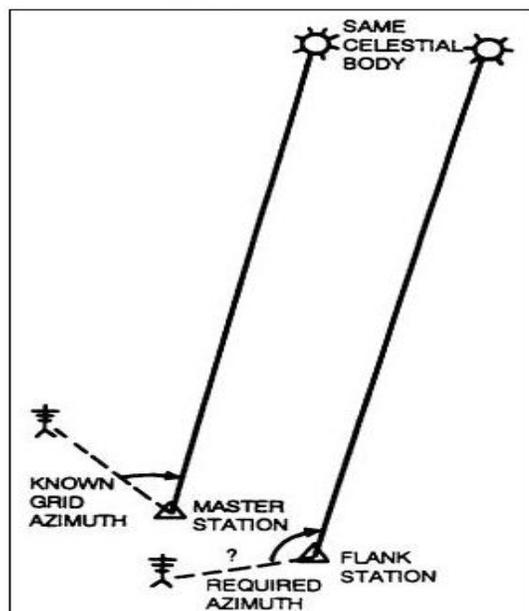


Figure 7-2. Simultaneous observation 1

7-24. An observing instrument is set up at the master station and oriented on the azimuth mark. An observing instrument is set up at each flank station and oriented on a reference mark to which the azimuth is required (see figure 7-3 on page 7-7). The observing instrument at the master station must be of equal order as, or higher order than the instrument used at the flank station. A prominent celestial body is selected by the observer at the master station and identified to the observer at each flank station. On command, an assistant will key the microphone so the observer can transmit information at the same time he observes a celestial body. A headset, loudspeaker, or other device must be provided for the observer at each flank station so he can hear instructions from the observer at the master station. When all stations are ready to observe, the master station observer announces READY, START TRACKING (countdown), TIP. Each flank station observer, when observing a star, places the vertical cross hair of his instrument on the star and keeps it there by using the horizontal recording motion tangent screw. When observing the sun, he centers the sun inside the solar circle. He keeps it centered by using the tangent screws. The master station observer announces TIP at the instant the star is at the intersection of the cross hairs or when the sun is centered in the solar circle. The observer at the master station records the readings on the horizontal and vertical scales. Each flank station observer records the reading on the horizontal scales. All observers then plunge their telescopes and repeat the tracking procedure.

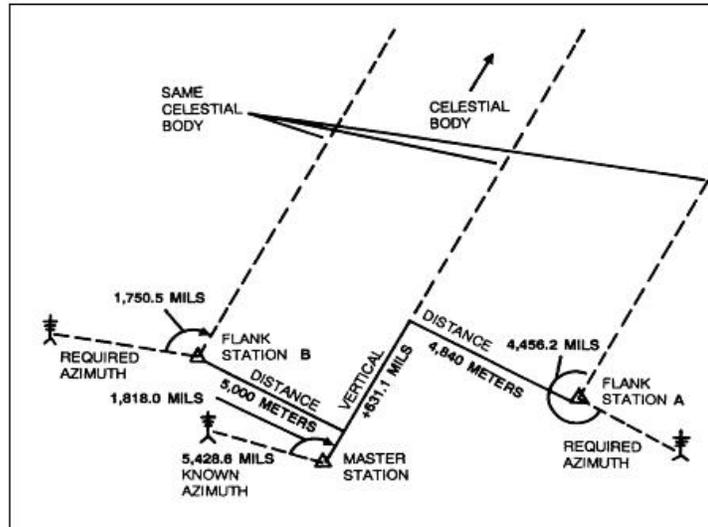


Figure 7-3. Simultaneous observation 2

7-25. At the master station, the measured horizontal angle is added to the known azimuth to the mark to determine the azimuth to the sun. The grid coordinates of the master station, the vertical angle to the sun, and the grid azimuth of the sun are transmitted to each flank station. The flank station operator plots on his map a line representing the azimuth from the master station to the celestial body. From the flank station, a line is drawn perpendicular to the line representing the azimuth from the master station to the celestial body (see Figure 7-3). The flank station observer then determines the correction to be applied to the azimuth from the master station to the celestial body. When this correction is applied (added or subtracted), the result is the azimuth from the flank station to the celestial body. The correction is determined by using the correction nomograph in figure 7-4 on page 7-8.

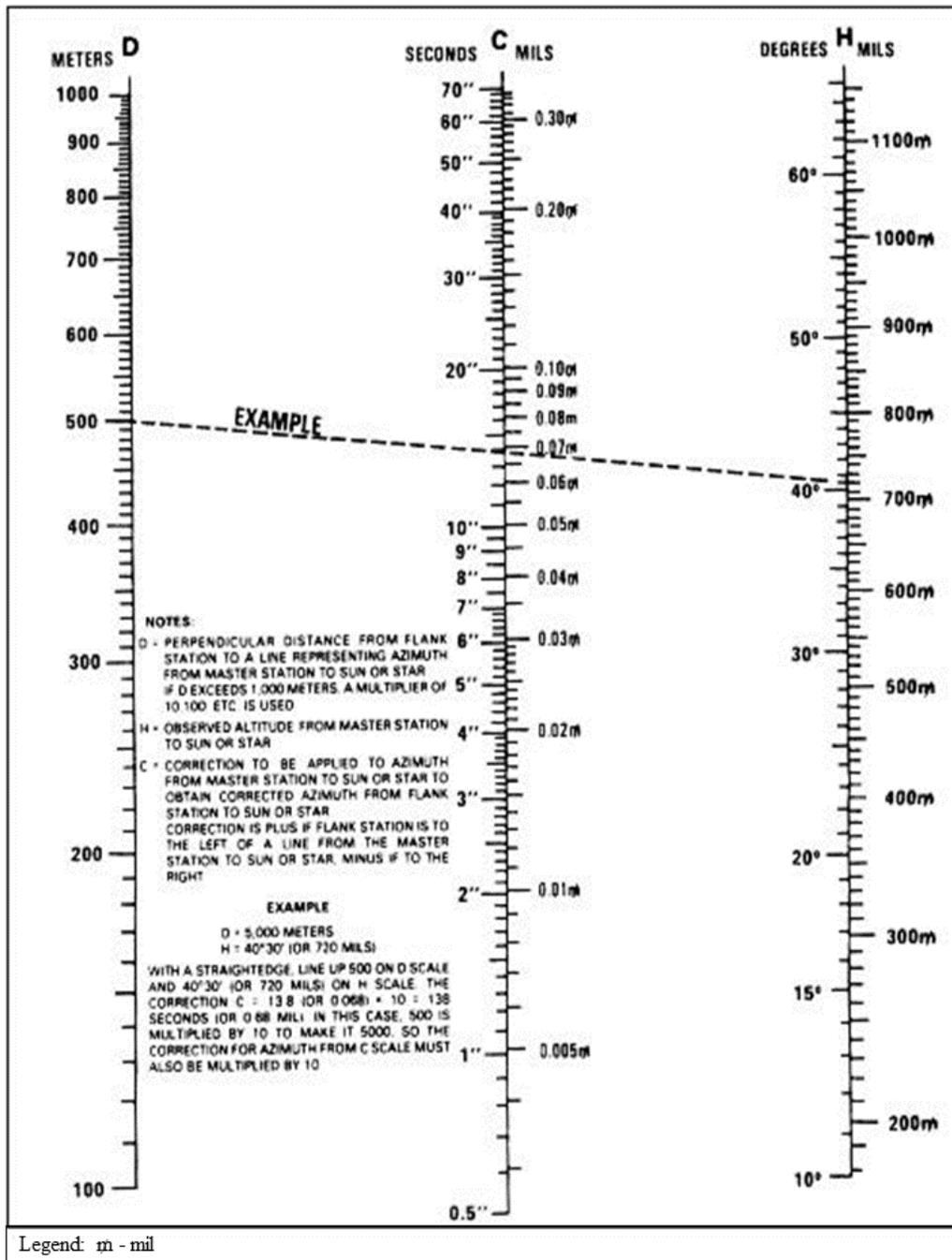


Figure 7-4. Correction nomograph

7-26. The nomograph consists of three columns. The left column is graduated in meters from 100 to 1,000. It represents the value of the length of the line (D) from the flank station to the plotted line that represents the azimuth to the sun from the master station. The center column is graduated in seconds and mils from 0.5" to 70" and from 0.003 mil to 0.34 mil and is the correction (C). The right column is graduated in degrees and mils from 10° to 65° and from 180 mils to 1,150 mils. It represents the vertical angle to the celestial body at the master station (H). Before C can be determined, the values of D and H must be known and used as arguments in the nomograph. When the distance exceeds 1,000 meters, it must be divided by 10, 100, or 1,000 to obtain a value between 100 and 1,000. In such cases, the chart value of C must be multiplied by the same value by which the distance was divided. The value H must be between 180 and

1,150 mils. If the flank station is to the left of the line from the master station to the celestial body, the sign of the correction is plus; if the flank station is to the right the sign of the correction is minus.

7-27. When the azimuth to the sun from the flank station has been determined, the measured horizontal angle is subtracted. The result is the azimuth to the azimuth mark at the flank station (see figure 7-5).

EXAMPLE		
Mean data from observations are as follows:		
Master station:		
Horizontal angle	1,818.0 mils	
Vertical angle	+631.1 mils	
Flank stations		
	<u>A</u>	<u>B</u>
Horizontal angle	4,456.1 mils	1,750.5 mils
Perpendicular distance	4,840 meters	5,000 meters
The grid azimuth to the mark at the master station is 5,428.6 mils. The relative locations of stations are as shown in Figure 7-50. The flank station observer enters the nomograph (Figure 7-51) by using the value of the mean vertical angle and the perpendicular distance from the flank station to the master station azimuth to the sun. The correction obtained from the nomograph (expressed to the nearest 0.01 mil) is applied to the grid azimuth from the master station to the celestial body. This is the grid azimuth from the flank stations to the celestial body. The sign of the correction is minus when the flank station is to the right and plus when the flank station is to the left of the master station when facing the celestial body.		
* Azimuth to master station azimuth mark		
		5,428.6 mils
Horizontal angle at master station		+1,818.0 mils
Sum		7,246.6 mils
		<u>-5,400.0 mils</u>
Azimuth to body		0846.6 mils
Flank station A		
Perpendicular distance 4,840 meters		
Azimuth to body		0846.6 mils
Correction from nomograph (station on right)		<u>-0.6 mil</u>
Azimuth to body at flank station		0846.0 mils
		<u>+5,400.0 mils</u>
		7,246.0 mils
Horizontal angle to body at flank station		<u>-4,456.2 mils</u>
Azimuth to flank station A azimuth mark		2,789.8 mils
Flank station B		
Perpendicular distance 5,000 meters		
Azimuth to body		0846.6 mils
Correction from nomograph (station on left)		<u>+0.6 mils</u>
Azimuth to body at flank station		0847.2 mils
		<u>+6,400.0 mils</u>
		7,247.2 mils
Horizontal angle to body at flank station		<u>-1,750.5 mils</u>
Azimuth to flank station B azimuth mark		5,496.7 mils

Figure 7-5. Azimuth to the azimuth mark at the flank station

ACCURACY OF SIMULTANEOUS OBSERVATIONS

7-28. Simultaneous observations are comparable in accuracy to an astronomic observation with a theodolite or aiming circle. The accuracy cannot exceed that of the instrument used. Requirements for the various accuracies are discussed below.

- Requirements for fourth-order azimuth (± 0.150 mil) are as follows:
 - A known azimuth of fourth-order or better and a NIKON NE-102 theodolite at the master station.
 - A NIKON NE-102 theodolite at the flank station.
- Requirements for fifth-order azimuth (± 0.3 mil) are as follows:
 - An azimuth of fifth-order or better and a NIKON NE-102 theodolite at the master station.
 - NIKON NE-102 at the flank station.

- Requirements for 1:500 azimuth (± 0.5 mil) are as follows:
 - An azimuth of fifth-order or better and a NIKON NE-102 theodolite at the master station.
 - An aiming circle at the flank station.
- Specifications are the same as for an astronomic observation (Appendix B).
- Station displacement (curvature) corrections must be applied (see Figure 7-4)

7-29. If the master station instrument is a NIKON NE-102 theodolite and the flank station instrument is an aiming circle, the maximum accuracy to be expected is ± 0.5 mil.

Note. Simultaneous observations will yield the same accuracy as astronomic azimuths taken with the instructions used to a maximum D value of approximately 26,000 meters. Observations may be conducted over much longer distances if a 1-mil or 2-mil accuracy is acceptable.

HASTY ASTRONOMIC OBSERVATION

7-30. This method enables battalion surveyors and firing battery personnel to compute a grid azimuth and a check angle from observations of the sun or a selected survey star. The accuracy of the computation depends on which instrument is used to perform the observations. The fieldwork for this method is the same as the fieldwork for a flank station simultaneous observation. The procedures for hasty astronomic are listed below:

- Emplace the NIKON NE-102 over the orienting station.
- Place 0000.0 mils on the horizontal scale. Lock the scale with the horizontal clamp.
- Track the celestial body (with scale locked), and announce TRACKING when the instrument is oriented on the sun or selected survey star. Announce TIP when the center of the reticle is exactly aligned on the sun or star (see figure 7-6).
- At the announcement of TIP record the date and time of tip.
- Depress the telescope, and emplace the EOL.
- Unlock the scales, and repeat steps 3 and 4 (see Figure 7-4). Record all data on appropriate form and enter into the HTU. The HTU will display the check angle. Compare the check angle from the HTU to the check angle on the instrument. If the difference is ± 2.0 mils for the aiming circle and ± 0.3 mil for the NIKON NE-102 theodolite, the azimuth to the EOL displayed by the HTU is good; if not, check all data and/or reobserve.

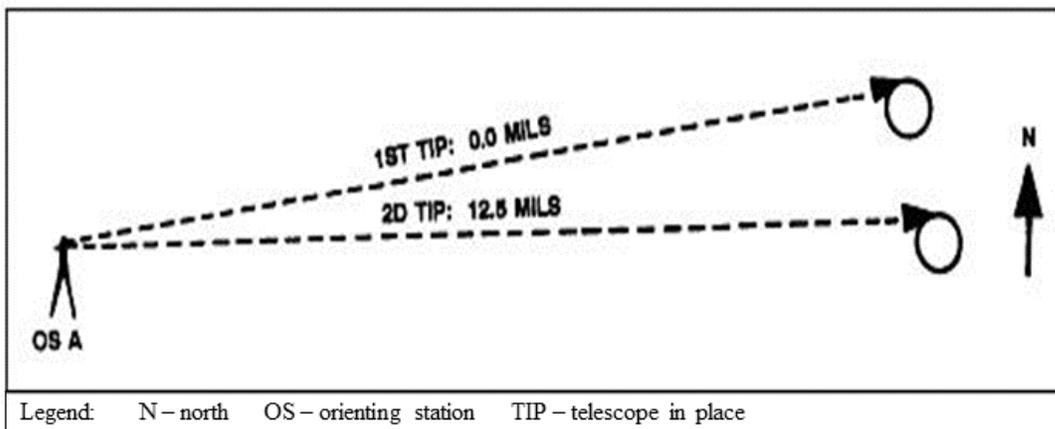


Figure 7-6. Announce telescope in place (TIP)

CHOICE OF A CELESTIAL BODY

7-31. During daylight hours, the sun is the only celestial body that can be readily observed. At night, Polaris is one of the most easily identified stars in the Northern Hemisphere. It is ideal for observation

because of its slow movement. However, Polaris cannot be seen in many parts of the Northern Hemisphere because of local weather conditions, and it cannot be used in areas close to the equator and in the Southern Hemisphere. Therefore, it is inadvisable to depend solely on this star for night observations. Methods of ID and approximate locations of the stars on the celestial sphere in relation to the observer's position are presented in Section IV. All artillery surveyors must be familiar with the more common stars and their relative positions in the sky.

STAR SELECTION AND IDENTIFICATION

7-32. There are important advantages to using stars, rather than the sun as sources of an astronomic azimuth. Since they appear as pinpoints of light in instrument telescopes, stars are easier to track than the sun. At least one of the usable 73 can usually be found in a satisfactory position for observation regardless of the time of night or the observer's latitude. The North Star (Polaris) should always be used when the geographical location and tactical situation permit. When the telescope is directed at Polaris, the observer will see two other stars nearby that are not visible to the naked eye. However, Polaris will be the only star visible when the cross hairs are lighted.

STAR FINDER AND IDENTIFIER

7-33. The star finder and identifier (figure 7-7 on page 7-12) is a device used to determine the approximate ($\pm 2^\circ$) azimuth and altitude of a given star. This device is issued as a component of the survey set, artillery fire control, fourth-order. The star finder and identifier consist of a base, 10 templates, and a carrying case. The base is reversible with stars of the Northern Hemisphere on one side and stars of the Southern Hemisphere on the other. There is one template for each 10° of latitude from 5° to 85° (5° , 15° , 25° , 35° , and so forth). (The tenth template, designed for plotting the sun and planets, is not used in artillery survey). Each template is reversible with one side for north latitude and the other side for south latitude. The template constructed for the latitude nearest the latitude of the observer should be used. The base of the star finder in Figure 7-7 shows the stars visible in the Northern Hemisphere. The center of the device represents the celestial North Pole. The edge of the base is a circle graduated in degrees and half degrees, representing the local hour angle of the vernal equinox or the local sidereal time. On each template is a series of concentric ellipses. Around the outer edge of these ellipses are two sets of numbers from 0° to 360° . The inner set of numbers starts at the top of the template for north latitude and increases in a clockwise direction. The outer set of numbers starts at the bottom of the template for south latitude and increases in a clockwise direction around the ellipses. In the Northern Hemisphere, the inner figures are used; in the Southern Hemisphere, the outer figures are used. The inner set of figures represents the azimuth from the celestial North Pole to the line that the figures identify. The outer set of figures represents the same thing except that the azimuth is from the celestial South Pole to the line. The series of concentric ellipses represents altitudes above the horizon. The template has the horizon on its circumference, the zenith as its center, and a measure of azimuth around the edge. The 0° to 180° line represents the observer's meridian. Before the star finder can be oriented, the value of the local sidereal time must be determined. The pointer of the template is then placed over the appropriate value on the base of the star finder.

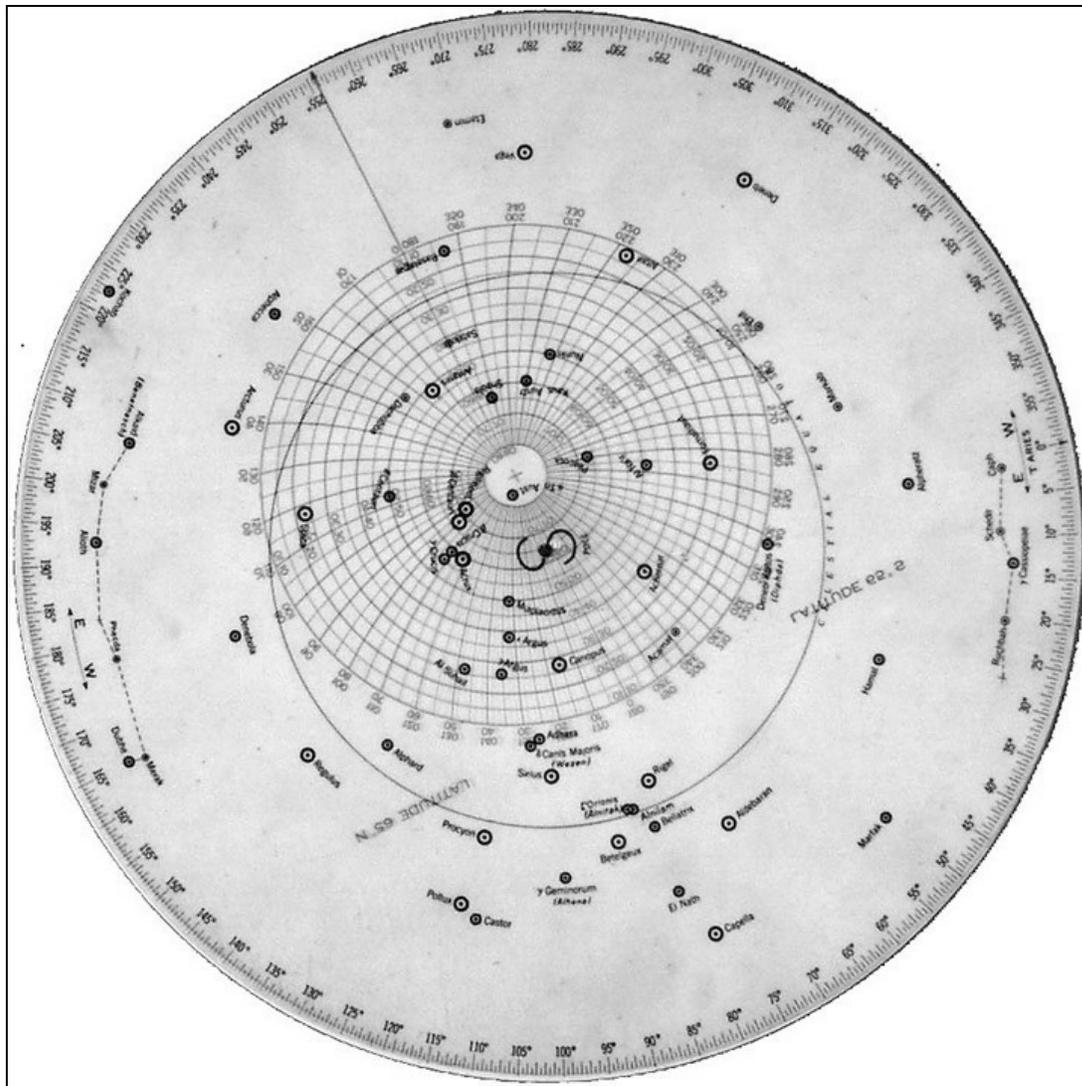


Figure 7-7. Star finder and identifier

Haught (Field-Expedient) Method for Orienting the Star Identifier

7-34. This is a simple method of computing the local sidereal time (LST) for orienting the star finder and identifier. The results are accurate to within 1° and can be used for any time or location. The final result is the LST for 1900 on the date of observation. Use the time-arc relationship to adjust for different observation times. One hour is equal to 15° of shift on the star finder and identifier, and 4 minutes is equal to 1° of shift. To compute the LST by using the Haught method, follow these procedures:

- Count the number of months this year preceding the observation month. Multiply that number by 30.
- Add the observation date.
- Add a constant of 24.
- Determine the difference between the observer's longitude and the longitude of the central meridian of the observer's time zone. Add the difference if the observer is east; subtract if west.
- If using daylight saving time, subtract 15. Daylight saving time in the US is currently from the second Sunday in March to the first Sunday in November. The result is the LST (orienting angle) to set on the star identifier for 1900.

