Example
"Spreading fires, right 200, repeat, over."

(2) Trend. A trend is the straying of the fall of shot from salvo to salvo. If the spotter notices a trend, he announces "trend," along with an indication of direction and distance (in meters). This is a correction to move the MPI back to the target.

Example
"Trend, southwest 100 per salvo."

(3) Check Solution. Check solution is an order transmitted by the spotter when he suspects an error in the gunnery solution for a salvo. Before transmitting "check solution," the spotter should check his target location data. The ship will respond with either "solution checks" or "neglect."

c. From the Ship

(1) Neglect. This report is sent by the ship to indicate that the last salvo was fired with incorrect data. The ship corrects the settings and transmits "ready, over" when prepared to fire.

(2) Delay. Delay is a report indicating that the ship is not ready to fire. The report is followed by an estimate of time in minutes, usually of short duration, that the ship will be unable to fire. When the ship is prepared to fire, the ship will report "ready, over."

(3) Will Not Fire. This report means that the ship will not continue the mission for a stated reason, for example, a gun mount malfunction (mount casualty) or a higher priority mission or circumstance such as counterbattery fire.

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Chapter 7

Aerial Observation

7001. Aerial Observer. An aerial observer is trained to observe the battlespace from an aircraft to conduct reconnaissance and adjust artillery and NGF. An aerial observer may also perform the duties of a FAC(A) or TAC(A). Aerial observers adjusting NGF are also referred to as air spotters. Marine aerial observers operate primarily from the F/A-18D fixed-wing aircraft and the AH-1W or UH-1N helicopter. The aerial observer uses procedures and terminology for adjusting fires similar to those employed by the ground observer or spotter. Some variations are imposed by his perspective from the aircraft. This chapter will discuss the unique aerial observer procedures for calling for and adjusting artillery and NGF.

7002. Prelaunch Considerations. The aerial observer and pilot are given a thorough briefing of the current tactical situation, including the friendly and enemy orders of battle. The briefing addresses the current friendly situation, including infantry objectives, locations, front lines, zones of action, patrol plans, and coordinating measures. Additionally, the following information should be obtained during mission preparation:

- Enemy locations, organization, and equipment
- Battery positions, known points, targets, reference lines available for making corrections, suspected target areas, areas to be searched, and ordnance available

- Maps and photographs, obstacles, and checkpoints
- Communications details (frequencies, call signs, prearranged signals, and authentication sheets)
- Established operational procedures or SOPs, such as the method of fire for immediate suppression, special munitions, and SEAD
- FSAs, FSSs, NGF ship disposition and availability, and radar beacon positions
- Specific mission preparation (includes time of takeoff and return, routes, mission, check-in times, control measures, known fires and airstrikes, restrictive fire plans, weather, and relief on station)
- Message drop and pickup stations
- Panel code
- Location of ground radios
- Pulse repetition frequency (PRF) code words.

7003. Reporting In and Out. The pilot reports in and out to air control agencies when airborne or over an assigned orbit point by using the UHF radio. The aerial observer reports in and out with ground agencies by using the UHF/VHF radio.

a. Communication Nets. In addition to the division artillery air spot net or the NGF air spot net (see chapter l), the following nets may be used.

(1) Ship Air Spot Reporting In and Out Net (Ultrahigh Frequency). When arriving on station, the aerial observer must check in with the SACC or the appropriate FFCC/FSCC. For NGF, the ship air spot reporting in and out net is employed for the following:

- To assign air spotters to specific gunfire support ships and SFCPs as directed
- To direct NGF air spotters to guard other air spot frequencies, if required
- To brief spotters, as directed, on the location of targets, friendly front lines, zones of action, and so on
- To release air spot planes when relieved and return them to the tactical air traffic control (TATC) net controller or senior air observer for departure from the area. The stations on this net include parent carriers, land base(s), tactical air commanders, the commander of the landing force, and all airborne NGF spotting aircraft that report in and out.

(2) MAGTF Air Observation Net (Ultrahigh Frequency/Very High Frequency). This net provides a means for controlling air observation and for the transmission of information from landing force aerial observers to landing force headquarters and other landing force units. It may also be used for adjustment of artillery or NGF on an emergency basis. Multiple air observation nets may be required, depending on the scope of the operation. The stations on this net include the SACC, the FFCC, the FSCC(s), and the senior artillery FDC.