- Determine the difference between 1900 and the time of observation. (Each hour is equal to 15° , and each 4 minutes is equal to 10.) Add if the observation time is after 1900, and subtract if the observation time is before 1900 (see figure 7-8 for an example).

EXAMPLE	
The observation will be at 2230 on 23 July (the year is not needed). The longitude of the observer is 98° (use closest 1°), and the time zone is S (central meridian = 90°).	
Number of full months x 30 =	180
Date of observation	23
Constant	<u>+24</u>
	227
Plus or minus the difference of observer's longitude from the longitude of the central meridian ($98 - 90 = 8$). (Observer is west.)	<u>-8</u>
	219
Subtract 15 for DST	<u>-15</u>
Result is LST (orienting angle) for 1900	204
The difference between 1900 and 2330 is 3 hours and 30 minutes; therefore,	
$3 \times 15 = 45$	
$30 \div 4 = +7.5$	<u>+52.5</u>
Result is LST for 2330 on 23 July	256.5
Legend: DST – daylight savings time LST – local sidereal time	

Figure 7-8. Determine the difference between 1900 and the time of observation

Selection of Stars for Observation

7-35. The apparent motion of a celestial body has two components—a horizontal motion, representing change in azimuth, and a vertical motion, representing change in altitude. An error in measuring the altitude of a celestial body will result in a final azimuth error related to the ratio between the two components of the apparent motion of the body (see figure 7-9 on page 7-14). When a star is moving at a small angle to the horizon, an error in measuring the altitude will result in a greater error in final azimuth than it would if the star were moving at a large angle to the horizon (see figure 7-10 on page 7-14). This relationship is called the star rate, which is the ratio of resulting azimuth error to error in vertical measurement. A star that changes in altitude but not in azimuth will have a star rate of 0, since an error in altitude measurement will result in no error in azimuth. A star that changes so rapidly in azimuth and so slowly in altitude that a one mil error in attitude measurement will result in a 3 mil azimuth error.

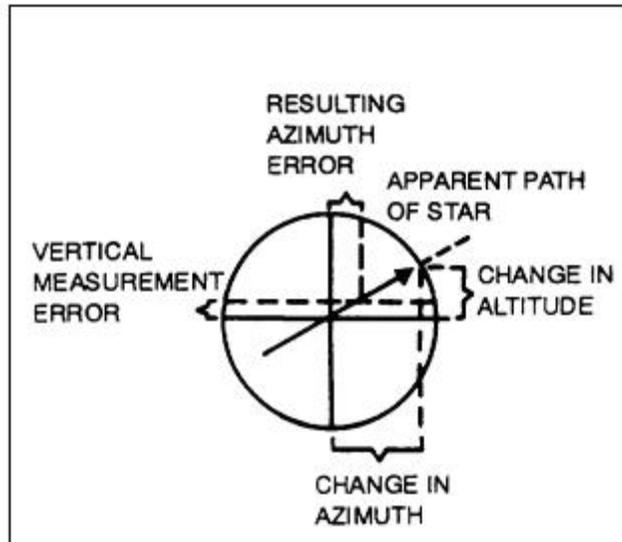


Figure 7-9. Celestial body final azimuth error 1

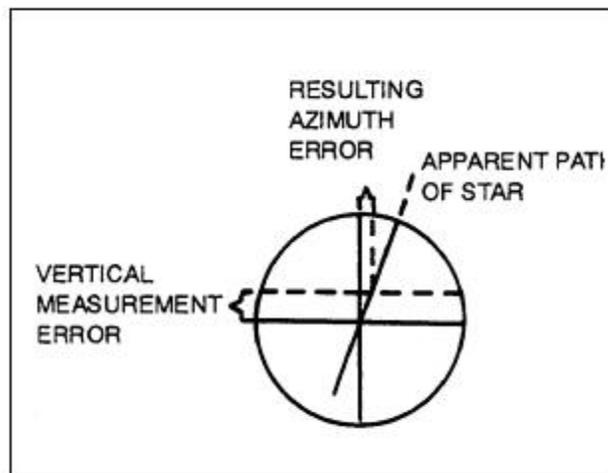


Figure 7-10. Celestial body final azimuth error 2

7-36. Low star rates are not essential for astronomic observations, because altitude is not measured. However, stars with low star rates will be moving more slowly in azimuth and will be easier to track than those with high star rates. Although Polaris has a high star rate in its culminations, its apparent motion is so slow that it can be observed successfully at any time. Avoid observing stars below 175 mils in altitude because of possible errors caused by refraction.

WORLD STAR CHART

7-37. A map depicts the prominent points on the earth, and the star chart depicts the prominent points in the sky (see figure 7-11 on page 7-15). On the earth latitude and longitude are used to fix the location of points; declination and right ascension are generally used to fix the stars at definite coordinates. Consequently, on a star chart the north-south location of a star is fixed by declination, and the east-west location is fixed by right ascension.

- 7-40. The following method can be used to orient the world star chart in the Northern Hemisphere.
- Determine the LST of observation from Figure 7-12.
 - Enter the table with the closest date of observation.
 - From the date, move to the right and stop in the column of the closest hour of observation.
 - Extract the LST from the hour column.
 - Locate the celestial equator.
 - Subtract the observer's latitude from 90° . The result is the distance above the horizon to the celestial equator.
 - Face south, and determine the position of the celestial equator. Remember, at arms length, a finger width is 2° , 1 hand width is 10° , and 1 hand span is 20° .
 - Hold the world star chart with the word North on top. Locate the graduation at the top the chart that represents the LST. Face south, and align the LST graduation just below the celestial equator along the observer's meridian. The world star chart is now oriented with the stars in the sky.
- 7-41. The following method can be used to orient the world star chart in the Southern Hemisphere.
- Determine the LST from figure 7-12.
 - Locate the celestial equator. This is done the same as in the Northern Hemisphere except the observer must face north and count up from the horizon to locate the celestial equator.
 - Hold the world star chart with the word South at the top. Locate the graduation at the top of the chart that represents the LST. Face north, and align the LST graduation just below the celestial equator along the observer's meridian.
- 7-42. To aid the observer, highlight the 30° N and 30° S lines on the star chart. Also highlight the 0° line, which is the celestial equator. The strip of sky as outlined by the 30° N and 30° S lines will contain the brightest stars (seen at any one time). Keep in mind that the strip of sky being looked at is about 6 hours either side of the LST.

DATE	EVENING HOURS	MIDNIGHT	MORNING HOURS
	2000	2400	0400
JAN 5	3	7	11
20	4	8	12
FEB 4	5	9	13
20	6	10	14
MAR 7	7	11	15
22	8	12	16
APR 7	9	13	17
22	10	14	18
MAY 7	11	15	19
22	12	16	20
JUN 7	13	17	21
22	14	18	22
JUL 7	15	19	23
22	16	20	0
AUG 7	17	21	1
22	18	22	2
SEP 7	19	23	3
21	20	0	4
OCT 6	21	1	5
21	22	2	6
NOV 6	23	3	7
21	0	4	8
DEC 6	1	5	9
21	2	6	10

Figure 7-12. Determine the local sidereal time (LST)

LOCATING STARS

7-43. The easiest way to identify stars and fix their locations in relation to each other is to learn something about constellations. Since stars are fixed in definite points in the sky with relation to each other, the relative position of stars has remained about the same for many centuries. In certain groups of stars, primitive stargazers saw the shapes of creatures or heroes of their folklore. Names were applied to the shapes of these various groups of stars. Later, people saw in the stars the shapes of household implements with which they worked. The development of the names of stars began early in the history of man and finally resulted in a catalog of the visible stars. The named shapes became constellations, and the individual stars were identified by name with the constellation of which they were a part. From this primitive development, the constellations were given Latin names. Other groups of stars were assigned names of gods and goddesses and creatures of land and sea that figured in Roman and Greek mythology. Much later in history, our forefathers saw in the many constellations objects common to their mode of living. Thus, the Big Bear came to be known as the Big Dipper. To the English, this same constellation is the Plough. Some of the more familiar Stars and Constellations are described below.

7-44. The familiar constellation called the Big Dipper is only part of the constellation Ursa Major (see figure 7-13). The seven stars of the dipper are easy to find on almost any clear night. The two outer stars of the bowl point toward the North Star, Polaris, which is about 30° away. The distance between the pointers is about 5° . Both measurements are very helpful when the star finder and identifier are being used.

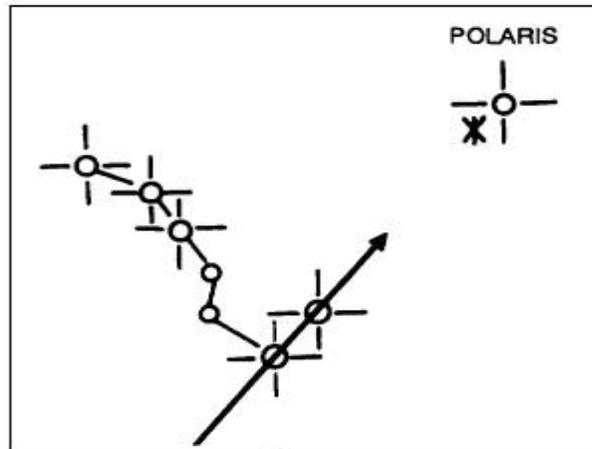


Figure 7-13. Ursa Major

7-45. Cassiopeia (see figure 7-14 on 7-18), sometimes called the Lady in the Chair, the Running M, or the Lazy W, is a prominent northern constellation. It is found directly across the celestial North Pole, opposite the Big Dipper. When the Big Dipper is below the horizon, Polaris can be found by drawing a line from the star Ruchbah bisecting the angle formed by the shallow side in Cassiopeia. The bisecting line points almost through Polaris.

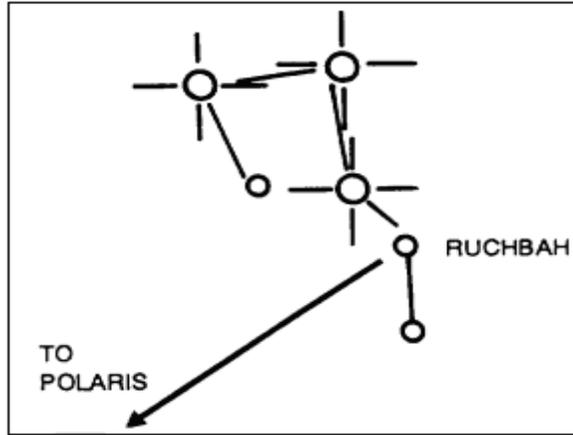


Figure 7-14. Cassiopeia

7-46. Polaris, the polestar, is the alpha star in the constellation Ursa Minor (see figure 7-15), commonly called the Little Dipper. On a clear night, the Little Dipper is easily seen. The handle of the dipper has a reverse curve, and Polaris is the last star in the handle.

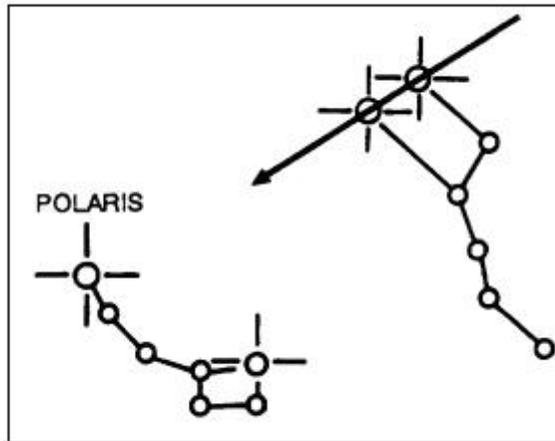


Figure 7-15. Polaris

7-47. The first prominent constellation after the vernal equinox has risen in the east is Taurus, the Bull (see figure 7-16 on page 7-19). On the forehead of Taurus is a red star of the first magnitude, Aldebaran. It is a royal star, one of the four stars most commonly used by navigators. On the upper foreleg of Taurus is the Pleiades. This aggregation is a tight cluster of stars, which is also called the Seven Sisters.

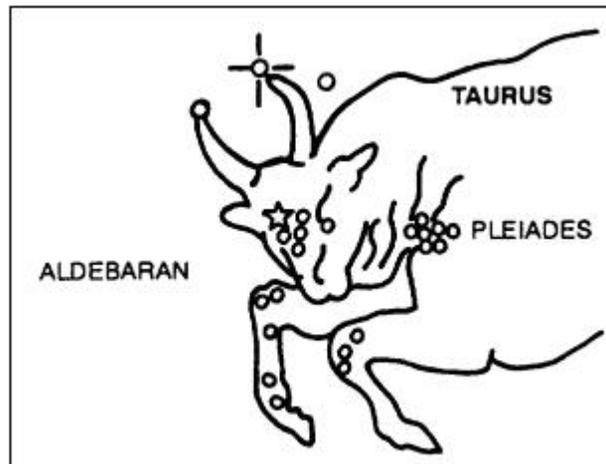


Figure 7-16. Taurus

7-48. Chasing these seven stars and the bull is Orion, the Hunter (see figure 7-17). There are two very bright stars in Orion. The hunter's right shoulder is Betelgeuse (α Orionis); his left knee is Rigel (β Orionis). Close on the heels of Orion are his two dogs, Canis Major and Canis Minor. In the big dog is the brightest star in the sky, Sirius. It is a brilliant blue-white star. Slightly behind Canis Major is the smaller dog in which Procyon is found.

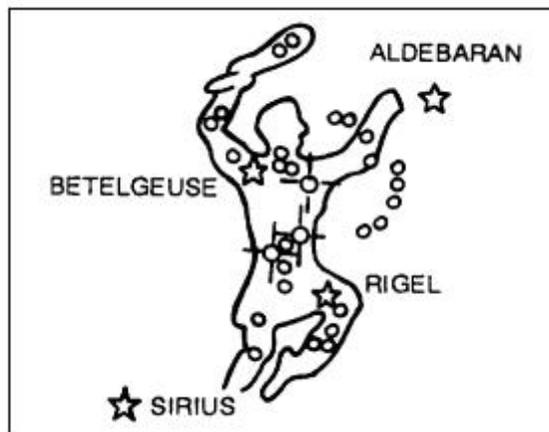


Figure 7-17. Orion

7-49. At about the same right ascension with the canine constellation is Gemini, the Twins (see figure 7-18 on page 7-20). Think of Gemini as a wedge pointed straight toward Orion. The bright star at the base of the wedge is Pollux (β Geminorum); the one above it is Castor (α Geminorum).

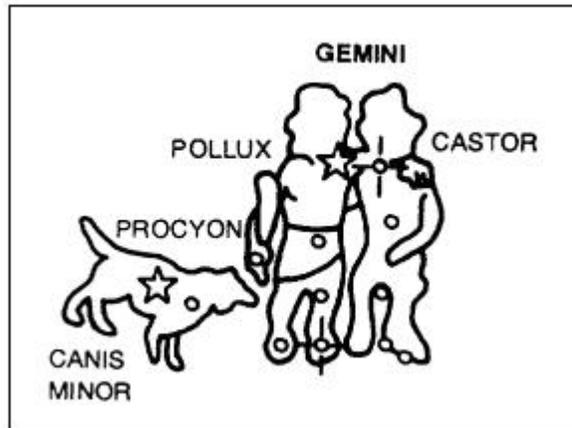


Figure 7-18. Gemini

7-50. About 2 hours behind Gemini and Canis Minor is Leo, the Lion (see figure 7-19). The head and forequarters of Leo are sometimes known as the Sickle. The body and tail extend off to the east. The heart of Leo is Regulus (α Leonis). Regulus is another of the four royal stars. It is brilliant white, whereas the others are red.

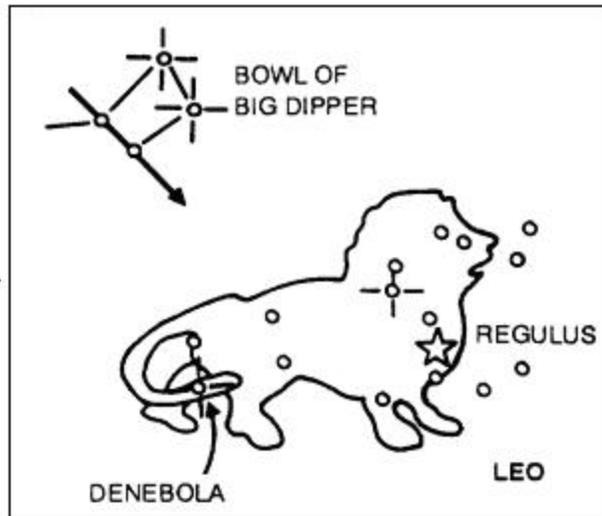


Figure 7-19. Leo

7-51. As soon as Leo is well up in the sky, Virgo (see figure 7-20 on page 7-21) will rise in the east. The bright star in Virgo, called Spica (α Virginis). It makes an approximately equilateral triangle with Denebola (β Leonis) and Arcturus (α Bootis). This triangle is sometimes called the Virgo triangle.

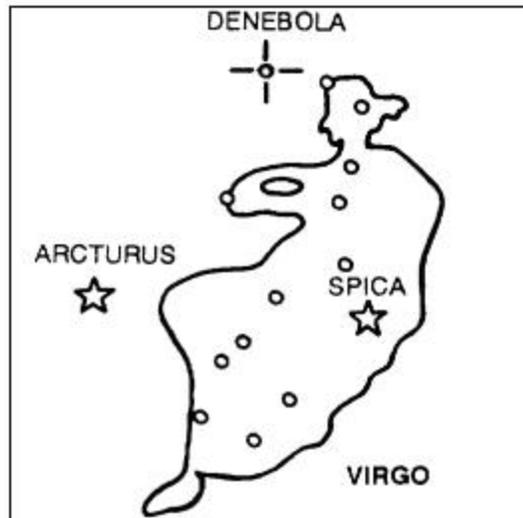


Figure 7-20. Virgo

7-52. One of the most easily recognized constellations is Scorpio (see figure 7-21). However, it is so far south that in northern latitudes it is visible during evening hours only through July and August. Antares (♏ Scorpii) is another of the four royal stars.

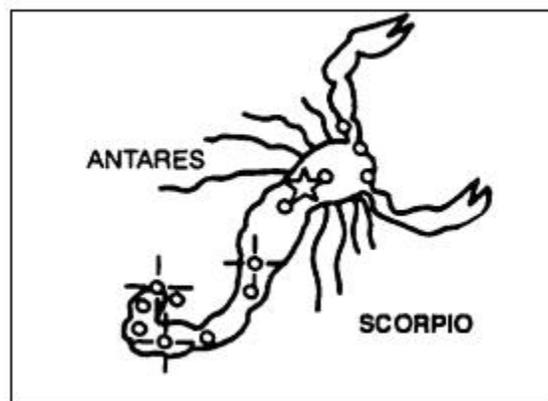


Figure 7-21. Scorpio

7-53. The Northern Cross, Cygnus, is found very close to the circumpolar region (see figure 7-22 on page 7-22). This is a very prominent constellation, and in northern latitudes in the fall, it will be nearly overhead in the evening. The head of the cross is Deneb (♠ Cygni). There are two neighbor stars in this sector of the sky--Vega (♌ Lyrae), which rises just before the cross, and Altair (♏ Aquilae), which trails it somewhat to the south. Cygnus is imagined by some to be a cross; to others, it takes the shape of a swan from which the name is derived.

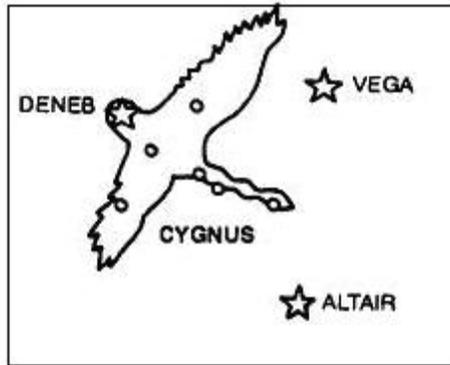


Figure 7-22. Cygnus

7-54. Pegasus (see figure 7-23), which includes the Great Square, straddles the hour circle of the vernal equinox. This is the constellation of the flying horse, a very prominent sky mark.

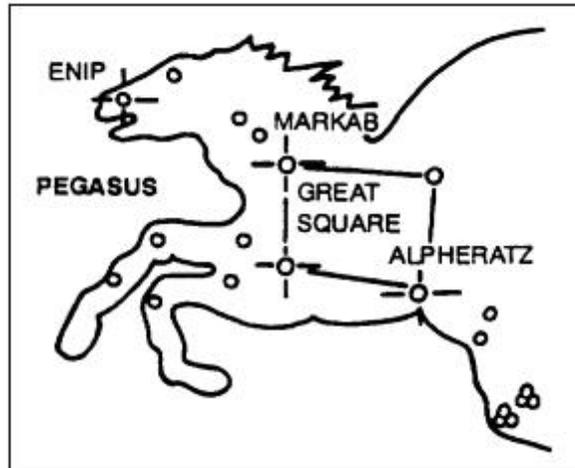


Figure 7-23. Pegasus

Chapter 8

Improved Position Azimuth Determining System

The IPADS is a self-contained inertial surveying system, capable of rapidly determining accurate position, altitude, and azimuth when used in either ground or airborne survey operations. The systems may be installed in and operated from an M998, M1097, or M1123 series high-mobility multipurpose wheeled vehicle (HMMWV) and M973 series small unit support vehicle (SUSV). It may be transported by a CH-47 cargo helicopter (by sling loading the land vehicle). IPADS may be used within any vehicle, ground or air, capable of carrying it, supplying required power and making periodic stops at five or ten minute intervals. IPADS is used to conduct FA surveys critical to the fire-control function, providing a common grid for weapons and target acquisition systems. It will determine the true or grid azimuth of azimuth lines used to orient weapons and target acquisition systems.

SYSTEM USES AND CONFIGURATIONS

IMPROVED POSITION AND AZIMUTH DETERMINING SYSTEM (IPADS)

8-1. The M111 IPADS is a self-contained inertial surveying system capable of rapidly determining accurate position, altitude and azimuth when used in either ground or airborne operations. IPADS must be initialized before it can perform survey operations. The system may be installed in and operate from a M998, M1097 or M1123 series high-mobility multipurpose wheeled vehicle (HMMWV) and M973 series small utility support vehicle (SUSV). The M973 must be modified to ensure proper installation, for example, removal of winch in accordance with (IAW) TM 9-6675-349-13&P. IPADS may be utilized within any vehicle capable of securely mounting it, supplying required power and making periodic stops at five and ten minute intervals. IPADS is capable of 4th and 5th order FA surveys critical to the fire-command function, providing a common grid for weapons and target acquisition systems. True or grid azimuth lines accurate to 0.4mils PE used to orient weapons and target acquisition systems are established with IPADS.

8-2. Special precautions must be taken in certain geographical areas. In areas of extreme cold the IPADS control display unit (CDU) Crystal Display may be permanently damaged if exposed to temperatures below -40°F. Permanent damage to the IPADS CDU hard disk drive (HDD) may result from operation at temperatures below -22°F. Ensure that vehicle temperature is raised above this level using the vehicle heater prior to installing the CDU. Operation of IPADS in ambient temperatures above 115°F may cause internal battery temperature to exceed 150°F. If the internal battery temperature approaches this threshold the battery may not provide backup battery power for continued operations.

8-3. Updates are required every 75 km radius from the last update point or every 221 km of total distance from last update point. IPADS requires the vehicle to be stopped every five minutes for 4th order survey and ten minutes for 5th order. With the fielding of the IPADS-G, due to an integrated GPS capability, the IPADS system will no longer be required to stop in order to perform zero velocity updates (ZUPT). The GPS feature aides in continuing mission beyond the 75km radius negating the update distance restrictions. This feature will greatly improve convoy security enabling survey vehicles to maintain a constant velocity thus ensuring operational integrity.

8-4. When the IPADS vehicle is unable to occupy a station the Nikon NE-102 Theodolite is used to optically transfer positional data to the IPADS. Optical transfer can be accomplished up to 24m from the system by means of a prism located on the compact position and navigational unit (CPNU) component of

the IPADS. The Porro Prism Assembly (PPA) will be in the locked position during transit to avoid permanent damage. The Nikon NE-102 provides accuracy of 0.02mils and has a magnification of 30X.

IMPROVED POSITION AND AZIMUTH DETERMINING SYSTEM-GLOBAL POSITIONING SYSTEM (IPADS-G)

8-5. The IPADS-G is currently being used in ground vehicles only for survey operations. The system can achieve 4 meters CEP in position and 2 meters Probable Error (PE) in altitude and 0.4 mils PE in azimuth. The IPADS-G is extremely accurate and meets or exceeds all prescribed requirements for FA Survey when using GPS aiding.

8-6. IPADS-G must be initialized before it can perform survey operations. It is flexible in initialization methods allowing seamless transitions between stationary (gyro-compassing method) and on-the-move (GPS-aided method). Three types of initializations are used; “moving base”, “normal” and “hot start”.

8-7. With GPS aiding, it is no longer necessary to wait 5 or 10 minutes for the IPADS-G to perform normal or hot start initialization. IPADS-G can start moving once countdown reaches 440 seconds if GPS aiding is selected, available and the internal GPS Receiver is initialized (position, Ephemeris, timing data). If IPADS-G is moved prior to counting down to 440 seconds, a fatal CPNU error will occur. When the operator starts driving the vehicle before the Hot Start or Normal Initialization is complete and GPS is available, 800 seconds (or less depending on how long normal initialization has been running while the vehicle was stationary). If the vehicle stops the navigation mode will switch from MOV. BASE to ALIGNING.

8-8. In the case where the IPADS (GPS Receiver) was not recently initialized at that location (e.g. after a long period of storage or after transporting over a long distance), and the GPS feature is enabled and available, a DAGR can be used to initialize the IPADS GPS Receiver within one minute. If a DAGR is not available the IPADS GPS Receiver will start downloading large amounts of data from the satellites (position, Ephemeris, timing data). This process will take 10 to 30 minutes.

SYSTEM USES

8-9. The system’s main purpose is to provide a common grid for the FA weapons systems and target acquisition assets rapidly determining accurate position, azimuth, and altitude on the modern battlefield. The IPADS or IPADS-G also contains a navigational aide to decrease travel time between missions and can be used in conjunction with hasty survey techniques or GPS receivers.

CONFIGURATIONS

8-10. IPADS or IPADS-G must be configured for the current mission including: normal operation mode or training, vehicle type, survey order, ellipsoid and datum, display settings, grid zone (if using UTM coordinates and operating within 40 km of a zone boundary) and date and time. Any vehicle used with IPADS must supply at least 100 amperes at 24 VDC for IPADS or IPADS-G operation. IPADS or IPADS-G retains configuration settings after shutdown. It is not necessary to reconfigure IPADS or IPADS-G for settings that do not change from the previous mission unless changing from a training mode to a tactical mode. See figure 8-1 (on page 8-3) for an example of an IPADS.



Figure 8-1. Improved Position Azimuth Determining System

IPADS OR IPADS-G COMPONENTS

8-11. The major components of the IPADS or IPADS-G include a CPNU, a CDU and a BCU. Connection of a GPS antenna (see figure 8-2 on page 8-4) to the CPNU via a GPS antenna cable makes it an IPADS-G. The CPNU contains the gyroscope and accelerometer sensors and the associated electronics necessary to maintain the survey coordinate frame and to measure the distance traveled to each coordinate axis (see figure 8-3 on page 8-4). The CPNU also contains the porro prism for optical transfer through use of auto-reflection. The CDU is the main interface between the operator and IPADS or IPADS-G (see figures 8-4 and 8-5 on page 8-5). The CDU contains the computer, keyboard, and graphic display for operator entry and to display survey data and system commands. The BCU contains IPADS or IPADS-G backup batteries and associated switching and charging electronics (see figure 8-6 on page 8-6). The BCU can be used to transfer IPADS or IPADS-G between host vehicles without losing information or requiring that the system be reinitialized (only updated). The IPADS or IPADS-G is configured for simple and rapid exchange between supporting vehicles and is a non-developmental item. The system is operated by trained personnel in support of combat or training operations.

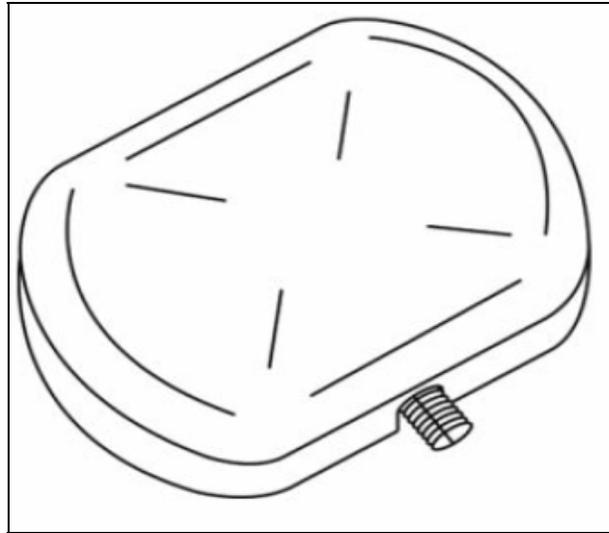


Figure 8-2. Global Positioning System antenna

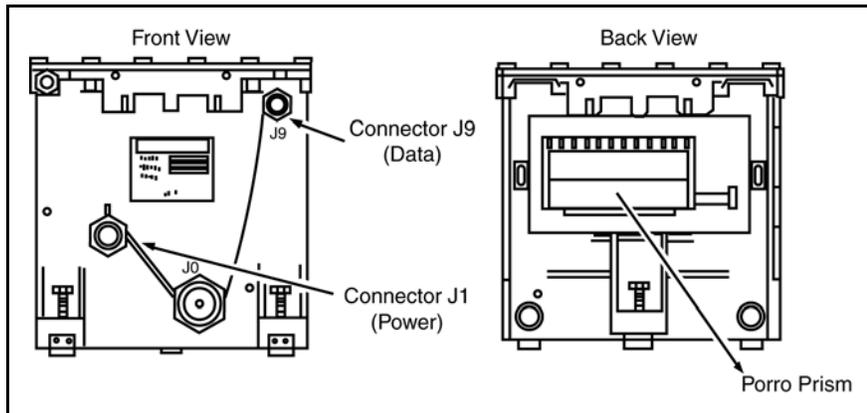


Figure 8-3. Compact position and navigational unit



Figure 8-4. Control display unit

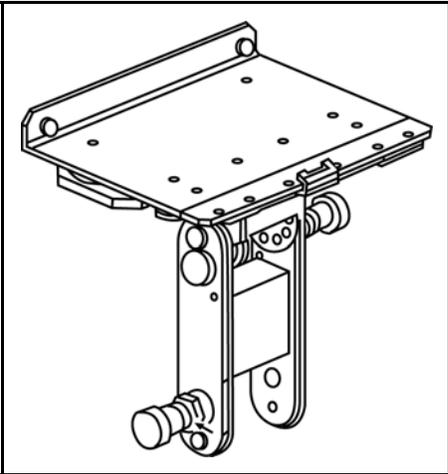


Figure 8-5. Control display unit mount

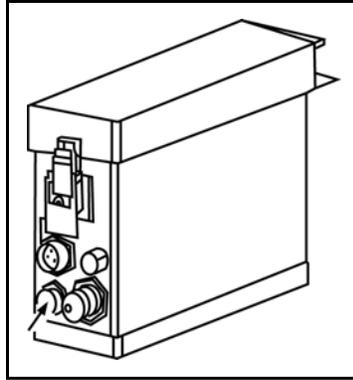


Figure 8-6. Battery charger unit

OPERATION

8-12. A crew of two soldiers can operate the IPADS or IPADS-G 24 hours a day with the capability for one soldier to operate the system for a limited period of time. The survey team leader assesses the supported unit and survey mission, conducts a risk assessment, and assigns section tasks based on these assessments. IPADS teams must be able to support a wide range of military operations, during various battlefield and training conditions/environments to ensure survey data is always available.

8-13. Operating the IPADS or IPADS-G consists of providing primary survey capability to minimize errors associated with precisely knowing the platform's position, altitude, and orienting direction. The IPADS or IPADS-G digitally transmits survey data by interfacing with HTU to the Advanced Field Artillery Tactical Data System located at the FA battalion, fire direction centers (FDCs), and to the FC at the FAB, DIVARTY, and BCT.

8-14. The IPADS or IPADS-G provides UTM and geodetic horizontal coordinates, elevation in meters and azimuth in mils, degrees, and decimal degrees for the use of various fire support elements. The IPADS or IPADS-G can determine:

- High-order survey with a horizontal position location to a threshold accuracy of 4 meters CEP.
- Vertical position to threshold accuracy of 2 meters PE and azimuth to threshold accuracy of 0.4 mils PE from 0 degree to 65 degrees North or South latitude and 0.6 mils from 65 degrees to 75 degrees North or South latitude.

Note. The IPADS or IPADS-G can function in all natural and battlefield environments to provide continuous, responsive, and accurate survey data.

PREPARATION FOR OPERATION

8-15. The mission begins with pre-turn-on checks and services, followed by configuration and initialization. Next, IPADS or IPADS-G is updated, using the position and altitude update procedure. IPADS or IPADS-G then performs a series of marks, where position, altitude, and azimuth are recorded. Update, data recall, and shutdown complete the mission.

Note. To save time, IPADS or IPADS-G tries a "hot start" using position and azimuth stored at last shutdown. If IPADS or IPADS-G senses motion since the last shutdown, it automatically switches to normal initialization where IPADS or IPADS-G automatically aligns after operator enters approximate IPADS or IPADS-G position. The IPADS or IPADS-G CDU can be configured for normal operation with a complete IPADS or IPADS-G or as a stand-alone emulator for training.

IPADS OR IPADS-G MAP MANAGER

8-16. IPADS or IPADS-G map manager allows the operator to prepare digital map files in the special format required when transferring to and from a laptop computer. Maps loaded are the ones to be used during survey operations.

Note. To ensure a proper map display, boundaries for the entire operational area to be covered should be entered. IPADS or IPADS-G map manager will prepare as many maps as necessary to cover the area with the data available for the selected data blocks.

Note. IPADS or IPADS-G map manager expects World Geodetic System (WGS) 84 coordinates referenced to another datum would not significantly impact map boundaries.

ELLIPSOID AND DATUM

8-17. IPADS or IPADS-G can store two sets of user-defined datum parameters for each predefined ellipsoid and for each of two user-defined ellipsoids. Verify parameters are for the intended datum when selecting a user-defined datum. Incorrect parameters may introduce significant position error.

8-18. IPADS or IPADS-G must be configured for datum of initial update SCP. Ellipsoid and datum can be change later if output of coordinates on a different datum is required. Datums are associated with ellipsoids. IPADS accepts entry of user-defined ellipsoid and datum parameters.

CAUTION

Ellipsoid and datum can be changed at any point during a mission. Datum shifts have unknown associated errors. Do not initialize and close IPADS surveys at SCPs on different datums. SCPs on different datums probably were established by different, unconnected surveys. Closing at a SCP on a different datum may introduce significant error into adjusted coordinates.

IMAGERY IPADS OR IPADS-G INITIALIZATION METHOD

8-19. If GPS, is not available the surveyor may use a technique using digital imagery precision strike suite–special operation forces (PSS-SOF) to establish an IPADS or IPADS-G initialization grid coordinate. This technique is only viable when the operator can determine a well-defined / distinguishable point Imagery (for example, (PSS-SOF) may be used to establish an initialization grid coordinate only. Due to the inherent circular error, imagery is not to be used to establish directional control. Establishing an initialization grid coordinate and uploading into IPADS or IPADS-G is acceptable. Direction is then established by IPADS or other manual/degraded methods (above). This method ensures a common grid coordinate is shared and disseminated throughout the area of operation.

Note. The operator must ensure the reference point used is clearly distinguishable on the ground and on the imagery itself (for example, corner of a building, road intersections, or base of a water tower. Marking a stake in the middle of an open area (field) is not an acceptable method.

8-20. Refining a Position Using Imagery. FOS 11.01.03, PSS-SOF, and the digital point positioning data base imagery that shows local imagery should be loaded on your computer. A database should also be present that includes your current location, a member (subscriber) so you can simulate transmitting messages, and geometries.

MISSION

8-21. The FA requires an inertial survey system capable of providing location to an accuracy of 4 meters CEP and 2 meters PE in altitude and providing direction to an accuracy of 0.4 mils PE. This level of accuracy is required to enable the systems that use the information to fully attain their functional accuracy requirements. FA target acquisition and weapons platforms are leveraging GPS technology to enhance current and proposed positive navigation (POSNAV) systems.

8-22. The GPS-inertial systems on FA platforms significantly enhance self-location, accuracy, and responsiveness of cannon, rocket, target acquisition, and missile systems. GPS technology and POSNAV systems have reduced the survey burden on FA units but cannot replace battlefield survey in the near to midterm future.

8-23. The presence of GPS/inertial POSNAV systems on the battlefield decreases, but does not negate, the need for a separate backup inertial capability to provide location, elevation, and direction. GPS/inertial POSNAV systems are susceptible to jamming, spoofing, loss of signal, and so forth. Loss of the GPS signal requires that GPS/inertial POSNAV systems be frequently updated at a surveyed update point. GPS/inertial systems require update points whenever the GPS is not available and inertial systems fall out of tolerance. To support these GPS-inertial systems and counter their vulnerabilities, a robust, non-GPS based, inertial survey capability is required—now and in the foreseeable future. As the number of GPS/inertial systems on platforms increases in maneuver and support units, IPADS provides SCPs for use by these systems should GPS not be available. Inertial survey capability ensures timely and accurate survey data is always available to critical war-fighting systems, when and where it is needed, whether GPS is functioning or not.

8-24. The following are special situations in which the IPADS or IPADS-G can be used. No additional personnel or equipment is required.