(3) MAGTF Artillery Air Spot Net (Very High Frequency/ Ultrahigh Frequency). This net provides the landing force headquarters, FFCC or senior FSCC, artillery regiment, artillery battalions, and liaison officers with an air spot net for conducting fire on deep and difficult targets. Stations on this net include landing force aerial observers, the force command element, GCE artillery aerial observers, and landing force artillery units, as required.

(4) Division Air Observation Net (Very High Frequency/Ultrahigh Frequency). This net provides a means for controlling air observation and for the transmission of information from division aerial observers to division headquarters and other division units. It may also be used for adjustment of artillery or NGF on an emergency basis. Stations on this net include the division headquarters, aerial observers, and subordinate division units, as required.

(5) Tactical Air Traffic Control Net (Ultrahigh Frequency/Very High Frequency). This net provides a means for the TACC/tactical air direction center (TADC), tactical air operations center (TAOC), and DASC to exercise airspace control of all tactical aircraft and itinerant aircraft in the objective area. The stations on this net include the TACC/TADC, the TAOC(s), the DASC, fixed-wing aircraft, and helicopters.

(6) Tactical Air Request/Helicopter Request Net (High Frequency/Very High Frequency). This net provides a means for the request of immediate air support from the DASC. The stations on this net include the DASC, TACP(s), FFCC/FSCC(s), the HDC, the FAC(A), the TAC(A), and the ASC(A), as required. In amphibious operations, a dedicated net (i.e., helicopter request (HF/VHF)) may be activated during ship-to-shore movement for immediate helicopter requests.

(7) Tactical Air Direction Net (Ultrahigh Frequency/Very High Frequency). This net provides a means to direct aircraft in the conduct of CAS missions and for the DASC to brief support aircraft on target information or for the DASC to assign to aircraft. There are multiple tactical air direction (TAD) nets available for assignment by the DASC to terminal control agencies (e.g., TACPs, FAC(A)s). The TAD net is not a planning net, but is a terminal control net on which extraneous traffic is to be avoided.

b. Communications Means. Table 7-1 on page 7-6 displays the radios that are available for communications by aerial observers.

Table 7-1. Communications Means Available to the Aerial Observer.

Aircraft	Communications Means

F/A-18D	Two ARC-182 transmitters/receivers with the capability to monitor any two frequencies in UHF/VHF/amplitude modulation (AM)/FM. The ARC-182 transmitters/receivers are capable of operating when covered.
AH-1W	Two ARC-182 transmitters/receivers with the capability to monitor any two frequencies in UHF/VHF/AM/FM. The ARC-182 transmitters/receivers are capable of operating when covered.
UH-1N	UHF and VHF (with the ASC-26 communications package installed—one additional UHF and two additional VHF radios with a retransmission capability). May also have HF capability.

7004. Call for Fire. The call for fire (artillery and NGF) used by the aerial observer is the same as that discussed in chapter 3. The following are special considerations for the aerial observer who is making a call for fire.

a. Marking the Target. The aerial observer may mark the target for a firing ship and use the ship adjust method of control. This technique should be used only in a low-threat environment.

b. Method of Control. The command “at my command” allows the pilot the time to position the aircraft for observation.

c. Target Location. Target location is determined by either the grid or shift from known point method. The methods are the same as discussed in chapter 2, with the following considerations or modifications. Obtaining accurate target location is difficult because targets are normally acquired by the naked eye. The use of gyrostabilized, low-light-capable binoculars facilitates accurate target location and adjustment of fire and increases aircraft survivability. (The Fujinon Stabiscope S-40 is used and available through open purchase.) Nongyrostabilized binoculars are difficult to use because of distortion caused by the windscreen and vibration of the aircraft. Hand measurements or estimations can be used to measure angular deviation. The aerial observer should seek an object to use as a yardstick for assistance in estimation.

Example

A bridge span that is measured on the map to be 200 meters can be used as a yardstick in target location and adjustment of fire.