- **Establishing a Declination Station.** When the IPADS or IPADS-G is used to establish a declination station, the criteria for the predetermined site is the same as that described in paragraph 8-21. The preferred procedure, time and tactical situation permitting, is to travel directly from an update point and determine the mean of two azimuths for each azimuth line (as a check) by following normal position and azimuth determining system (PADS) procedures for determining an azimuth. The azimuths should agree within 0.4 mil. To close out the declination station survey, update as soon as possible and record adjusted data. Record and include measured vertical angles with the declination station data. (The vertical angle is not used with IPADS or IPADS-G but will be used at the declination station to determine a vertical angle correction when the aiming circle is declinated.)
- **Using the PADS with Assumed Data.** The IPADS or IPADS-G can be operated in areas where known survey control or GPS data are not available. In such cases, the IPADS or IPADS-G operator must know the spheroid and UTM grid zone and must use all existing support elements (S2, FC) to determine the data needed to initialize the system. The initialization data used should be as accurate as possible. When conducting a IPADS or IPADS-G operation under these conditions, the IPADS or IPADS-G operator will update the system over the initialization point (assumed point) and all control will be extended from this point to ensure all elements are on a common grid. To close out this type of survey, the IPADS or IPADS-G must be updated over the initialization-initial update point (assumed SCP). This procedure should be used only in special missions where known survey control is not available.
- **Operating PADS at Night.** The PADS can be operated at night under blackout conditions as long as the CDU keyboard can be read with the lamps dimmed or with a flashlight with strict light control. Only the CDU status indicators and data display can be dimmed. The keyboard is either fully illuminated or dark. If optical transfer is to be performed, the theodolite front site can be painted white with typewriter correction fluid or can be illuminated with the hand lamp. The end of the azimuth line must be illuminated. Under blackout conditions, the two-position mark method is preferred in establishing an azimuth line. The only illumination required for this method is to aid in marking the station. For tactical reasons, the IPADS or IPADS-G team must be thoroughly familiar with all indicators and controls and the CDU keyboard.
- **Decontaminating IPADS or IPADS-G.** While in a survey mission, the system can continue to operate in a chemical, biological, radiological, and nuclear (CBRN) environment with partial

decontamination. To partially decontaminate the system, the PADS operator should use the M13 decontamination kit. The CDU, plumb bob arm, porro prism cover, circuit breaker covers, flashlight, and battery box latches should be decontaminated. When the survey mission is complete and the unit has established a decontamination point, the entire system can be decontaminated with soapy water. When the entire system is to be decontaminated, extreme caution must be used to prevent exposing the system to high-pressure water. The operator also must ensure that the circuit breaker covers are closed and that any unconnected cable connector is capped or taped.

8-25. A declination station is used to declinate the aiming circle. A compass is periodically checked on a known line of direction, such as a surveyed azimuth using a declination station. A declination station should be established at a place that is convenient to using units. It may be established by a target acquisition platoon survey team. The ideal declination station should have known grid azimuths to four prominent features (for example, a church steeple, radio towers, quad markers). Preferably there should be one prominent feature in each quadrant and at least 1,000 meters from the declination station. When time, tactical situation, or lack of prominent features limits operations, azimuth marks can be established (for example, range pole). However, a minimum distance of 300 meters should be used if possible.

8-26. In establishing a declination station, the direction of each azimuth mark may be determined by computing the azimuth (if the coordinates of the declination station and azimuth marks are known), by applying a measured angle to a known direction, by using PADS/IPADS with optical transfer. The theodolite is used in measuring angles to determine the azimuths for the declination station.

8-27. Declination stations should be established in an area free from local magnetic attraction. The following minimum distances from common objects with magnetic attraction are prescribed:

- Power lines and electronic equipment: 150 meters.
- Railroad tracks, artillery, tanks, and vehicles: 75 meters.
- Barbed wire and personal weapons: 10 meters.

8-28. Whenever a declination station is established, the vertical angle to each azimuth mark should be determined. The vertical angle correction for the aiming circle can then be determined at the same time it is being declinated.

8-29. Any SCP with an azimuth mark may be used as a declination station if the area is free from local magnetic attraction.

ESTABLISH A DECLINATION STATION

8-30. When the IPADS or IPADS-G is used to establish a declination station, the criteria for the predetermined site is the same as that described in paragraph 8-21. The preferred procedure, time and tactical situation permitting, is to travel directly from an update point and determine the mean of two azimuths for each azimuth line (as a check) by following normal IPADS or IPADS-G procedures for determining an azimuth. The azimuths should agree within 0.4 mils. To close out the declination station survey, update as soon as possible and record the adjusted data. Record and include measured vertical angles with the declination station data. (The vertical angle is not used with IPADS or IPADS-G but will be used at the declination station to determine a vertical angle correction when the aiming circle is declinated.)

TEAM DUTIES

TEAM CHIEF (SGT, 13T20)

8-31. The IPADS or IPADS-G team chief:

- Advises the supported unit commander on the tactical and technical aspects of the IPADS or IPADS-G team.
- Performs initialization, operation, and PMCS on the IPADS or IPADS-G.
- Sets up and operates the theodolite when used to mark and update or perform optical transfer.

- Directs the assistant IPADS or IPADS-G operator for optical transfer or plumb bob emplacement over the SCP or other points to be established.
- Records IPADS or IPADS-G data and maintains the field notebook, ensuring all entries conform to prescribed format.
- Briefs assistant IPADS or IPADS-G operators and aircraft crew on the survey mission and zero-velocity correction requirements.
- Performs or assists in transferring and strapping down/securing the IPADS or IPADS-G for air assault operations.
- Performs other duties, as directed.

FIELD ARTILLERY SURVEYOR (SPC/PFC, 13T10)

8-32. The assistant IPADS operator:

- Operates and performs maintenance on the IPADS or IPADS-G vehicle as specified in technical manuals and unit maintenance policies.
- Operates and maintains communications equipment.
- Maneuvers vehicle for autoreflexion or plumb bob emplacement over the SCP or points to be established under the direction of the IPADS or IPADS-G operator.
- Sets up range poles and establishes survey stations, as directed by the IPADS operator.
- Assists the IPADS operator in transferring and strapping down/securing the IPADS for air assault operations.
- Assists the IPADS operator in performing all of his duties.
- Performs other duties, as directed.

UNIT MAINTENANCE

8-33. Preventive maintenance begins with the IPADS or IPADS-G operator. Operator maintenance is one of the most critical aspects to maintaining the IPADS or IPADS-G system in a working condition. Operator maintenance includes the following:

- Performing before, during, and after operations checks.
- Performing scheduled PMCS as established in the operator's manual.

8-34. The operator monitors and determines the functionality of IPADS or IPADS-G equipment and performs noncritical preventative maintenance. Preventative maintenance is performed concurrently with system setup and consists primarily of visual checks and cleaning activities.

Chapter 9

Global Positioning System Application and Systems

The satellite signals navigation set AN/PSN-11 Precision Lightweight Global Positioning System Receiver (PLGR) and AN/PSN-13, Defense Advanced Global Positioning System Receiver (DAGR) will provide worldwide position, velocity, and time to the FA surveyor. When survey control is not available and time or the tactical situations preclude using existing survey control, the surveyor can use the AN/PSN-11 or AN/PSN-13 DAGR to establish positioning data.

SECTION I – PRECISION LIGHTWEIGHT GLOBAL POSITIONING SYSTEM RECEIVER

9-1. The AN/PSN-11 PLGR (see figure 9-1) is a receiver. It is used in the GPS, standard positioning system (SPS), and precise position system. (PPS).

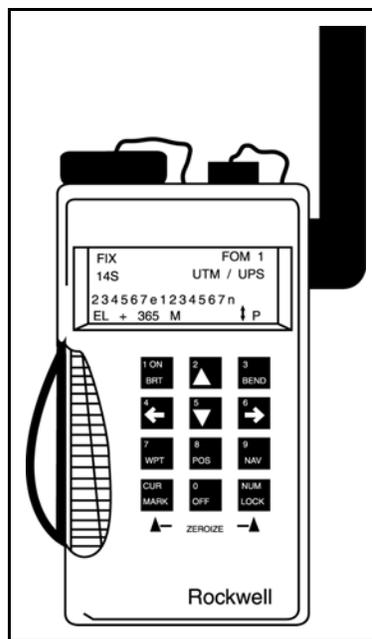


Figure 9-1. AN/PSN-11 Precision Lightweight Global Positioning System Receiver

GLOBAL POSITIONING SYSTEM

9-2. The NAVSTAR GPS is a space-based navigation and positioning system that provides accurate, three-dimensional position and velocity information, and time. The GPS has three major segments as shown in figure 9-2 on page 9-2.

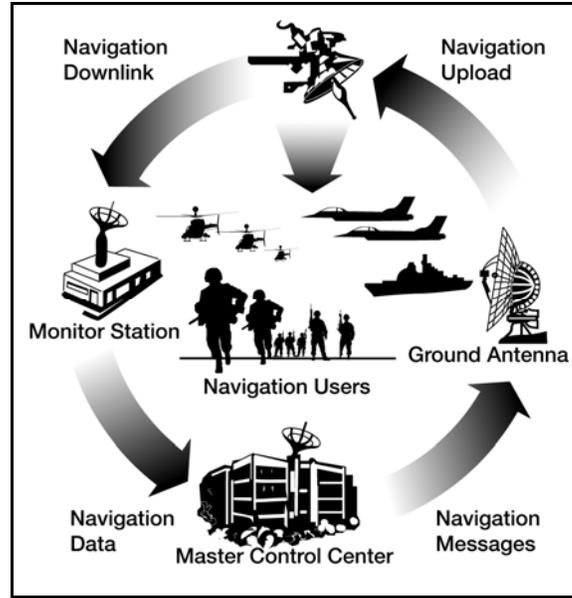


Figure 9-2. Global positioning system

SPACE SEGMENT

9-3. The space segment is made up of a 24-satellite constellation that orbits the earth once every 12 hours. These satellites are deployed in six orbital planes and are configured so that four or more satellites will be in view at all times. This arrangement allows for 24-hour, three-dimensional, worldwide coverage. As with the stars, the satellites rise above the horizon about 4 minutes earlier than the previous day.

CONTROL SEGMENT

9-4. The control segment consists of five passive-tracking monitoring stations, active-tracking ground antennas, and the master control center. These tracking stations, located around the world, are capable of monitoring the satellite navigation messages and time signals better than 90 percent of the time. This information is relayed to the master control center, which has the capability to effect any needed corrections to the satellite timing and navigation messages.

USER SEGMENT

9-5. The user segment consists of navigation receivers designed for marine, aircraft, and man pack or vehicle use. The receivers must have electrical line of site with the satellites to receive and decode the satellite signals. The internal computer uses these satellite data to generate a precise time, velocity, and 3D position data. The receiver must track four satellites to obtain a 3D position, and three satellites will yield a 2D position. Current position coordinates and height are obtained from a 3D position and only current coordinates are obtained from a 2D position. The receiver needs only one satellite for precise time.

STANDARD POSITIONING SYSTEM AND PRECISE POSITIONING SYSTEM

9-6. The standard position system (SPS) is available to all GPS receivers worldwide, both military and civilian. When a receiver is in the SPS mode, almanac, navigation, and timing information are received on the **non-encrypted** course acquisition (CA) code satellite signal. To deny unauthorized users the full accuracy of GPS, the Department of Defense (DOD) intentionally places errors in the navigation and timing signal. This process is called selective availability (SA). The SA errors are unpredictable and can produce significant horizontal and elevation errors. This is one reason why SPS receivers are not authorized for combat operations.

9-7. The satellites also broadcast an encrypted precise (P/Y) code. This transmission is the basis for the PPS that is used by military GPS receivers. These receivers must have crypto keys loaded to detect and nullify the SA errors, which allows for more accurate position data. Also, the crypto keys provide a means of unscrambling the encrypted P/Y code, which is an anti-spoofing (AS) protection. Receivers such as the AN/PSN-11 have this capability and are considered to be precise position system (PPS) receivers. Only PPS receivers are authorized for combat operations.

FIELD ARTILLERY SURVEY APPLICATION

9-8. Each IPADS or IPADS-G team is allocated one each PLGR. FA survey personnel may use the AN/PSN-11 to initiate surveys when existing survey control is not available. This receiver allows the surveyor to begin surveying immediately with more accuracy than assumed data or a map spot. In extreme cases when a PADS/IPADS is not available the surveyor can use two AN/PSN-11s set-up as explained in Table 9-1 to provide position area data. The surveyor will mean the difference in data between the two AN/PSN-11s to obtain the most accurate data.

9-9. A description of all parts, components, and detailed operating procedures for the AN/PSN-11PLGR is in TM 11-5825-291-13. All operators should be thoroughly trained on all functions of the system before using the PLGR. The general PLGR survey positioning and orientation procedures are as follows:

- **Setup.** The setup selections allow the PLGR operator to select several options and modes of operation. (See TM 11-5825-291-13.) An example of a typical setup for artillery surveyors is shown in table 9-1 on page 9-4.

Table 9-1. Example AN/PSN-11 setup

PROMPT	EXPLANATION
SETUP MODE: AVG	The averaging mode is used for static positions. This is the required mode setting for critical positions and IPADS or IPADS-G operations. Averaging produces more stable and accurate coordinates and height. The receiver tracks satellites, updates position data every second, and continuously averages each data set to the previous average.
SV-TYPE: All-Y	The selection for the satellite vehicle (SV) type causes the system to use only the encrypted "Y" code satellite signal, which provides the most protection against jamming and spoofing.
SETUP UNITS: UTM/UPS Metric	Artillery surveyors normally use UTM coordinates for IPADS or IPADS-G and conventional survey operations. The metric selection will cause the PLGR to calculate speed in kilometers per hour and to calculate distance in meters.
ANGL: Mil Grid	Artillery azimuth is normally expressed in mils and referenced to grid north.
SET UP MVAR TYPE: Calc	This selection is only used when calculating a magnetic azimuth with the PLGR. This function is not required with IPADS, IPADS-G, or conventional survey operations. Any type of calculated azimuth determined from a PLGR cannot be used for survey purposes.
SET UP ELHold: Automatic	Elevation hold (ELHold) set to automatic will cause the PLGR to automatically show the elevation as ELHold whenever fewer than four satellites are being observed or the satellite geometry is causing excessive elevation error. Regardless of the figure of merit (FOM) noted on the position screen, do not use elevation values when ELhold is being observed. Only use elevation values associated with an EL on the position screen.
TIME: Zulu	Zulu time will allow for global operations regardless of any local time offset.
ERR: FOM	Figure of merit is a system estimate of position accuracy. FOM 1 or 2 can be used for PAS initialization. Only a FOM 1 can be used for a IPADS or IPADS-G update point or other critical locations.
SET UP DTM: NAS-C	This is where the datum selection is made. It is extremely important that the datum selected be the same as the directed operational datum.
AUTOMATIC OFF TIMER: Off	This setting can cause the system to automatically shut down after a selected time.
SETUP I/O SERIAL: Standard	Used primarily during a PLGR download operation. During system-to-system download, both receivers should be set to standard.
HAVEQUICK: & 1PPS: Off	Used primarily for timing and radio synchronization. Normally set to off.
SET UP AUTOMARK MODE: Off	Can cause the system to automatically activate and mark locations on a timed basis. For normal survey operations, set to off.
<p>Legend: AVG – average DTM – datum EL – elevation FOM – figure of merit I/O – input/output IPADS – Improved Position and Azimuth Determining System IPADS-G – Improved Position and Azimuth Determining System-Global Positioning System NAS-C – North American 1927 Datum PLGR - Precise Lightweight Global Positioning System Receiver PPS – precise position system SV – satellite vehicle UTM/UPS – Universal Transverse Mercator/Universal Polar Stereographic</p>	

- **Position.** Whenever coordinates are being determined for a critical position such as an orienting station, howitzer location, and IPADS or IPADS-G initialization or update point, use extreme care. To meet required accuracy, the system must have crypto keys loaded, be set on the correct

datum, and indicate a FOM 1 before the coordinates will be used. The PLGR with a FOM 1 will meet or exceed an accuracy of 10 meters CEP for horizontal and 10 meters PE for vertical. The averaging mode will yield a more stable and accurate set of coordinates. After the set attains FOM 1, switch to the averaging mode, and allow the counter to increment to at least 300 counts. (This will take about 5 minutes.) Position data should always be checked by a second independent mean; for example, a second receiver, an accurate map spot, or the current coordinates on the IPADS or IPADS-G.

- **Height.** The PLGR can determine height (elevation) relative to either the horizontal datum ellipsoid (spheroid) or mean sea level. Both modes of operation can be set for meters or feet as a unit of measurement. Normally, mean sea level and meters will be the preferred selections.
- **Direction.** The **PLGR cannot be used to determine orientation azimuth** for firing positions. As with the IPADS or IPADS-G, azimuth computed between two sets of GPS coordinates will produce erratic results.
- **IPADS or IPADS-G operation.** The PLGR does not require any special installation for IPADS or IPADS-G operation. Position coordinates for initialization or update can be obtained by moving a short distance away from the vehicle and placing the set directly over the desired location. Using the system away from the vehicle will reduce the possibility of antenna masking. When the averaged FOM 1 coordinates have been recorded, move the IPADS or IPADS-G vehicle to the PLGR position. If the PLGR auxiliary antenna is mounted on the vehicle when using IPADS or IPADS-G, the precise GPS vehicle lever arms information (X, Y, and Z) must be entered during system initialization. When using the PLGR during IPADS or IPADS-G operations, only data determined from a FOM 1 will be used.

LIMITATIONS AND CONSIDERATIONS

MASKING

9-10. GPS receivers rely on electronic line of sight with the satellites. Therefore, dense foliage, buildings, mountains, and canyons may mask the signal. The PLGR will initially select satellites that are 10 degrees or more above the **true** horizon. If usable satellites are not detected, the set will switch to 0 degree until satellite acquisition. After acquisition, the set will switch to 5 degrees above the horizon for normal operation. If enough satellites cannot be acquired, the receiver must be moved to a more suitable location.

JAMMING

9-11. The AN/PSN-11 is subject to jamming. When low signal to noise ratios are detected or reception is blocked altogether, jamming may be the cause. Move to a new location, and try to place something between the receiver and the suspected jammer. When the signal to noise ratio is above 34 decibels (db), jamming has probably been eliminated.

SPOOFING

9-12. The PLGR may be subject to spoofing errors. These errors are caused by false satellite signals designed to generate errors in navigation and position data. Maximum protection against spoofing is attained by using the crypto keys and the All-Y setup selection. If the PLGR is in a spoofing environment, the system may sense spoofer activity and generate a POSSIBLE SPOOFERS warning screen.

TEMPERATURE

9-13. The PLGR operating range is -4°F to +158°F. When operating in cold regions, protect the receiver by carrying it inside your outer clothing or operating it from a heated vehicle and using the auxiliary antenna.

POWER

9-14. The PLGR will normally be operated by using either a BA5800/U lithium battery or 24-volt vehicle power. Operating in the continuous mode, the battery will provide adequate power for about 15 hours at 71°F. During extended missions, spare batteries must be readily available. Using vehicle power eliminates this problem; however, the correct polarity must be observed to prevent damage to the system.

WARNING

Remove lithium batteries from AN/PSN-11 PLGR before connecting it to external power. (The AN/PSN-11 PLGR could explode and injure Soldiers or damage equipment.)

SECTION II – DEFENSE ADVANCED GLOBAL POSITIONING SYSTEM RECEIVER AN/PSN-13

9-15. The DAGR is a handheld or host platform mounted unit that receives and decodes RF signals from satellites to provide PVT (position, velocity [ground speed], and time) position reporting, and navigation capabilities. The DAGR's primary function is to navigate through terrain using stored waypoint position information. Crypto keys may be loaded into the DAGR for increased PVT accuracy and protection from intentional false or spoofed satellite signals. Mission data can be selectively cleared or zeroized at any time. The DAGR is used in other operations such as waypoint calculations, data transfer, targeting, determining jamming sources, gun laying, and man overboard.

NAVSTAR GLOBAL POSITIONING SYSTEM

9-16. The NAVSTAR GPS is a space-based navigation and timing system. It provides highly accurate, continuous, all weather, 3D PVT. A constellation of satellites transmit radio frequency (RF) signals for use by navigation sets. Each signal is modulated with a unique code sequence and navigation data message. The code sequence allows the navigation sets to identify each satellite. The navigation data message provides the navigation set information about the operation of each satellite. The navigation sets receive the signals and compute PVT. GPS receiver provides precision guidance capabilities for vehicular, hand-held, sensor, and gun laying applications. The DAGR offers the smallest and lowest weight hand-held receiver, with an easy-to-use man-machine interface (Graphical User Interface [GUI] and moving maps) and a proven design that passes environmental, serial port, and software testing for a low risk, field-ready unit.

9-17. The GPS structure is made up of multiple satellites, a ground control system, and any number of navigation sets. The satellites orbit the earth while the ground control acts as a monitor and control center for the satellites. The navigation sets are receivers that can be installed in a host platform or carried by personnel.

9-18. Satellites provide navigation data to the navigation set. The satellites are arranged in six rings that orbit the earth twice a day. This arrangement provides worldwide, continuous coverage.

9-19. The Ground Control System tracks the satellites, checks and controls satellite orbits, and updates the satellite navigation data message. The ground control system consists of monitor stations and a control center. Monitor stations are unmanned stations located throughout the world. They use special GPS receivers to track each satellite. The tracking information is sent to the control center where it is used to calculate precise satellite position and satellite clock error for each individual satellite. This data is called ephemeris data. The control center calculates satellite position for all satellites, called almanac data. Once each 24 hours, the control center sends the ephemeris and almanac data to each satellite. This updates the navigation data message broadcast by the satellite.

9-20. The navigation set receives and decodes RF signals from the satellites. This decoded information is used to calculate 3D position, 3D speed, and exact time data. The navigation set is able to track satellites

that are in open view of the sky from the receiver's antenna position, and measures the time it takes for signals to travel from the tracked satellite to the navigation set. By multiplying travel time by the speed of light, the navigation set determines the exact range to each satellite. By calculating the range to four satellites, an exact 3D position is calculated. The navigation set calculates speed by measuring the rate of change of the RF signals.

LOCATION AND DESCRIPTION OF MAJOR COMPONENTS

9-21. Refer to figure 9-3 to identify DAGR physical feature locations. The DAGR uses four external connectors and other physical features as follows:

- J1 provides a serial data I/O port (COM Port 3: crypto key fill, single-channel ground and airborne radio system, and pulse per second).
- J2 provides a serial data I/O port (COM Port 1 and COM Port 2: pulse per second and HAVE QUICK).
- J3 provides an external antenna input.
- J4 provides an external power input.
- Integral antenna.
- Display.
- Keypad.
- Primary battery pack.
- Memory battery and cover.

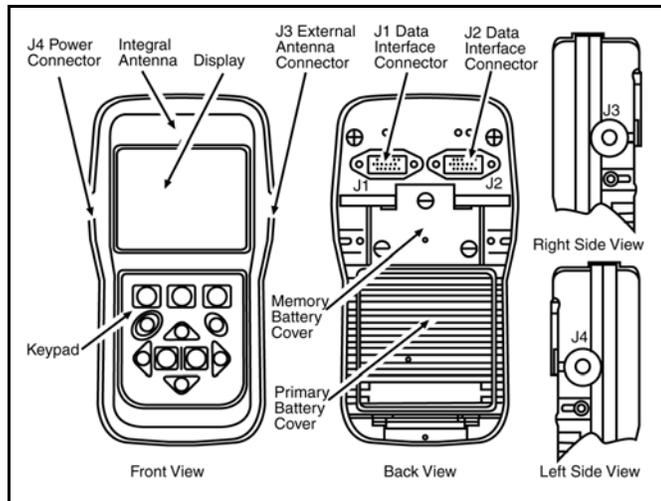


Figure 9-3. Physical features

SELECT OPERATION MODE

9-22. The DAGR mode of operation can be selected from the present position page menu, GPS setup page, SV sky view page menu, or receiver status display menu. The status key can also be used to check current mode of operation information. Continuous is the normal operating mode for external power and fix is the normal initial operating mode when operating on battery power.

- From any display, push and hold the POS key until the present position page is displayed.
- If a field is highlighted, push the QUIT key to un-highlight the field.
- Push the MENU key.
- Highlight Select Op Mode, and then push the ENTER key.
- Highlight the desired operating mode, and then push the ENTER key.

CONTINUOUS

9-23. At the completion of power on, the DAGR transitions to continuous mode if the receiver is connected to external power and is configured to operate as if connected to an unlimited power source (for example, vehicle power) and no self-test failures have been found. When in continuous mode, the DAGR tracks satellites to produce a continuous PVT solution. This mode requires more power than fix or standby modes.

FIX

9-24. At the completion of power on, the DAGR transitions to fix mode momentarily when the receiver is operating on battery power or when connected to external power and configured to operate as if connected to a limited power source and no self-test failures have been found. When in fix mode, the DAGR tracks satellites to produce a current PVT solution. The DAGR automatically transitions to standby mode after a position fix has been obtained. This conserves battery power.

AVERAGE

9-25. Average mode is for survey applications where the DAGR is stationary and must not be moved. Satellite signals are continuously received. This mode is also used to improve performance in very low signal environments (such as under dense foliage) but will not improve performance when the satellite signal is lost (such as being in a cave). The DAGR displays a note to the operator upon entering average mode indicating that the receiver and external antenna (if applicable) must remain stationary (approximately 2 to 4 hours). The DAGR produces more accurate PVT solutions in this stationary position. The DAGR provides an average position and a counter to show the number of position samples used in calculating the position.

DAGR LIMITATIONS AND CONSIDERATIONS

Note. The DAGR antenna must have an unobstructed view of the sky. When using the DAGR internal antenna, the receiver must be held at a 90-degree angle to the horizon for best reception.

MASKING

9-26. When attempting to acquire satellites after the signals have been blocked for a period of time (for example, when exiting a cave) acquisition time may be improved by momentarily cycling the unit to Standby mode and then back to the previous operating mode.

9-27. If expecting to operate in conditions where tracking satellites is not possible (such as entering a cave), the DAGR should be placed in standby mode prior to entering these conditions. When back in unobscured conditions, set the DAGR back to a satellite tracking mode, and the DAGR performs a direct Y-code acquisition (if CV keys are loaded). If the DAGR is left in a satellite tracking mode for a period of 1 hour or more while obscured, the ability to perform direct Y-code reacquisitions may be lost.

9-28. If expecting to operate in conditions where satellite signals are weak (such as dense foliage), the DAGR should be placed in average mode and DAGR should be kept stationary. Do not move DAGR in average mode. When back in unobscured conditions, cycle the DAGR to standby then back to a satellite tracking mode, and the DAGR performs a direct Y-code acquisition (if CV keys are loaded). If the DAGR is left in a satellite tracking mode for a period of 1 hour or more while obscured, the ability to perform direct Y-code reacquisitions may be lost.

TEMPERATURE AND HUMIDITY

9-29. DAGR temperature and humidity ranges are listed below. Anything outside these limits is considered unusual conditions.

- **Operating temperature range.** 32 to +70 °C (-26 to +158 °F).
- **Storage temperature range (without batteries).** 55 to +70 °C (-67 to +158 °F).

- **Humidity range.** 0 to 100 percent.
- **Display heater.** When enabled, turns on at -20 °C.

ALTITUDE

9-30. DAGR altitude ranges:

- **Operating altitude range.** -400 to +9,100 meters (-1312 to +29,848 feet) mean sea level (maximum rate of change for operation is -100 meters [328 feet] per second).
- **Storage altitude range.** -400 to +15,000 meters (-1312 to +49, 200 feet).

DUST AND WATER

9-31. The DAGR is sealed against dust and water to a depth of 1 meter (3 feet) for 20 minutes.

ELECTRONIC WARFARE

9-32. When loaded with crypto keys, the DAGR provides accurate PVT in a spoofing environment; including fast direct-Y acquisition and area navigation functions. No operator action is necessary to initiate anti-jamming.

SPOOFING AND ANTI-SPOOFING

CAUTION

To enable DAGR operation during spoofing, the receiver must be loaded with current crypto keys.

L-band radio transmissions may interfere with DAGR operations.

9-33. Hostile parties may attempt to imitate (spoof) GPS satellite signals to cause errors in navigation and position information. The DAGR employs crypto keys to protect against these attempts. Other than loading crypto keys, no other operator action is necessary to initiate anti-spoofing. Some signals generated by the satellites are encrypted to deny certain users the reception of those signals. This is called antispoofing (A-S). Entering crypto keys allows the DAGR to receive those signals, when available. A selective availability antispoofing module (SAASM) is used for advanced security as well as code types course/acquisition (C/A), precise (P), and encrypted Y code. When operating the DAGR in a secure environment, valid crypto keys are loaded into the receiver for protection from intentionally degraded (spoofing) satellite signals. To improve operation when spoofing occurs, ensure current crypto keys are loaded.

CAUTION

Accidental jamming may occur when operating the DAGR near a tank, dense foliage, or a source of high power electronic emissions. Move away from these sources and verify operation.

DETECTION OF JAMMING

9-34. The DAGR provides multiple methods of detecting jamming as follows:

- **Jammer finder page of the application submenu**—The L1 and L2 frequencies are monitored for signal jamming noise. The direction of the jamming signal is determined by signal strength. The signal azimuth and the DAGR present position are stored as an EW waypoint. Multiple EW waypoints are used to calculate the jammer signal source position.
- **Channel status page of the satellite submenu**—Individual satellite data for active channels is viewed using the channel status page of the satellite submenu. The J/I (jamming or interference)

column of the page indicates if jamming or interference is detected (yes or no). Refer to chapter 13, TM 11-5820-1172-13&P for more information on using the channel status page.

HOW TO IMPROVE OPERATION WHEN JAMMING OCCURS

9-35. Operate the DAGR close to the ground while maintaining a clear view of the sky. Block the jamming signal by placing a barrier (for example, your body) between the DAGR and the source of jamming. The effects of any ground-based signals are minimized. Avoid operating the DAGR near a tank, dense foliage, or a source of high power electronic emissions. Move away from these sources and verify operation. For detailed information on the AN/PSN-13 (DAGR), see TM 11-5820-1172-13&P.

Chapter 10

Conversion and Transformation

Universal Transverse Mercator (UTM) grid zones are 6 degrees wide. There are 60 such zones surrounding the earth. At the equator, each of these zones is about 360 nautical miles wide. When moving north or south from the equator, each zone decreases in width. In the UTM grid system, there are overlap areas east and west of zone junctions. It is very possible that survey operations will take place at the junctions of these zones. It is also probable that missiles and longer-range FA will be required to fire from one zone to another. Since FA operations will span such large areas, survey personnel may have to transform coordinates or azimuth from one zone to another. They may have to convert geographic coordinates to UTM grid coordinates in areas where existing survey is available only in geographic coordinates.

SECTION I – CONVERTING GEOGRAPHIC COORDINATES TO UTM COORDINATES AND UTM COORDINATES TO GEOGRAPHIC COORDINATES

CONVERSION AND TRANSFORMATION WITH THE FORWARD OBESERVER SYSTEM

10-1. Conversion computations depend on the method of computation and the spheroid that is used for a particular locality. To determine the spheroid for a particular locality, refer to local trigonometric lists, maps, or higher headquarters.

10-2. The FOS survey transformation and conversion function allows the operator to perform various types of coordinate conversions and datum-to-datum transformations. The options are selected from the transformation menu.

COORDINATE CONVERSION

10-3. Three types of coordinate conversion may be performed by the FOS. They are GEO to UTM coordinate, UTM to GEO coordinate, and Zone-to-Zone transformation.

UTM/GEO LISTED DATUM TRANSFORMATION

10-4. Four types of UTM/GEO datum transformations may be performed by the FOS. They are UTM to UTM, UTM to GEO, GEO to UTM, and GEO to GEO.

GAUSS-KRUGER DATUM TRANSFORMATION

10-5. Four types of Gauss-Kruger datum transformations may be performed by the FOS. They are Krassovsky to UTM, UTM to Krassovsky, Bessel to UTM, and UTM to Bessel.

USER-DEFINED DATUM TRANSFORMATION

10-6. Three types of user-defined datum transformations may be performed by the FOS. They are user defined to user defined, user defined to listed, and listed to user defined.

SUMMARY LIST

10-7. When one of the above options is selected from the transformation menu, the associated summary list is displayed. From this list, the operator may select a record for review and edit, create a new record by selecting a blank record, or delete all records from the list. Additional screen prompts may be provided to print forms and to display additional lists or information.

COORDINATE CONVERSION, TRANSFORMATION, AND SOLUTION DISPLAYS

10-8. When a listed record without a solution is selected from the summary list, only the associated record is displayed. If the selected record has a calculated solution, the solution record is displayed. Depending on the type of record or solution displayed, one or more screen prompts may be provided. For record displays, prompts to calculate a solution, access the survey point file, and delete the record are included on the screen. For solution displays, prompts to delete the record, show input data, add the calculated survey point to the survey point file, and scan other solution records are included on the solution screen.

CONVERSION OF GEO COORDINATES TO UTM COORDINATES COMPUTATION

10-9. The FOS is the primary means of conversion computations. To create a record in the coordinate conversion file, do the following:

- Display a record.
- Display the SURVEY MODE MENU.
- Select the TRANSFORMATION MENU.
- Press the <A> key to select COORDINATE CONVERSION. Observe the COORDINATE CONVERSION SUMMARY LIST.
- To create a record, press the letter key corresponding to a blank record in the COORDINATE CONVERSION SUMMARY LIST. Observe the COORDINATE CONVERSION display.
- To manually enter information in the display, press the **Enter/Return** key to display the first field of the message format. Refer to TB 11-7021-228-10-1, for field descriptions and legal entries.
- The following fields are required: CONVERSION TYPE, ELLIPSOID, and GRID ZONE.
 - If the entry in CONVERSION TYPE is UTM TO GEO COORD, the EASTING, NORTHING, and HEMISPHERE fields are required.
 - If the entry in CONVERSION TYPE is GEO TO UTM COORD, the LATITUDE and LONGITUDE fields are required.
 - If the entry in CONVERSION TYPE is ZONE TO ZONE, the EASTING, NORTHING, HEMISPHERE, AZIMUTH, and ENDING GRID ZONE fields are required.
- Enter other fields as needed.
- Press the **Enter/ Return** key to toggle off the edit mode and to review the message.
- Observe the prompt <C> = CALCULATE at the bottom of the screen. Press the <C> key to calculate the solution. Observe the COORDINATE CONVERSION SOLUTION display.
- To print a survey form (DA Form 7368-R) of an existing record, press the <F> key.
- Select the letter key for the desired record. One of the following is printed depending on the type of coordinate conversion in the record:
 - UTM to GEO Coordinate.
 - GEO to UTM.
 - Zone-to-Zone Transformation.

CONVERSION OF UTM COORDINATES TO GEO COORDINATES COMPUTATION

10-10. The FOS program converts UTM coordinates to geographic coordinates. The survey control point file can be accessed from this calculation. See TB 11-7021-228-10-1, for step-by-step procedures.

SECTION II – ZONE-TO-ZONE TRANSFORMATIONS

10-11. The FOS program also creates a record for zone-to-zone transformation, transforms UTM grid coordinates and azimuth from one grid zone into terms of an adjacent grid zone. The survey control point file can be accessed from this calculation. See TB 11-7021-228-10-1, for step-by-step procedures.

SECTION III – DATUM-TO-DATUM TRANSFORMATIONS

10-12. A datum is a point, a line, or surface used as a reference in surveying and mapping. A *datum* (*geodetic*) is a mathematical model of the earth used to calculate the coordinates on any map (JP 2-03).

10-13. The main problem warfighters face is that many countries use their own datum when making their maps and doing their survey. These are referred to as local datum. The same area may have two datum giving each point two different coordinates. In addition, datum generated by individual countries does not match at their boundaries.

10-14. The FOS device provides a means of transforming coordinates referenced to one datum into coordinates referenced to a different datum.

10-15. For the survey operational mode only, the survey transformation and conversion function allows the operator to perform various types of coordinate conversions and datum-to-datum transformations. The options are selected from the transformation menu. See TB 11-7021-228-10-1, for step-by-step procedures.

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Appendix A

Example Survey Standard Operating Procedures

A-1. Figure A-1 is an example of a survey SOP.

<p>1. REFERENCES</p> <p>A. ATP 3-09.50, <i>Field Artillery Cannon Battery</i>.</p> <p>B. ATP 3-09.02, <i>Field Artillery Survey</i>.</p> <p>C. ATP 3-09.30, <i>Observed Fire</i>.</p> <p>D. ATTP 3-21.90, <i>Tactical Employment of Mortars</i>.</p> <p>2. MISSION: The mission of FA survey is to provide a common grid that will permit the massing of fires, delivery of surprise observed fires, delivery of effective unobserved fires, and transmission of target data from one unit to another to aggressively neutralize or destroy enemy targets. The establishment of a common grid and the single operational datum within the common grid is a command responsibility.</p> <p>3. PRINCIPAL DUTIES AND RESPONSIBILITIES OF KEY PERSONNEL</p> <p>A. Chief Surveyor</p> <ol style="list-style-type: none">1) Advises the commander on survey capabilities.2) Formulates, implements, and supervises the execution of the survey plan.3) Prepares, organizes, and schedules the survey teams.4) Directs collection, evaluation, and dissemination of FA survey information.5) Coordinates survey operations with other units and maintains survey data bases, maps, and overlays.6) Verifies all survey data. <p>B. IPADS or IPADS-G Team Chief</p> <ol style="list-style-type: none">1) Supervises and coordinates IPADS or IPADS-G vehicle operations.2) Operates IPADS or IPADS-G: Prepares IPADS or IPADS-G for operations, performs calibrations, zero velocity updates, and PMCS, computes survey data, plots geographic/UTM grid coordinates, and performs optical transfer with IPADS or IPADS-G.3) Operates Nikon NE-102 Theodolite: Prepares theodolite for operation, performs set-up, measures angles, performs PMCS, and march-orders theodolite.4) Supervises and checks the recorded and measured survey data in the Level, Transit, and General Survey Record Book (Recorder's Notebook).5) Responsible for the accuracy of survey data in the Recorder's Notebook and the transfer of data to the IPADS or IPADS-G.6) Assists the Chief in the collection, evaluation, and dissemination of survey information. <p>C. FA Surveyor and Vehicle Operator</p> <ol style="list-style-type: none">1) Assists IPADS or IPADS-G Team Chief with the transfer, strap down, and preparation for operation of the IPADS or IPADS-G.2) Records and means survey data and prepares schematic sketches.3) Prepares and marks all survey stations.4) Operates and performs PMCS on IPADS or IPADS-G vehicle and radios.
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Figure A-1. Example survey standard operating procedures

4. PRE-COMBAT CHECKS AND PRE-COMBAT INSPECTIONS	
Individual Equipment	CHECK
Ruck Sack packed IAW TACSOP	
IOTV complete IAW TACSOP	
Camelbak	
IFAK	
Ammunition pouches (3)	
Grenade pouches (2)	
Canteen pouches (2)	
Ear plugs	
Kevlar with cover/band/rhino mount/goggles	
Knee Pads	
Gloves	
Flashlight with batteries and lens filters	
ID Card	
ID Tags worn	
Military Driver's License	
Weapon	
NVGs	
Survey Equipment	
Coordinate pick-up of DAGR, PLGR, CDU	
CDU for IPADS or IPADS-G	
DAGR	
IPADS or IPADS-G PMCS complete	
Nikon NE-102 Theodolite	
Tripod	
Survey bag complete	
Hubs	
Survey tags	
Black permanent marker	
Red survey tape	
OS Identification stakes (short)	
EOL stakes (long)	
Sledgehammer	
Recorder's notebook	
Pencils (3H or harder)	
Fort Drum Map	
Trig list	
IPADS or IPADS-G Technical manual	
Plumb bob	
Vehicle plumb bob bracket	
Survey Communications Equipment	
Coordinate pick-up of VAA/Radio (1)	
Coordinate pick-up of SOI	

Figure A-1. Example survey standard operating procedures (continued)

Survey Communications Equipment	
Radio (PMCS complete)	
Vehicle antenna	
W2 Cable (short)	
VAA	
Handset	
Communication card	
Frequencies loaded in radio IAW mission	
Radio checks complete	
Spare equipment	
Handset	
Vehicle antenna	
W2 cable	
Driver/Vehicle Preparation	
Vehicle BII present and serviceable	
First aid kit	
Warning triangles	
Fire extinguisher	
TM 9-2320-280-10	
Pamphlet bag	
Tool Bag with tools (complete)	
Ax	
Jack kit (complete)	
Max tool kit OR Pioneer kit (Complete)	
Lug wrench	
Dispatch folder	
Vehicle dispatched	
Dispatch	
SF 91 (2) (Motor Vehicle Accident Report)	
DD Form 518 (2) (Accident Identification Card)	
QA and QC checklist complete	
5 gallon water can (filled)	
5 gallon fuel can (filled)	
Vehicle fuel above ¼ tank	
Vehicle PMCS complete	
Vehicle loaded IAW load plan	
Trailer properly hooked	
Trailer Preparation	
Trailer loaded IAW load plan	
Tents	
Cots	
Heater	
Extension cords	
Camouflage nets/poles	
Fuel cans	

Figure A-1. Example survey standard operating procedures (continued)

Water cans	
Lights	
MREs	
Chem lights	
Personal bags	
Survey Team Leader	
Coordinate pick-up of MREs	
Coordinate meal plan	
PCI complete	
Vehicle and trailer load plan verified	
Issue ammunition	
Review reference publications	
Receive Survey Order	
Read and understand Survey Order	
Personnel accounted for	
Brief Survey Order	
Convoy brief	
Radio checks complete	
Sensitive items accounted for	
Map and overlays read and understood	
Coordinate link-up with supported element	

5. PRIORITIES OF SURVEY: The Battalion S-3 will determine all priorities of survey support. The priorities will be addressed in the Survey Order. When a priority is not established, the Survey Team will use the following priority of survey:

- A. Radar directional and positional control.
- B. Firing Battery and Platoon directional control.
- C. Firing Battery and Platoon positional control.
- D. Alternate firing Battery and Platoon directional control.
- E. Alternate firing Battery and Platoon positional control.
- F. FIST directional control.
- G. FIST positional control.
- H. Mortars directional control.
- I. Mortars positional control.