The aerial observer's capability to determine an accurate target location may be limited by the enemy situation. Because of the enemy acquisition capability, the aerial observer may be afforded only a short exposure time. The aerial observer can offset the enemy's acquisition capability by using the forward looking infrared (FLIR) receiver. (See chapter 9.)

d. Direction. The aerial observer selects one of the types of direction based on the battlespace environment, terrain, type of aircraft, and his experience and training.

(1) Gun-Target Line. The GTL provides an effective type of direction for the adjustment of fire. In *artillery*, if the aerial observer has knowledge of the firing unit's location, he can readily use the GTL for adjustment. The FDC will assume that the GTL is being used unless otherwise specified by the observer. In *NGF*, if the aerial observer can see both the ship and the target or can clearly visualize the GTL on the ground, this type of direction can be used. The aerial observer must specify "direction GTL" if he desires to use this type of direction.

(2) Arbitrary Reference Line. The aerial observer can use visible terrain or a manmade feature as a reference line. The aerial observer uses this line or a corresponding parallel line and projects it through the target. The aerial observer must be able to see both the target and the reference line feature simultaneously from all angles of approach. Roads, rivers, power lines, and railroads are examples of good reference lines.

(3) Observer-Target Line. OT direction is excellent for an aerial observer who is observing from a helicopter. The bearing-distance heading indicator (BDHI) on the aircraft instrument panel can be used to determine OT direction in degrees magnetic. The aerial observer may have to transmit a new OT direction for subsequent adjustments. Aerial observers have a difficult time using the OT direction while performing the observation from a fixed-wing aircraft. The aircraft will not normally head directly for the target on every pass. Therefore, the aerial observer may have to estimate OT direction from the sides of the aircraft. The clock method using the nose of the aircraft can facilitate this estimation.

(4) Cardinal Direction. Cardinal direction, although less accurate, can be used for direction.

e. Summit or Maximum Ordinate. The aerial observer may desire to know the summit or maximum ordinate for use in aircraft positioning and flight-path selection. In *artillery*, the aerial observer may request the maximum ordinate from the firing unit. In *NGF*, the summit is automatically reported in the prefiring report. (See chapter 3.)

f. Time of Flight. The aerial observer is automatically sent TOF in the artillery MTO or NGF prefiring report. This allows the pilot time to position the aircraft for observation.

7005. Adjustment of Fire

a. Spottings

(1) Deviation and Range. The aerial observer determines spottings by map spot, estimation, or hand measurement depending on the aircraft positioning, the threat, and the type of aircraft.

(2) Height of Burst. The aerial observer cannot readily determine HOB. Consequently, adjustments to HOB for HE with fuze time are difficult. The aerial observer must rely on the fragmentation pattern on the ground as a means for determining spots. The use of VT or CVT eliminates this problem.

b. Corrections. Because of the aerial observer's elevated view, the one-round adjustment method is preferred. However, other methods discussed for the ground observer may be used. (See chapter 3.)

c. Adjustment Techniques From a Helicopter. When the aerial observer is adjusting from a helicopter, he may use either the stationary hover or pop-up technique for adjustment.

(1) Stationary Hover Technique. In a stationary hover, the pilot positions the aircraft behind trees or other terrain features that conceal the aircraft and still permit observation of the target.

(2) Pop-Up Technique. In the pop-up technique, the pilot will unmask the aircraft two to three seconds before impact of the round. After the aerial observer observes the burst, the aircraft returns to the hide position or moves to another hide position. The aerial observer sends his corrections as the pilot remasks the aircraft.

7006. Forward Looking Infrared Receiver. The FLIR receiver is a passive device used to detect targets by their infrared radiation. The FLIR receiver views the terrain in the vicinity of the aircraft. Infrared energy is converted into electrical signals and displayed on a terminal in the cockpits of F/A-18, F-14, AV-8B (night attack version), AH-1W, AH-64A, AC-130, F-15E, F-16, and OH-58D aircraft. The device allows for the recognition, identification, and classification of targets that would otherwise go undetected as a result of darkness or camouflage. The FLIR receiver provides the aircrew with an excellent target day or night, although it is usually better at night. The FLIR receiver in conjunction with the laser makes night adjustment of artillery, mortars, or NGF possible without illumination and the inherent time delays associated with illumination missions. The call for fire using the FLIR receiver is the same as discussed previously. (See chapter 3.)