6. ACCEPTABLE METHODS OF SURVEY

- A. All survey data must have a second independent verification. For example, a GLPS can be used to lay the Firing Battery. However, an IPADS or IPADS-G or declinated aiming circle must be used to validate and verify common survey before a round can be fired.
- B. The GLPS will never be used to establish a declination station. The telescope's minimal range of elevation does not meet the specifications for establishing a declination station.
- C. Directional Control.
 - 1) Primary: IPADS or IPADS-G.
 - 2) Secondary: GLPS or Dual DAGR.
 - 3) Tertiary: Astronomic or simultaneous observation.
- D. Positional Control.
 - 1) Primary: IPADS or IPADS-G.
 - 2) Secondary: DAGR with Figure of Merit (FOM) 1 accuracy or Directional Traverse with aiming circle.

Figure A-1. Example survey standard operating procedures (continued)

- E. The Nikon NE-102 Theodolite, through optical transfer with the IPADS or IPADS-G, will be used to determine an azimuth to an azimuth mark (DAP) over 1000 Meters away (for example, establishing a declination station).
 - F. The Nikon NE-102 Theodolite will be used to determine all vertical angle requirements (for example, establishing a declination station, Q-36 Radar Boresight Reference Point).
7. PROVIDING SURVEY SUPPORT
- A. Firing battery, platoon, section locations
 - 1) The coordinates and height (Easting, Northing, Altitude) of the Orienting Station (OS) and a line of known direction (Azimuth from OS to EOL) is required.
 - 2) Time permitting, a survey team will precede or accompany firing platoon advance parties in their reconnaissance of positions.
 - 3) Survey Teams will use the IPADS or IPADS-G and conduct a two-position mark in order to establish an OS/EOL.
 - 4) If required, Survey Teams will use the IPADS or IPADS-G and conduct a one-position mark in order to establish a battery or platoon area SCP.
 - B. Radar Locations
 - 1) The coordinates and height of the Radar location, a line of known direction to an azimuth mark, and the distance and vertical angle from the Radar location to the azimuth mark is required.
 - 2) Survey Teams will use the IPADS or IPADS-G and conduct a two-position mark in order to establish the coordinates and height of the Radar location and the distance (at least 200 meters) and direction to an azimuth mark.
 - 3) Survey Teams will plumb the Nikon NE-102 Theodolite over the Radar location hub and determine the vertical angle to the azimuth mark. The aim point (top left corner of the wooden stake) will be identified to the Radar Technician.
 - C. Meteorological Sites
 - 1) The coordinates and height of the Profiler location is required.
 - 2) Survey Teams will use the IPADS or IPADS-G and conduct a one-position mark in order to provide easting, northing, and altitude.
 - D. FIST (LLDR)
 - 1) The coordinates and height of the OS and a line of known direction (Azimuth from OS to EOL) is required.
 - 2) Survey Teams will use the IPADS or IPADS-G and conduct a two-position mark in order to establish an OS and EOL.
 - 3) If a two-position mark with the IPADS or IPADS-G is not feasible, directional and positional control will be established through use of the Nikon NE-102 theodolite by performing optical transfer. A distance will not be determined to the EOL.
 - E. Mortar Firing Points
 - 1) The coordinates and height of the OS and a line of known direction (Azimuth from OS to EOL) is required.
 - 2) Survey Teams will use the IPADS or IPADS-G and conduct a two-position mark in order to establish an OS and EOL.
8. SPECIFICATIONS AND TECHNIQUES.

Figure A-1. Example survey standard operating procedures (continued)

- A. Recording techniques
- 1) All survey missions will be recorded in the "Level, Transit, and General Survey Record Book" (Recorder's Note Book).
 - 2) All lettering and symbols will be made IAW the Battalion standards found on Page 2, "Sample Lettering and Symbols", in the Recorder's Note Book.
 - 3) All entries in the Recorder's Note Book will be made IAW the Battalion standards found on Pages 3-4 in the Recorder's Note Book.
- B. Nikon NE-102 Theodolite Operations
- 1) Manner of measuring angles:
 - a) All vertical angles measured to range poles or EOL and far stakes will be made to the top left corner.
 - b) All horizontal angles measured to range poles or EOL and far stakes will be made to where the ground and the bottom left corner meet.
 - c) All vertical and horizontal angles measured to DAPs will be to the same aim point at the top left corner of the highest visible point.
 - 2) Minimum closure for angles (Nikon NE-102 Theodolite).
 - a) Fourth Order (0.02 mil readings): Angles must agree within 0.15 mils.
 - b) Fifth Order (0.05 mil readings): Angles must agree within 0.30 mils.
- C. IPADS Operations
- 1) General: Survey support provided to any (insert unit name here) element will be within 5th Order accuracy standards at a minimum. If time permits, survey support will be provided within 4th Order accuracy standards. The Chief Surveyor will determine accuracy requirements for every survey mission.
 - 2) Naming Convention
 - a) All points entered in the IPADS or IPADS-G will match the names written in the Recorder's Notebook.
 - b) When establishing an SCP, OS, or Near Stake (NS), the occupied position will be named as follows:
 - (1) When providing survey support to Radar, the name will be Radar NS (Near Stake) – (Training Area). Example: **RDRNS15B**.
 - (2) When providing survey support to Howitzers, the name will be OS – (Platoon) – (Battery) – (Training Area). Example: **OS1B8B**.
 - (3) When providing survey support to FIST, the name will be OS – (Unit) F – (Training Area). Example: **OS2-14FOP5**.
 - (4) When providing survey support to Mortars, the name will be OS – (Unit) M – (Training Area). Example: **OS2-14MOP5**.
 - c) When conducting a two-position mark or determining an azimuth with the theodolite, the forward station (EOL, AZMK, or FS) will be named in the IPADS or IPADS-G, without spaces, as follows:
 - (1) When providing survey support to Radar, the name will be Radar FS (Far Stake) – (Training Area). Example: **RDRFS15B**.
 - (2) When providing survey support to Howitzers, the name will be E – (Platoon) – (Battery) – (Training Area). Example: **E1B8B**.

Figure A-1. Example survey standard operating procedures (continued)

- (3) When providing survey support to FIST, the name will be E – (Unit) F – (Training Area). Example: **E214FOP4**.
 - (4) When providing survey support to Mortars, the name will be E – (Unit) M – (Training Area). Example: **E214MOP5**.
- 3) Required degrees of accuracy
- a) Cannon Artillery (105mm): Azimuth (orientation) within 0.40 mils, position within 10 meters, elevation (vertical) within 10 meters.
 - b) Radar: Azimuth (orientation) within 0.40 mils, position within 10 meters, elevation (vertical) within 3 meters.
 - c) FIST (LLDR): Azimuth (orientation) within 2.0 mils, position within 30 meters, elevation (vertical) within 20 meters.
- 4) Minimum closure
- a) IPADS or IPADS-G, upon closure of a survey mission by updating on a known point, will determine if the current survey mission was within the desired accuracy. If not, the IPADS or IPADS-G will display an update error. Operator will use procedures in TM 9-6675-349-13&P to troubleshoot the update error.
 - b) An "E" in any location on an IPADS or IPADS-G PAE (Position, Azimuth, Elevation) Code indicates the data for that PAE code location may not meet accuracy requirements and should not be used.
 - (1) An "E" in Position and Altitude indicates the radial or total distance traveled limit was exceeded or the travel time between ZUPTs was exceeded. The STATUS page will identify the cause.
 - (a) If exceeding the 4TH order ZUPT interval caused the error indication, the operator may elect to switch to 5TH order survey if the reduced accuracy is acceptable for the mission.
 - (b) Accuracy can be restored by performing a position update at a known SCP.
 - (2) An "E" in azimuth of a 2-position azimuth mark indicates the distance between points was not at least 100 meters or the travel time between points was too long.
 - (a) This can be corrected by deleting the point from POINT LIST and repeating the mark.
 - (b) The IPADS or IPADS-G will not adjust the azimuth of a two position mark upon updating.
- D. Station marking techniques
- 1) Orienting Station (OS)/SCP/Near Stake (NS).
- a) A .50 caliber brass hub flush with the ground will be used as the OS.
 - b) The OS location will be marked with a wooden, 2 – 3 foot ID stake positioned at a 45 degree angle toward the OS. The stake will be positioned so that it is pointed towards the EOL for ease in locating the EOL.
 - c) Red engineer tape with 1 foot tails will be tied around the ID stake.
 - d) A survey tag will be tied to the ID stake with the following information:
 - (1) Front of Tag:|

Figure A-1. Example survey standard operating procedures (continued)

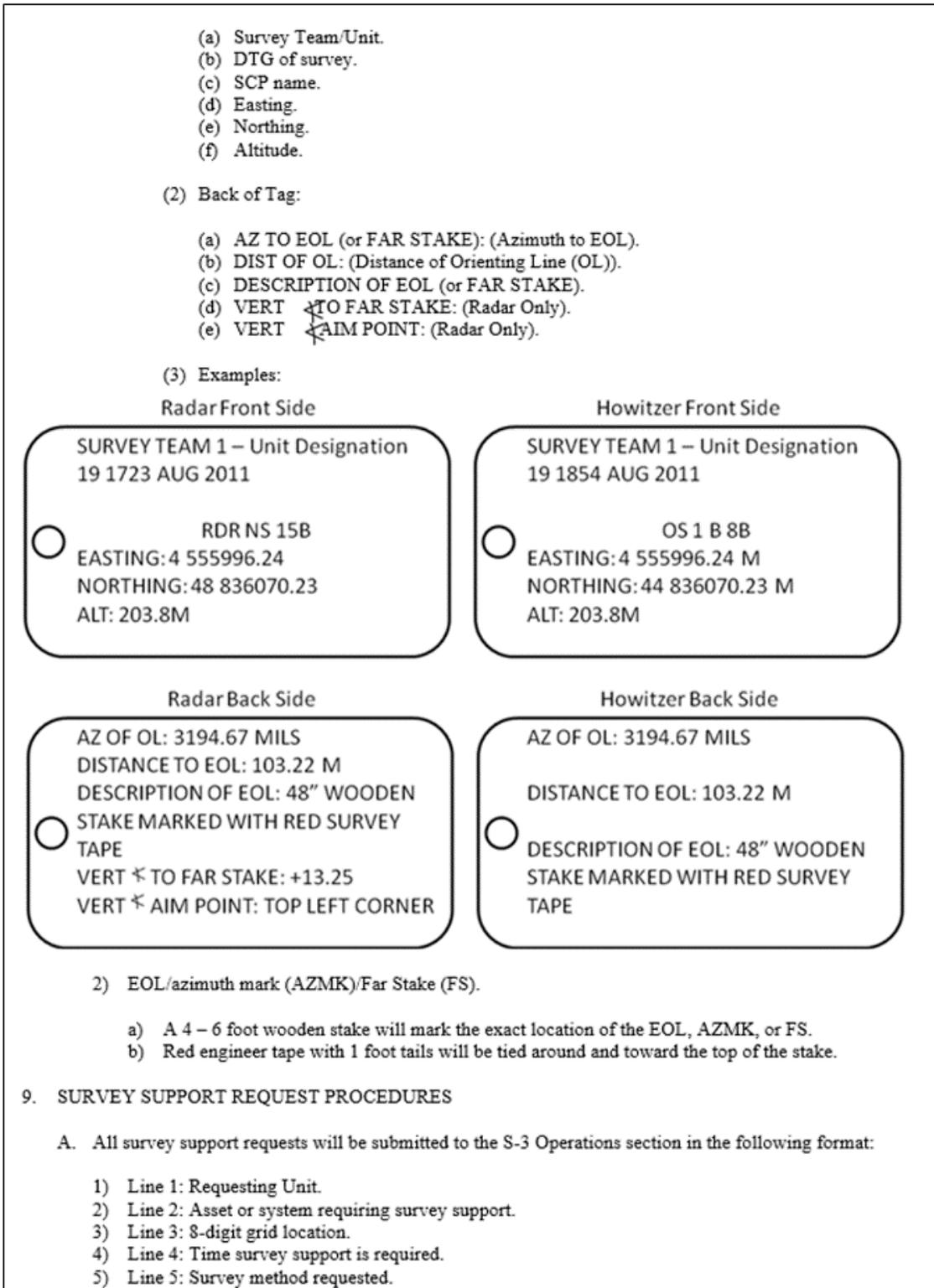


Figure A-1. Example survey standard operating procedures (continued)

- B. The S-3 Battle Captain will forward the request to the Chief Surveyor who will publish and push a survey order to the Target Acquisition Platoon.
- C. All survey support requests will be submitted NLT 12 hours prior to time survey support is required.

10. SUPPLY AND MAINTENANCE INFORMATION.

- A. Supply procedures: All requests to replenish any class of supplies will be made through the Target Acquisition Platoon Sergeant.
- B. Stock levels.

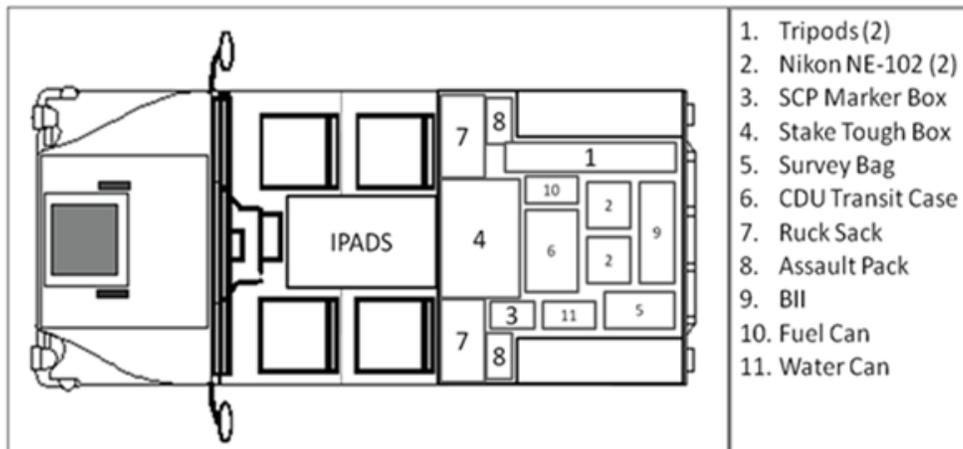
1) Survey Bag.

- a) 3H Pencils: 5.
- b) Survey Tags: 50.
- c) Black, Permanent, Fine-tip Markers: 5.
- d) Rolls of Survey Tape (Red): 5.
- e) .50 cal brass hubs: 30.
- f) Brass plumb bob: 1.

2) Stake Tough Box.

- a) 3H Pencils: 1 Box.
- b) Survey Tags: 200.
- c) Black, Permanent, Fine-tip Markers: 5.
- d) Rolls of Survey Tape (Red): 10.
- e) .50 cal brass hubs: 30.
- f) 24-36" wooden OS identification stakes: 20.
- g) 36-48" wooden EOL marking stakes: 20.

C. HMMWV Load Plan:



D. Maintenance Responsibilities:

- 1) The Survey Team Leader will conduct PMCS on the IPADS or IPADS-G IAW TM 9-6675-349-13&P (Operator and Field Maintenance Manual Including Repair Parts and Special Tools List for Surveying Instrument Azimuth: Improved Position and Azimuth Determining System [IPADS]).

Figure A-1. Example survey standard operating procedures (continued)

<p>2) The Survey Team Leader will conduct maintenance on the Nikon NE-102 Theodolite IAW Pages 4 – 5, Nikon Electronic Digital Theodolite NE-102 Instruction Manual.</p> <p>3) The Survey Team Vehicle Operator will conduct PMCS on their M1097 HMMWVs IAW TM 9-2320-280-10, Operator’s Manual for [HMMWVs].</p> <p>11. The point of contact for this memorandum is the Battalion Chief Surveyor, SSG name, at xxx-xxxx.</p> <p style="text-align: center;">Commanders Name Rank, FA Commanding</p>
<p>Legend: ATP – Army techniques publication ATTP – Army tactics, techniques, and procedures ALT – altitude AZ – azimuth AZMK – azimuth mark BII – basic issue item CAL - caliber CDU - control and display unit DAGR - Defense Advanced Global Positioning System Receiver DAP – distant aiming point DD – Department of Defense DIST – distance DTG – date time group EOL – end of orienting line FA – field artillery FIST – fire support team FOM – figure of merit FS – far stake GLPS – gun laying and positioning system HMMWV – high mobility multipurpose wheeled vehicle IAW – in accordance with ID – identification IFAK – individual first aid kit IOTV – improved outer tactical vest IPADS - Improved Position Azimuth Determining System IPADS-G - Improved Position Azimuth Determining System-Global Positioning System LLDR – lightweight laser designator rangefinder M - meters MRE – meal, ready to eat NLT – no later than NS – near stake NVG – night vision goggles OL – orienting line OS – orienting station PCI – pre-combat inspection PLGR - Precise Lightweight Global Positioning System Receiver PMCS – preventative maintenance checks and services QA – quality assurance QC – quality control RDR - radar S-3 – operations staff officer SCP – survey control point SF – standard form SOI – signal operating instructions SSG – staff sergeant TACSOP – tactical standard operating procedures TM – technical manual UTM – Universal Transverse Mercator VAA – vehicle amplifier adapter VERT - vertical</p>

Figure A-1. Example survey standard operating procedures (continued)

Appendix B

Survey Standards and Specifications

The U.S. government makes nationwide surveys, maps, and charts of various kinds that must be referenced to national datum. These are necessary for the conduct of public business, for national defense, and for development of the country.

GEODETIC CONTROL SURVEYS

B-1. Geodetic surveys, executed with high precision, are used to control mapping and charting operations and engineering projects. The terms geodetic survey and control survey are almost interchangeable.

B-2. Control surveys are of two types—horizontal and vertical. Horizontal control surveys determine latitudes and longitudes referenced to a national datum and provide the basis for rectangular coordinate systems. Horizontal geodetic surveys are adjusted to the mathematical figure of the earth applicable to the national datum. Vertical control surveys determine elevations to a national datum that has been referenced to tidal measurements. Vertical geodetic surveys are adjusted with respect to the geoid. These surveys provide permanently marked and properly described stations.

B-3. Horizontal control is established by triangulation, trilateration, and traverse procedures. Vertical control is established by leveling of a high order of accuracy.

B-4. The classifications and standards of geodetic control surveys in the United States are issued by the Federal Geodetic Control Committee (FGCC) under the authority of the Office of Management and Budget (OMB). The specifications are published in a document titled *Classification, Standards of Accuracy and General Specifications of Geodetic Control Surveys* and in a supporting document titled *Specifications to Support Classifications, Standards of Accuracy, and General Specifications of Geodetic Control Surveys*. Both documents are published by and can be obtained from the National Geodetic Survey Division, National Oceanic and Atmospheric Administration (NOAA), Rockville, Maryland 20852.

FA CONTROL SURVEYS

B-5. FA control surveys are performed to fourth- and fifth-order specifications as described below.

- Fourth-order survey—an FA survey performed to an accuracy of 1 unit of error in 3,000 similar units of survey. It usually is written 1:3,000.
- Fourth-order azimuth—an azimuth of a line used in the extension of fourth-order survey that has depreciated in accuracy by a PE value of 0.030 mil per main scheme angle, or it is the azimuth of a line determined by computation between a fourth-order SCP and an SCP of equal or higher order. In the latter case, considered accuracy for FA survey is 0.300 mil.
- Fifth-order survey—an FA survey performed to an accuracy of a maximum of 1 unit of error in 1,000 similar units of survey. It usually is written 1:1,000.
- Fifth-order azimuth—an azimuth of a line used in the extension of fifth-order survey which (from its point of origin) has depreciated in accuracy by a PE value of 0.09 mil per main scheme angle. A fifth-order azimuth cannot be obtained by computation between a fifth-order SCP and an SCP of equal or higher order.

B-6. The specifications presented in table B-1 (on page B-2) are the permissible tolerances allowed to ensure that the overall standards for fourth- and fifth-order surveys are achieved. The specifications apply for determining a 1:500 azimuth. If direction is not extended from the line established by observation, the rejection limit can be relaxed to 1.0 mil with a considered accuracy of 1.0 mil.

Note. In table B-1, D/R means direct/reverse, N represents the number of main scheme angles used to carry azimuth, and K represents the total main scheme distance surveyed to the nearest 0.1 kilometer. When a computer or calculator is used, angles and distances may be used in computations to the nearest 0.001. Table B-1 is for reference purposes only.

Table B-1. Astronomic azimuth survey specifications

REQUIREMENT	FOURTH ORDER	FIFTH ORDER
Minimum number of sets observed	3	3
rejection limit	0.150 mil	0.3 mil
Minimum number of sets remaining after rejection	2	2
Horizontal angles: • Measured • Recorded to	One position 0.001 mil	One position 0.1 mil
Vertical angles: • Measured • Recorded to	1 D/R 0.001 mil	1 D/R 0.1 mil
considered accuracy	0.150 mil	0.3 mil
Legend: D/R – direct/reverse		

Appendix C

Ellipsoids and Datums

To permit the delivery of accurate FA fires without adjustment and the massing of fires of two or more artillery units, all firing and target-locating element must be located and oriented with respect to a single ellipsoid, datum plane or grid, known as the common grid or control.

ELLIPSOIDS

C-1. Table C-1 is a list of ellipsoids and their parameters. This is not a list of all ellipsoids; however, it is the most complete one-table list of ellipsoids and their parameters available to artillery surveyors. The semimajor axis (a) and flattening (1/f) are listed when available. Semiminor axis must be computed by the user with the formula $b = a(1 - f)$ (see figure C-1 on page C-2).

Table C-1. Reference ellipsoid names and constants

<i>Reference Ellipsoid Name</i>	<i>Code</i>	<i>a (meters)</i>	<i>1/f</i>
Airy 1830	AA	6377563.396	299.3249646
Australian National	AN	6378160	298.25
Bessel 1841 Ethiopia, Indonesia, Japan and Korea	BR	6377397.155	299.1528128
Bessel 1841 Namibia	BN	6377483.865	299.1528128
Clarke 1866	CC	6378206.4	294.9786982
Clarke 1880	CD	6378249.145	293.465
Everest Brunei and E. Malaysia (Sabah and Sarawak)	EB	6377298.556	300.8017
Everest India 1830	EA	6377276.345	300.8017
Everest India 1956	EC	6377301.243	300.8017
Everest Pakistan	EF	6377309.613	300.8017
Everest West Malaysia and Singapore 1948	EE	6377304.063	300.8017
Everest West Malaysia 1969	ED	6377295.664	300.8017
Geodetic Reference System 1980	RF	6378137	298.257222101
Helmert 1906	HE	6378200	298.3
Hough 1960	HO	6378270	297
Indonesian 1974	ID	6378160	298.247
International 1924	IN	6378388	297
Krassovsky 1940	KA	6378245	298.3
Modified Airy	AM	6377340.189	299.3249646
Modified Fischer 1960	FA	6378155	298.3
South American 1969	SA	6378160	298.25
World Geodetic System (WGS) 1972	WD	6378135	298.26
World Geodetic System (WGS) 1984	WE	6378137	298.257223563

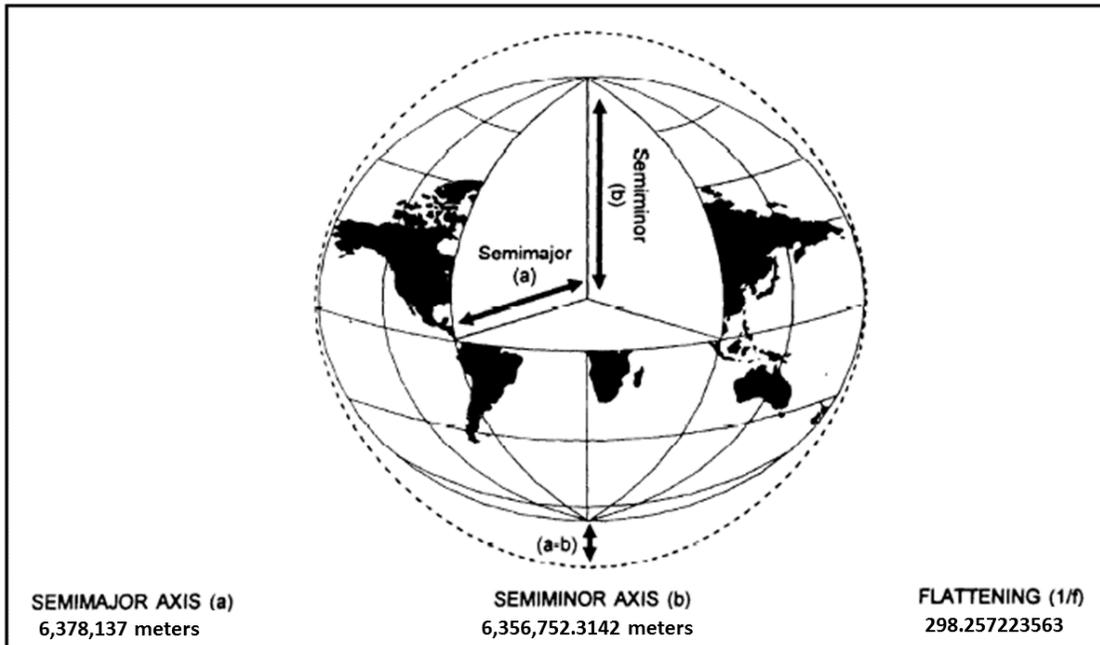


Figure C-1. World geodetic system 1984

DATUMS

C-2. The datum transformation parameters are listed corresponding to the ellipsoid to which they are referenced. The transformation parameters are from the local geodetic datum to World Geodetic System (WGS)-84; therefore, a datum table with WGS-84 will not be published. Also, datum tables for ellipsoids in table C-1 with no listed datums are not published.

C-3. Differences in data published in the above references are explained in the notes section at the end of this appendix.

WORLD GEODETIC SYSTEM

C-4. Because of the large amount of mapping, charting, geodetic, gravimetric, and digital products produced by NGA for DOD, it became apparent that a single geocentric coordinate system was needed to ensure accuracy and user interface. This system must support the widest range of applications. A geocentric system provides a basic reference for the mathematical figure of the earth. It also provides a means for establishing various geodetic datums to an earth-centered, earth-fixed coordinate system. This system is termed World Geodetic System (WGS) (see figure C-1).

C-5. Previously, DOD has adopted three such systems: WGS-60, WGS-66, and WGS-72. With each system proving more accurate than the last, WGS-72 can still be used for some applications. It does, however, have several shortcomings. For example, the WGS-72 Earth Gravitational Model and Geoid are obsolete. Also, more accurate datum shifts from local geodetic datums to a WGS were needed. Several other factors contributed to the need to replace WGS-72. These included the replacement of North American datum (NAD) 27 with NAD 83 and the development of the Australian Geodetic Datum 84. Also, a large increase in data and more advanced types of data (satellite ranging for example) are now available. WGS-84 was developed as the replacement for WGS-72.

C-6. In determining the WGS-84 ellipsoid and its associated parameters, the WGS-84 development committee closely followed the procedures used by the International Union of Geodesy and Geophysics (IUGG) who had already developed the Geodetic Reference System 1980 (GRS-80). Four parameters were used to develop WGS-84: the semimajor axis (a), the earth's gravitational constant, the normalized second degree zonal gravitational constant (C_{20}), and the angular velocity of the earth. All are identical to GRS-80

except that the second degree zonal used is that of the WGS-84 gravitational model instead of the notation J_2 used for GRS-80. Because of that difference, the ellipsoid parameters differ slightly between GRS-80 and WGS-84. These differences are insignificant from a practical application standpoint; therefore, it has been accepted that GRS-80 and WGS-84 are the same and their associated datums are based on the same ellipsoid. Even so, it must be understood that WGS-84 is datum within the WGS-84 ellipsoid, and NAD-83 is a datum referenced to the GRS-80 ellipsoid.

C-7. WGS-84 is the preferred ellipsoid and datum for all mapping, charting, and geodetic products. Some areas of the world can still be covered by other systems.

DATUM TRANSFORMATION TABLES

C-8. Datum transformation tables (figures C-2 on page C-4) include the following information:

- Continent name.
- Local geodetic datum name and code. The datum name as it appears in Defense Mapping Agency (DMA) TR 8350.2. In cases where a datum has more than one name, the second name is listed in parentheses.
- Reference ellipsoids and parameter differences, to include:
 - Ellipsoid name.
 - Δa , which is the difference between the semimajor axes of the local reference ellipsoid and WGS-84.
 - $\Delta f \times 10^4$ which is the difference between the flattening of the local reference ellipsoid and WGS-84 multiplied by 10^4 .

Note. Both Δa and $\Delta f \times 10^4$ are necessary for the user-defined option in the AN/PSN-11 (PLGR) Version V04b.2.

- Transformation parameters, to include:
 - Cycle number. A cycle number of zero indicates that the set of parameters is as it was published in DMA TR 8350.2, Second Edition, 1 September 1991 including Insert 1, 30 August 1993 or that the parameters are new to this edition (1997 Publication Date). A cycle number of one indicates that the current parameters have replaced outdated parameters that were in the previous edition.
 - Publication date.
 - ΔX axis. Intersection of the International Earth Rotation Service Reference Meridian and the plane passing through the origin and normal to the Z-axis.
 - ΔY axis. Completes a right-handed, Earth-Centered Earth-Fixed orthogonal coordinate system.
 - ΔZ axis. The direction of the International Earth Rotation Service Reference Pole. This direction corresponds to the direction of the Bureau International de l'Heure Conventional Terrestrial Pole.

Continent: AFRICA										
Local Geodetic Datums		Reference Ellipsoids and Parameter Differences			No. of Satellite Stations Used	Transformation Parameters				
Name	Code	Name	$\Delta a(m)$	$\Delta f \times 10^4$		Cycle Number	Pub. Date	$\Delta X(m)$	$\Delta Y(m)$	$\Delta Z(m)$
ADINDAN	ADI	Clarke 1880	-112.145	-0.54750714						
Mean Solution (Ethiopia and Sudan)	ADI-M				22	0	1991	-166 ±5	-15 ±5	204 ±3
Burkina Faso	ADI-E				1	0	1991	-118 ±25	-14 ±25	218 ±25
Cameroon	ADI-F				1	0	1991	-134 ±25	-2 ±25	210 ±25
Ethiopia	ADI-A				8	0	1991	-165 ±3	-11 ±3	206 ±3
Mali	ADI-C				1	0	1991	-123 ±25	-20 ±25	220 ±25
Senegal	ADI-D				2	0	1991	-128 ±25	-18 ±25	224 ±25
Sudan	ADI-B				14	0	1991	-161 ±3	-14 ±5	205 ±3
AFGOOYE	AFG	Krassovsky 1940	-108	0.00480795						
Somalia					1	0	1987	-43 ±25	-163 ±25	45 ±25

Legend: m – meters no. – number pub. - publication

Figure C-2. Example World Geodetic System (WGS) 1984 transformation parameters

C-9. WGS-72 is transformed to WGS-84 with a formula that is more accurate than the Abridged Molodensky formulas; therefore, datum shifts are not necessary. The formulas used are shown in figure C-3:

$$\begin{aligned} \phi_{WGS-84} &= \phi_{WGS-72} + \Delta\phi \\ \lambda_{WGS-84} &= \lambda_{WGS-72} + \Delta\lambda \\ h_{WGS-84} &= h_{WGS-72} + \Delta h \end{aligned}$$

whereas:

$$\begin{aligned} \Delta\phi'' &= (4.5 \cos \phi) / (a \sin 1'') + (\Delta f \sin 2\phi) / (\sin 1'') \\ \Delta\lambda'' &= 0.554 \\ \Delta\lambda &= 4.5 \sin \phi + a \Delta f \sin^2 \phi - \Delta a + \Delta r \end{aligned}$$

when:

$$\begin{aligned} \Delta f &= 0.3121057 \times 10^{-7} \\ a &= 6378135 \text{ m} \\ \Delta a &= 2.0 \text{ m} \\ \Delta r &= 1.4 \text{ m} \end{aligned}$$

Figure C-3. World Geodetic System (WGS)-72 to World Geodetic System (WGS)-84 formulas

Note. These formulas are explained in detail in DMA TR 8350.2.

Appendix D

Azimuth Determining System (ADS)

The azimuth determining system (ADS) is currently used by the USMC as a means of hasty survey. This is an approved capability for Army units if they have obtained the proper equipment. The ADS is approved by TRADOC Capabilities Manager (TCM) Brigade Combat Team (BCT) Fires; however, units must use their own funds to purchase the equipment.

AZIMUTH DETERMINING SYSTEM HASTY SURVEY CAPABILITY

D-1. The ADS is a hasty survey capability that uses two (2) DAGRs in conjunction with each other (see figure D-1). The ADS is properly set-up and initialized over the Orienting Station (OS). The azimuth from the OS to the EOL will be determined by transporting the “master” DAGR from the OS to the EOL.

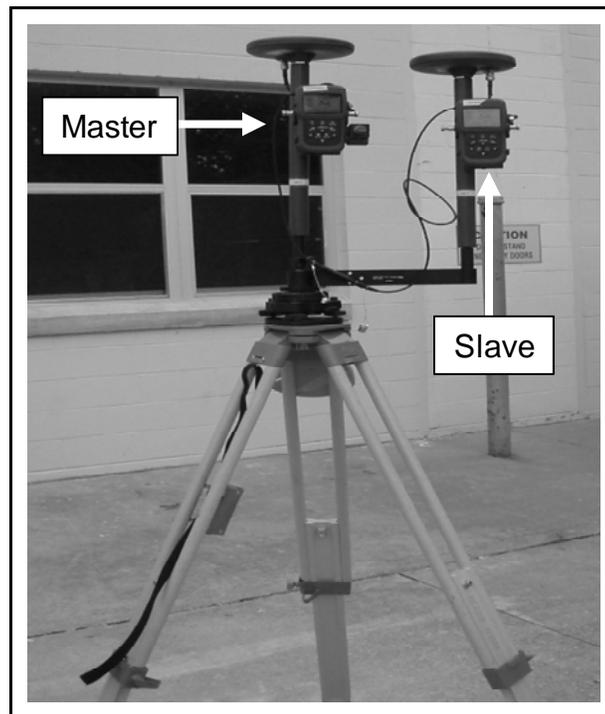


Figure D-1. Dual DAGR configuration

D-2. The operator sets up over the OS and initializes the system. He disconnects the “master” DAGR from the “slave” DAGR and sets up the master over the EOL. First option, a second tripod with antenna pole receptacle mounted on it, may be set up over the EOL connecting the master to the antenna pole receptacle upon arrival. Second option, if the operator has a telescopic range pole with an attached circular leveling bubble, he may attach the master to the range pole after disconnecting the data cables, walk to the EOL, steady and level the range pole by stabilizing with his body.

D-3. Once the EOL data is stored in the DAGR, the operator re-connects the “master” to the “slave” at the OS. The ADS will then compute a single continuous phase line over the orienting line and provide an absolute position and elevations for the OS and EOL and a processed azimuth to the EOL.

D-4. The accuracy of the OS is the same as any DAGR location and elevation; the accuracy of the orienting line is dependent on satellite geometry, common satellites, and the length of the line. Longer lines (in excess of 200 meters) will have better accuracies than shorter lines. In practice, a line that exceeds 50 meters will very seldom include an error in excess of 1m; a line that exceeds 100 meters will very seldom include an error in excess of 0.6m.

Note. The operator should ensure that the orienting line is greater than 100 meters in length.

AZIMUTH DETERMINING SYSTEM PROCEDURES

D-5. When performing ADS procedures, the use of remote antennas are required. This will ensure that both DAGRs are communicating with the same satellites and fixing their relative locations to create the best possible azimuth. The receivers will also be placed upon a plumb and level GST-20 tripod to ensure the starting location is accurate.

- Place the tribrach on the tripod and level it using the three leveling screws and circular bubble level. Ensure the tribrach is optically plumb before proceeding.
- Connect the dual antenna mount to the tripod. One antenna mount will slide onto the antenna mounting pole receptacle via a quick disconnect connector. This is the master antenna, as it can quickly be removed. The second antenna will screw onto the threaded bar. This is the slave antenna, and will not move.
- Attach the DAGRs into their mounts and attach them with the DAGR to DAGR cable in the J2 port. The antennas will be connected at the J3 port.

D-6. The Azimuth Determinations page is accessed from the Applications submenu using the advanced function set. The Azimuth Determinations page is used to store and access multiple sets of azimuth determination (AD) calculation data. Each AD data set (after an AD calculation) provides an accurate azimuth between two points used in applications such as sighting weaponry to a target. The Azimuth Determinations page provides a table showing all DAGR AD data sets (maximum of twenty). Capabilities are provided to create, copy, clear, and edit AD data sets. The AD calculation, viewing data, and editing data are each performed using the Azimuth Determination Editor page. The Azimuth Determination Editor page is accessed from the Azimuth Determinations page.

D-7. AD data sets that are saved in memory will re-display when returning to the Azimuth Determinations page (unless both primary and memory battery power is lost or mission data is cleared/zeroized).

D-8. The AD table rows wrap from the last row to the first row (or vice versa) when vertically scrolling through the table. Scroll horizontally to view all columns. The table row contains double dashes when data entry has not been made. The Azimuth Determinations table includes the following information:

- NUM—Displays the AD data set number (01 through 20). The data set numbers cannot be edited.
- NAME—Displays the AD data set name of up to ten characters. The name can be edited using the Azimuth Determination Editor page.
- METHOD—Displays the type of azimuth determination selected from the Azimuth Determination Editor page. Selections are Orienting Line, Aiming Circle, and Weapon.

D-9. Azimuth Determinations page menu functions are:

- Create/New — Displays the Azimuth Determination Editor page to set up a new AD data set.
- Edit AD — Displays the Azimuth Determination Editor page to edit the selected AD data set.
- Copy/Clear—Allows copying data of a selected AD data set into a storage clipboard. This data can then be pasted into another AD data set. Operator confirmation is required prior to overwriting any existing AD data set. Allows clearing (removal) of one or all AD data sets. Operator confirmation is required prior to clearing any AD data set.
- To create a new AD Data Set, highlight the desired new AD data set (table row) or if the highlighted table row is not changed, the first unused table row will automatically be used and push the MENU key.

- Highlight Create/New, then push the ENTER key. The Azimuth Determination Editor page displays the first unused AD data set (up to twenty can be created) if none were previously selected or the operator selected AD data set. Revise information as necessary using standard editing techniques.
- Push the MENU key. Multiple options are provided. Highlight the desired option, then push the ENTER key. The operator can choose to save and exit, exit without saving, edit a selected field, undo and changes, or request help.

D-10. You can also edit, copy and paste, or clear an existing AD Data Set using standard editing techniques.

D-11. Two separate measurement positions are required in this calculation. A secondary position will be established with a marker no less than 100 meters away. The greater the distance, the greater the accuracy. All commands will be entered into the master DAGR.

D-12. Configure the Azimuth Determination page fields by setting the estimated walk time from point 1 to point 2, using a max of 180 seconds. Remember that if the walk time is exceeded during the procedure, the procedure must be restarted. The method will normally be set to Orienting Line, although Aiming Circle or Weapon may be used, depending on the mission.

D-13. Scroll down to Status and press ENTER to start the program. The status field display will indicate that it is tracking satellites. Remember that you need at least four satellites in order to perform the calculation. When you have enough satellites, press ENTER again to begin the process.

Note. Both DAGR receivers must have the same crypto key status (for example, both DAGRs loaded or not loaded with crypto keys) in order for ADS to work.

D-14. Detach the DAGR to DAGR cable and remove the master antenna. Head to point 2, keeping the DAGR elevated and level as possible to prevent a loss of signal. Walking in a straight line is not required, but maintaining satellite visibility is required, keep the antenna held above your head. When the second point is reached, quickly level the DAGR and press ENTER to indicate you have reached the point.

D-15. After all time has expired and the Status field displays Reconnect Receivers to Complete Calculation, return the master DAGR to the point 1 position. Secure the master DAGR to the mount and reconnect the cable. The calculation is performed automatically.

D-16. The master DAGR Status field displays Calculation Complete Computed at: (time and date of AD calculation). The slave DAGR Status field displays Azimuth Determination Calculation Complete. The DAGRs will display information such as the azimuth, back azimuth, and range between the two points.

Note. For more information see TM 11-5820-1172-13&P.

USE OF PRECISION IMAGERY

D-17. The same tools and methods used to mensurate an accurate target location can be used to determine an accurate firing location when other means are not available. Below are a list of parameters that must be met before this method can be used:

- The firing element must have access to precision imagery and a target mensuration tool precision strike suite - special operation forces (PSS-SOF) or precision fires imagery (PSSOF or PFI).
- Firing battery or platoon leadership must be trained on the use of a target mensuration tool.
- Must be able to clearly identify a spot in the battery/platoon position area that is clearly identifiable on the imagery.

D-18. Step 1—Use the PSS-SOF help function to learn more about the software:

- OK the Warning Banner. The 'Date/Time' window is displayed.
- Check the date/time, update it if necessary, and OK it. The 'System Login' window is displayed.