7007. Laser Designators. The F/A-18, F-14, (laser target designator, low-altitude navigation and targeting infrared for night

(LANTIRN)-equipped) AC-130, AH-1W, and AH-64 aircraft are currently the only aircraft that have laser designators that are capable of designating for other acquisition systems or for laser-guided munitions.

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Chapter 8

Suppression of Enemy Air Defenses

SEAD is that activity that neutralizes, destroys, or temporarily degrades enemy air defenses in a specific area by physical attack and/or electronic warfare. SEAD should be considered when friendly aircraft or unmanned aerial vehicles (UAVs) cannot complete their missions without critically exposing themselves to enemy air defenses. Although typically associated with offensive air support (OAS) missions, SEAD may be employed to protect any type of aircraft or UAV mission, including air reconnaissance, assault support, antiair warfare, and electronic warfare. When determined to be appropriate, SEAD fires are delivered during the critically vulnerable portions of friendly flight profiles. Although SEAD can be provided by various destructive and disruptive means from either ground or aviation forces, this chapter focuses on the delivery and coordination of artillery and NGF SEAD fire missions.

8001. SEAD Coordination. Because aircrews may rely largely on closely delivered SEAD fires for protection, all details of SEAD missions must be closely coordinated between aircrews, terminal controllers, spotters/observers, and fire support coordinators. *In coordinating timing for SEAD missions, everything is based on the timing of the air mission. Supporting indirect fires will be scheduled based on a specific aircraft event time, for example, CAS TOT/TTT, assault support L-hour, UAV mission area arrival time, and so on.* Coordination should ensure that aircraft are protected not only from enemy fires, but also from friendly SEAD fires. Protection from friendly fires is achieved by separating aircraft from SEAD fires by time and/or distance. Time and distance separation techniques are discussed in detail in paragraph 8005. Munition marking rounds may be incorporated into SEAD fires to aid target identification by OAS aircraft. Target marking is discussed in paragraph 8007. Depending on the type of air mission supported, SEAD fire missions are either planned or immediate.

8002. Planned SEAD Missions. Planned SEAD missions are scheduled during fire planning to support preplanned or on-call air missions. Units requesting these types of air missions must consider the air defense threat and submit requests for SEAD support as appropriate. Typically, known air defense artillery (ADA) targets will be attacked immediately; however, support for suppressing undetected systems must be planned. Planned SEAD missions are the result of coordinated planning by the air support request, or appropriate FSCCs, and the unit providing aviation or UAV support. See MCWP 3-16 for more information on the fire support planning process.

8003. Immediate SEAD Missions. Immediate SEAD missions are conducted to support immediate air missions. Because of the urgency of immediate air requests, planning and coordination for immediate SEAD missions are abbreviated. Critical SEAD decisions are made primarily by the requesting unit with supervision by the battalion FSCC. Requests for immediate artillery, mortar, or NGF SEAD fires are made as calls for fire.

8004. SEAD Decisionmaking

a. Validate Requirement for SEAD. SEAD fire missions do not guarantee safety from enemy air defenses. These fire missions divert indirect-fire weapons from other fire support tasks and may expose those weapons to enemy counterfire. Therefore, terminal controllers should first attempt to route aircraft away from enemy air defenses rather than automatically request SEAD fires. If aircraft cannot be routed away from enemy air defenses, then fire support personnel must balance aircraft vulnerability against the risk of exposing indirect-fire weapons to determine whether SEAD fires are appropriate for that air mission. The temporary diversion of fire support and the consumption of fire support resources must also be considered. Before requesting OAS that would require SEAD support, fire support personnel must first consider whether artillery or NGF could range the mission target and achieve the desired effects. If so, an artillery or NGF attack would be more efficient than an OAS attack supported by SEAD. If the mission target cannot be ranged by indirect fire or is most efficiently attacked by aircraft, OAS supported by SEAD fires may be appropriate.

b. Select SEAD Targets. Targets should be selected based on aircraft flight tactics/routing and enemy air defense capabilities. The prerequisite to selection is target location. Often, enemy ADA is not detected until aviation enters the area; therefore, observers must be able to acquire ADA based on its battlespace signature. Suppressive fires are placed as accurately as possible on enemy air defense sites that can engage aircraft.

c. Select Appropriate Weapons System and Firing Unit. Select an available weapons system and a firing unit that is capable of firing the appropriate ordnance when and where required.