- Enter the Login Name and Password for this computer. The Start button is displayed. OK the next two messages.
- Click on the start button. The five Start button options are displayed.
- Place pointer on the Help option, then Click “View PSS-SOF 2008 Guide”.

Note. Once digital precision strike suite (DPSS) software is loaded onto your computer, the PSS-SOF Help application becomes available for your use.

- Select “Setting Your Preferences”. Setting Your Preferences information is displayed.
- Read the information on Setting Your Preferences. (Maximize the Help application for more comfortable reading.)
- Select the Index tab on the left. The thirty-three options under the Index tab are listed.
- Select the first “Image Navigation”. An explanation of Image Navigation is displayed. Read this information.
- Exit the Help program by selecting ‘X’ at the top right of the screen. The Start Bar is displayed.

D-19. Step 2—Select the preferred settings for operating in PSS-SOF:

- Select Start, Programs. The five Program options are displayed.

Note. Once DPSS-Suite software has been loaded onto a FOS system, these additional applications become available under Programs: (1) PSS-SOF (2) DPSS-SM, (3) PFI Generator, (4) NITF-Chipper, (5) NITF-Viewer, (6) File Manager, (7) Chart Tool, and (8) DPPDB Manager. Each of these applications is a tool used to more precisely define a target.

- Select PSS-SOF. The PSS-SOF toolbar is displayed.
- Select Tools, Program Options. The ‘PSS-SOF Configuration’ window is displayed. Observe the four tabs: Position, Connection Options, Environment Options, and Digital Terrain Elevation Data (DTED).
- Select the Position tab. There are five options (1) Degrees Minutes Seconds, (2) Degrees, (3) Military Grid Reference System, (4) Universal Traverse Mercator and (5) Latitude and Longitude.
- Select ‘Universal Traverse Mercator’ under Position as the coordinate format. Notice that Height Above Ellipsoid (HAE) is the default setting under height. There are 3 Additional Options: (1) Mean Sea Level (Earth Gravity Model (EGM)96), (2) Mean Sea Level (EGM84/JDAM), and (3) Mean Sea Level (EGM84-NS/GLMRS). You should select the Height option based on your available imagery and NOTE: EGM96 imagery is considered the most precise. EGM96 imagery is 15’ x 15’ post spacing, high resolution. DPPDB is this.
- Select the Environment Options tab. From the Environment Options tab you can set certain PSS-SOF parameters that deal with image view, display of No Strike Points, chip size, and logo display. Check ‘Rotate Imagery to North Up.’ For Windows, check Show Inconsistent NO STRIKE POINTS. For Logo display, select No Logo. Do not change Chip Size unless directed.
- Select the DTED tab. Do not change DTED information unless directed. Select Apply and OK. (Windows only).

Note. Because of the way we are used to looking at maps, most images of the earth’s surface are easier to understand if north is straight up.

The DTED optional levels (0-2) provide additional terrain resolution data (when software is available) for PSS-SOF computation.

- Select OK when the ‘PSS-SOF DPPDB Exploitation Tool’ warning is displayed.
- Close the PSS-SOF DPPDB Exploitation Tool. You have now established the settings in DPSS for your mode of operation.

D-20. Step 3—Chip on a coordinate:

- Select Start, Programs, FOS. The FOS Desktop is displayed.
- Display a CFF – Grid message. The CFF - Grid message format is displayed.

Note. When DPSS-Suite software is loaded onto a FOS system, and a CFF - Grid message format is displayed, ‘(<R>=REFINE TGT POSITION)’ is displayed at the bottom left of the screen. Also, the ‘TLE’ (Target Location Error) field is displayed.

- ENTER ‘B’ in the DEST field to address this message to your member. Then enter your current grid coordinates:
 - EASTING: 12345.
 - NORTHING: 67890.
- Press the ‘Refine’ key to begin the process of more precisely refining this location/target. The PSS-SOF toolbar and the ‘Extract DPPDB stereo image pair’ window are displayed.
- Select the Extract button on the ‘Extract DPPDB stereo image pair’ window. The ‘PSS-SOF DPPDB Exploitation Tool’ window is displayed.

Note. Selecting ‘Extract’ causes the program to search for the appropriate DPPDB Chip and Stereo Image for the left and right view. It also generates the ‘PSS-SOF DPPDB Exploitation Tool’ window that tells you how many meters and degrees the target marker on the stereo image is from the coordinates you entered in the CFF - Grid message.

If the appropriate DPPDB image segment has not been loaded on your computer, you will receive a warning message that says ‘Failed to Find a DPPDB image segment that contains the specified target coordinates.’

- OK the window. The Left Chip View and Right Chip View are displayed:
 - The Left Chip View and Right Chip View are stereo views of DPPDB chips. Each satellite image may have been taken at different times and at a slightly different angle. The initial target location that you are refining is marked with a red target marker near the center of the image.
 - The Left Chip View image bar is yellow because it is the active chip. To activate the Right Chip View click on it one time.
 - Notice the Graphic/Scale in yellow at the bottom left of each image. The vertical yellow line and horizontal yellow line represent the length of 50 meters on this image based on the pixel ratio of 1:1. Once you change the ratios to 1:2 or 1:4, the distance each yellow line represents also changes to the corresponding computed distances.
 - North is up because of the changes we made to the default settings.
- Click on the Right Chip View. The Right Chip View is activated.
- Select the drop-down arrow that is to the left of the yellow bar. This arrow opens the Brightness and Contrast options.

Note. To more precisely define a location it may be very important to set the contrast and brightness so you can see more details about the area. The brightness and contrast can be adjusted by using the sliders. Or you can enter numbers into the boxes. The sliders can also be adjusted by selecting one of the sliders and then using page up or page down. This moves the sliders in increments of 10. When you select the slider, and then use the arrow keys, it moves the sliders in increments of one. No other action can be performed on the imagery until this dialog box is closed using the Close button.

There are two additional buttons, SAVE MPG and OUTPUT. These buttons are used if you are equipped with the proper external equipment to copy the target image to an external source.

- Use the different methods discussed above to change the brightness and contrast of the images on each chip until you feel that you have the most detail in each image. You might want to use different Brightness and Contrast settings for each image in order to make out different details.
- Close the 'Brightness/Contrast' window.
- Change the pixel ratio to 1:4 by clicking on the down arrow located next to the ratio 1:1. The selections are 1:1, 1:2 and 1:4. The area around the building now becomes more visible in the image and the scale has changed to 200mts.
- Activate the Left Chip View and click once on the center of the building. The target marker in the Left Chip View moves to the new location.
- Clicking once on a chip that is not yet active, activates that chip. Clicking again in the active chip moves the marker to the new location. The marker in the other chip does not move.
- Re-center the image in the Left Chip View on the middle of the building by selecting the double black box on the toolbar (to the right of the ratio). The Left Chip View re-centers on the new location of the target marker.

Note. You cannot re-center on a position if the position is too close to the edge of the chip.

- Click twice rapidly on the target marker in the Left Chip View. The target marker in the Right Chip View moves to the same location as the target marker in the Left Chip View.

Note. Clicking twice rapidly on a location causes the markers in both images to move to that location.

The small box in the center of the screen directly below the 'Get Coordinate' tab tells you (in green) that the location (red marker) is the active marker. The area above that tells you the current coordinates of the active marker. (If this information is not displayed, click on the 'Get Coordinates' bull's-eye icon located just above the active marker selection.)

- Re-center the Right Chip View on the Target Marker and Return the ratio to 1:1.
- Activate the Left Chip View and again place the cursor in the center of the building.
- Click twice rapidly on the center of the building. The target markers in each chip view move to the center of the building.
- Click on the box with the four arrows that is to the right of the Brightness and Contrast arrow. The Left Chip View becomes the full screen. In Windows, a small dialog box appears at the bottom of the screen with the necessary tools to "refine" your target.
- Adjust the target marker in the Left Chip View using the keyboard arrow keys so it is more precisely centered on the building.
- Return to the two images by pressing Alt+F4.
- Activate the Right Chip View and make it full screen. Adjust the target marker in the Right Chip View so it also is more precisely centered on the building. Select Alt+F4 to return to the double image view. The double images reappear. Activate the Left Chip View. Select the Magnifying glass on the toolbar. Magnifications of 2X and 4X are available. The rest are Large, Medium, Small, Upper Left, Upper Right, Bottom Left, Bottom Right and Tracking. "Tracking" moves the magnified area while the marker remains fixed. The target area is magnified 2X.
- Click on the Left Chip View to activate it. Adjust the red dot so that it is more precisely centered on the building. (Ratio should be 1:1) There are two ways to adjust the red dot. You should practice both of them. Place the pointer in the magnified area, press the Left Mouse Button and move the pointer. The magnified area moves, following the pointer. Press the arrow keys on the keyboard until the red dot is in the location you want it. (This is the best method to use.)

Note. The Binoculars icon allows you to see the entire 8-mm tape. The highlighted area is the Chip size area default of 4096 X 4096 pixels segment extracted based on the target location and on the date of the DPPDB. The bottom of the screen provides you with a Color Box, which can be changed, and the RECHIP function key. The RECHIP function key allows you to zoom in to an area of 4km or 2km, and display it as a grid sheet. Normally the pixel will be 1.1 or .55 meters.

The Pen Icon allows you to draw onto the target area, by a dialog Box at the bottom of the stereo views.

The Tx Icon will allow text to display or to be hidden.

- You have more precisely adjusted the target marker in the Left Chip View. Therefore, you decide to transfer the location in the Left Chip View to the Right Chip View. Select L to R on the toolbar. The target position in the Left Chip View is copied to approximately the same position in the Right Chip View.
 - Click on the arrow beside the magnifying glass icon on the toolbar and change the pixel to 4X. Notice that you lose resolution whenever you magnify an area, so you might have more detail at 2 X magnifications or at no magnification at all. When you feel that you have adjusted the target in each view as precisely as possible, select the Get Coordinate icon.
 - Click on the drop-down arrow to the right of the Get Coordinate data. If required to change the coordinate and elevation format, select the desired coordinate and elevation format and click OK.
-

Note. The coordinate and elevation format entries shown were entered as parameters set in the Program Options > Startup Configuration Format screen.

D-21. Step 4—View different locations on the imagery:

- Return to the DPPDB image by selecting Alt+Tab until the images appear. (Make sure the magnifying glass is off.) You can move between the PSS-SOF and other applications by pressing the Alt+Tab key.
- Use the horizontal and vertical scroll bars to move the DPPDB imagery to different locations. Then adjust the image so that the target is displayed. (If you cannot find the target again, simply press the Re-center icon or increase the ratio.)
- Select the white hand that appears on the toolbar. While pressing the left mouse button, move the image.
 - The white hand that appears on the tool bar is used to rapidly move the imagery location that appears on each chip. When in this mode, points cannot be selected in the imagery, but all other functions are available.
- Using the hand, look at different areas around the target location. Click the hand off and redisplay the target in the center of the images.
- Press Alt+Tab until the CFF message format is displayed. Select the Cancel button and this should bring you back to FOS.

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Glossary

SECTION I - ACRONYMS AND ABBREVIATIONS

2D	two-dimensional
3D	three-dimensional
AC	alternating current
ADS	azimuth determining system
AO	area of operations
BCT	brigade combat team
BCU	battery computer unit
CDU	control and display unit
CEP	circular error probable
CPNU	compact position and navigation unit
DA	Department of the Army
DAGR	Defense Advanced Global Positioning System Receiver
DC	direct current
DIVARTY	division artillery
DOD	Department of Defense
EOL	end of orienting line
FA	field artillery
FAB	field artillery brigade
FC	fires cell
FCS	fire control system
FFA	force field artillery
FIST	fire support team
FM	field manual
FOS	forward observer system
FS	fire support
FSCOORD	fire support coordinator
FSO	fire support officer
GEO	geographic
GN	grid north
GPS	Global Positioning System
HDD	hard disk drive
HIMARS	high-mobility artillery rocket system
HMMWV	high-mobility multipurpose wheeled vehicle
HQ	headquarters
HTU	handheld terminal unit
IAW	in accordance with
ID	identification

IPADS	Improved Position and Azimuth Determining System
IPADS-G	Improved Position and Azimuth Determining System-Global Positioning System
IUGG	International Union of Geodesy and Geophysics
LCD	liquid crystal display
LCU	lightweight computer unit
LM	launcher module
LST	local sidereal time
MAPS	modular azimuth positioning system
METT-TC	mission, enemy, terrain and weather, troops and support available, time available, and civil considerations
MLRS	multiple launch rocket system
NAD	North American datum
NGA	National Geospatial-Intelligence Agency
OL	orienting line
OPORD	operation order
OS	orienting station
PAA	position areas for artillery
PADS	Position and Azimuth Determining System
PAE	position, azimuth, elevation
PC	personal computer
PCMCIA	personal computer memory card International Association
PDS	position determining system
PLGR	Precise Lightweight Global Positioning System Receiver
PMCS	preventive maintenance checks and services
PNU	position navigation unit
POSNAV	position navigation
PSS-SOF	precision strike suite–special operation forces
S&D	survey and design
S-3	battalion or brigade operations staff officer
SAASM	selective availability antispoofing module
SCP	survey control point
SOI	signal operating instructions
SOP	standard operating procedure
SPS	Standard Positioning System
SRP/PDS	stabilization reference package/position-determining system
SUSV	small-unit support vehicle
TA	target acquisition
TCIM	tactical communications interface module
TM	technical manual
URN	unit reference number
UTM	universal transverse mercator

WGS	World Geodetic System
WLR	weapons locating radar
ZUPT	zero velocity update

SECTION II - TERMS

***common control**

The horizontal and vertical map or chart location of points in the target and position area, tied in with the horizontal and vertical control in use by two or more units.

***common grid**

Refers to all firing and target-locating elements within a unified command located and oriented to prescribed accuracies with respect to a single three-dimensional datum.

Datum (geodetic)

A mathematical model of the earth used to calculate the coordinates on any map. (JP 2-03)

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References

All URLs accessed on 26 August 2015.

REQUIRED PUBLICATIONS

These documents must be available to the intended users of this publication.

ADRP 1-02, *Terms and Military Symbols*, 2 February 2015.

JP 1-02, *Department of Defense Dictionary of Military and Associated Terms*, 8 November 2010.

RELATED PUBLICATIONS

These documents contain relevant supplemental information.

JOINT PUBLICATIONS

Most joint publications are available online: http://www.dtic.mil/doctrine/new_pubs/jointpub.htm

JP 2-03, *Geospatial Intelligence in Joint Operations*, 31 October 2012.

ARMY PUBLICATIONS

Most Army doctrine publications are available online:

https://armypubs.us.army.mil/doctrine/Active_FM.html.

ADRP 5-0, *The Operations Process*, 17 May 2012.

ATP 3-09.30, *Techniques for Observed Fire*, 2 August 2013.

ATP 3-09.50, *The Field Artillery Cannon Battery*, 7 July 2015.

ATP 3-09.60, *Techniques for Multiple Launch Rocket System (MLRS) and High Mobility Artillery Rocket System (HIMARS) Operations*, 10 January 2014.

ATP 5-19, *Risk Management*, 14 April 2014.

ATTP 3-21.90, *Tactical Employment of Mortars*, 4 April 2011.

ATTP 3-97.11, *Cold Region Operations*, 28 January 2011.

FM 3-06, *Urban Operations*, 26 October 2006.

FM 6-0, *Commander and Staff Organization and Operations*, 5 May 2014.

FM 27-10, *The Law of Land Warfare*, 18 July 1956

FM 90-3, *Desert Operations*, 24 August 1993.

FM 90-5, *Jungle Operations*, 16 August 1982.

TB 11-7021-228-10-1, *Operator's Manual for Forward Observer Systems (FOS Version 7.01) Digital Data Sets AN/PSC-9(V) (HUT) (V)1(NSN 7035-01-452-4305) (EIC: N/A) Fire Control System, Field Artillery AN/GYK-37(V)2 (LCU) (1230-01-380-9228) (EIC: GDN) Computer Systems, Digital AN/PSG-11(V)1 (RHC) (7021-01-491-9157) (EIC: N/A) AN/GYK-51 (SCU) (7010-01-496-1336) (EIC: N/A)*, 15 March 2005.

TM 9-1015-252-10, *Howitzer, Light, Towed: 105-MM, M119A2 (NSN 1015-01-482-4914) (EIC: 3WE) LIN: H57505*, 30 September 2010.

TM 9-1025-215-10, *Howitzer, Medium, Towed 155-MM, M777 (1025-01-445-0991) Howitzer, Medium, Towed: 155-MM-M777A1 (1025-99-411-1447) (EIC: 3ET)/Howitzer, Medium, Towed: 155-MM, M777A2 (NSN 1025-99-463-7551) (EIC: 3EU)*, 30 November 2014.

TM 9-2320-280-10, *Operator's Manual for Truck, Utility: Cargo/Troop Carrier, 1-1/4 Ton, 4X4, M998 NSN 2320-01-107-7155 (EIC: BBD)*, 27 September 2013.

TM 9-2350-314-10-1, *Operator's Manual for Howitzer, Medium, Self-Propelled: 155MM, M109A6 (NSN 2350-01-305-0028) (EIC 3FC)*, 30 May 2014.

References

- TM 9-6140-200-13, *Technical Manual Operator and Field Maintenance for Automotive Lead-Acid Storage Batteries 4HN, 24 Volt (Dry) (NSN 6140-00-059-3528) M11188/2-24V 4HN, 24 Volt (Wet) (NSN 6140-01-390-1968) M11188/2-24V 2HN*, 26 May 2011.
- TM 9-6675-349-13&P, *Operator and Field Maintenance Manual Including Repair Parts and Special Tools list for Surveying Instrument Azimuth: Improved Position and Azimuth Determining System (IPADS) M111 NSN: 6675-01-515-4610 (P/N: 7050004-9) (NSN 6675-01-598-0874)*, 24 May 2013.
- TM 11-5820-1172-13&P, *Operator and Maintenance Manual Defense Advanced GPS Receiver (DAGR) Satellite Signals Navigation Set AN/PSN-13 (NSN 5825-01-516-8038) and AN/PSN-13A (NSN 5825-01-526-4783)*, 9 May 2014.
- TM 11-5825-291-13, *Satellite Signals Navigation Sets AN/PSN-11 (NSN 5825-01-374-6643) and AN/PSN-11(V)1 (5825-01-395-3513) {TO 31R4-2PSN11-1; EE174-AA-OMI-010/PSN-11}*, 1 April 2001.
- TM 11-7021-225-12&P, *Operator's and Unit Maintenance Manual (including Repair Parts and Special Tools List) for Computer, Digital, NSN 7021-01-444-9260, (EIC: N/A) V3 Handheld Terminal Unit*, 1 May 2001.

OTHER PUBLICATIONS

- DMA TR 8350.2, *Department of Defense World Geodetic System 1984*, 3 January 2000. Available at <http://earth-info.nga.mil/GandG/publications/tr8350.2/wgs84fn.pdf>.
- Classification, Standards of Accuracy and General Specifications of Geodetic Control Surveys and in a supporting document titled Specifications to Support Classifications, Standards of Accuracy, and General Specifications of Geodetic Control Surveys*, September 1984. Available at http://www.ngs.noaa.gov/FGCS/tech_pub/1984-stds-specs-geodetic-control-networks.pdf.

PRESCRIBED FORMS

- Unless otherwise indicated, DA forms are available on the Army Publishing Directorate (APD) web site (www.apd.army.mil).
- DA Form 5075, *Artillery Survey Control Point*.

REFERENCED FORMS

- Unless otherwise indicated, DA forms are available on the Army Publishing Directorate (APD) web site (www.apd.army.mil). DD forms are available through the Department of Defense forms Management Program website (<http://www.dtic.mil/whs/directives/forms/>). Standard forms (SF) are available through the GSA Forms Library website (<http://www.gsa.gov/portal/forms/type/SF>).
- DA Form 2028, *Recommended Changes to Publications and Blank Forms*.
- DA Form 4446, *Level, Transit, and General Survey Record Book*.
- DA Form 7368-R, *Computation—Conversion UTM to GEO Coordinate, GEO to UTM Coordinate, Zone-to-Zone Transformation (FED MSR)*.
- DD Form 518, *Accident Identification Card*.
- SF 91, *Motor Vehicle Accident Report*.

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ATP 3-09.2
16 February 2016

By Order of the Secretary of the Army:

MARK A. MILLEY
General, United States Army
Chief of Staff

Official:

A handwritten signature in black ink, appearing to read "Gerald B. O'Keefe". The signature is fluid and cursive, with the first name "Gerald" being the most prominent.

GERALD B. O'KEEFE
Administrative Assistant to
the Secretary of the Army
1601403

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