Requirements include accuracy, range, ordnance availability, and state of training. The selection of a particular weapons system and/or firing unit should not adversely affect other fire support requirements. Although several indirect-fire systems are capable of delivering SEAD fires and target marks, artillery is generally most appropriate because of its range, responsiveness, ordnance, and fire direction capabilities.

d. Determine Marking Requirements. Specific aircraft missions such as CAS may require a mark to orient the aircrew onto the target. Refer to paragraph 8007. for descriptions of various marking options.

e. Select Appropriate Ordnance. Select the ordnance that will most effectively suppress the SEAD target(s) without endangering the aircrew or hindering future maneuver. When firing a munition marking round, select the ordnance that will best identify the target to the aircrew. Refer to table 8-1 on page 8-5 and paragraphs 8008. and 8009. for more information on the vulnerability of enemy air defense systems and suitability of specific ordnance.

f. Determine Method of Separating Aircraft and SEAD Fires. To prevent fratricide, aircraft must be separated from SEAD fires and trajectories. Separation may be by distance (lateral, altitude, or a combination of altitude and lateral) or by time (interrupted, nonstandard, or continuous). Distance separation permits the continuous engagement of enemy air defenses during aircraft vulnerability and thus requires less coordination. If an aircraft must fly near the effects or trajectories of SEAD fires, SEAD fires may have to be interrupted to ensure aircraft safety. This interruption of fires is time separation. Refer to paragraph 8005. for a discussion of separation techniques.

Table 8-1. Vulnerabilities of Selected Air Defense Weapons.

Weapon	Vulnerabilities
ZPU-3/ZU-23	Exposed personnel
ZSU 57-2/S-60	Optics
ZSU 23-4 2S6	Thin armor plating, optics, exposed radar and antennas
SA-7/14, SA-16	Exposed gunners
SA-9/13	Exposed missiles, optics
SA-6, SA-8	Thin armor plating, exposed radar and antennas, exposed missiles, susceptibility of radar to jamming

g. Determine Duration and Volume of Fires. Determine the duration and volume of fires required to protect friendly aircraft during vulnerable periods of flight. Consider the vulnerability, resiliency, range, and method of acquisition of the targeted enemy air defense weapon(s); number and type of friendly aircraft; aircraft flight tactics and the separation required between aircraft and SEAD fires; type of ordnance used for suppression; and vulnerability of the SEAD firing unit. If aircraft must fly near SEAD trajectories or effects, SEAD fires must be separated to prevent fratricide.

h. Timing the Delivery of Fires. Use of a synchronized clock to coordinate timing, for example, “CAS TOT 1305,” is the desired means of timing fires. As an alternate method, elapsed time can be used, for example, “CAS TTT six plus zero, zero . . . stand by, hack." In selecting a synchronized or elapsed time to coordinate ground and air activities, terminal controllers and observers must allow sufficient time for all units to prepare for the mission and for FSCC coordination. Observers should send calls for fire as early as possible during aircraft routing, for example, before the aircraft departs the IP, to ensure that firing units can deliver SEAD fires on time.

i. Prepare Call for Fire and Coordinate. When all SEAD decisions have been made, prepare and transmit the appropriate call for fire and ensure that all required coordination is completed. See paragraphs 8008. and 8009. for artillery and NGF SEAD call for fire procedures.

8005. Separation Techniques. Aircraft and SEAD fires may be separated by distance (lateral, altitude, or a combination of altitude and lateral) or by time. Separation by distance is preferred because it permits the continuous attack of SEAD targets. If distance separation is too restrictive on aircraft routing, time separation may be used to protect aircraft from friendly fires. Time separation is the least flexible and often precludes suppressive fires at critical moments. Select the separation technique that requires the least coordination while still providing adequate flexibility and protection to aircraft.

a. Distance Separation

(1) Lateral Separation. Lateral separation is effective for coordinating SEAD fires against targets that are safely separated from flight routes. This technique is effective when aircraft can be routed away from SEAD trajectories and targets. (See figure 8-1.) For low-level CAS attacks, lateral separation should be used when aircraft and firing units engage safely separated targets and when aircraft will not cross GTLs. (See figure 8-2 on page 8-8.)

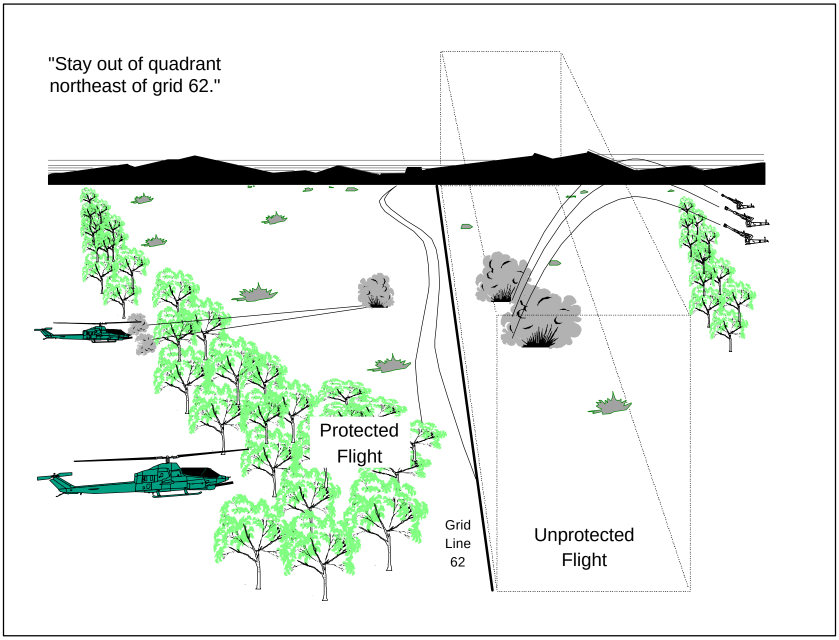


Figure 8-1. Artillery-Assault Support Aircraft Lateral Separation.

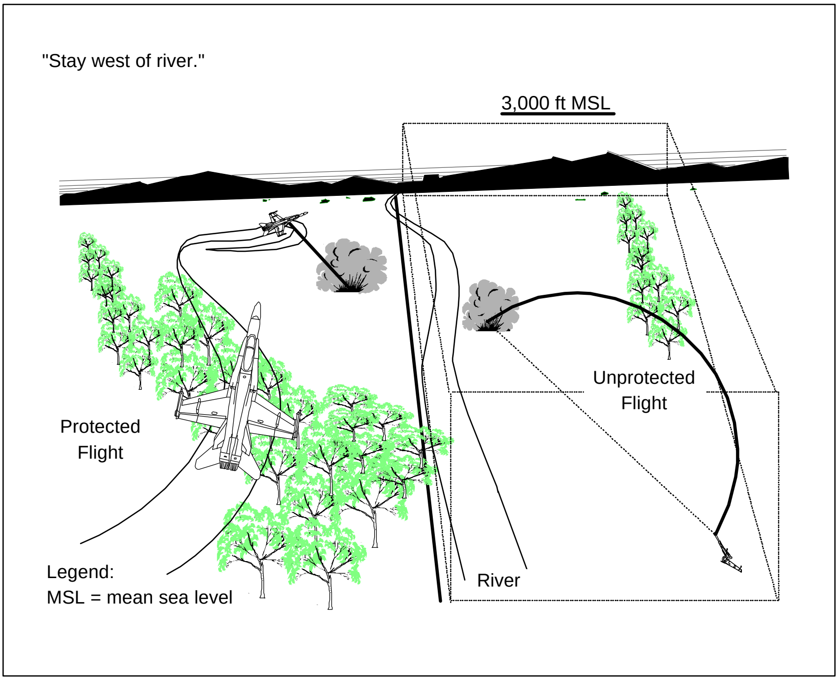


Figure 8-2. Artillery-Close Air Support Aircraft Lateral Separation.

The minimum separation distance between SEAD targets and aircraft routes varies based on SEAD ordnance and its fragmentation pattern. Terminal controllers or the FSCC must know the GTL so that they can restrict aircraft from crossing trajectories. Establishing a temporary informal ACA is one method of maintaining lateral separation, for example, “stay out of quadrant northeast of grid 6215” or “stay west of river.”

(2) Altitude Separation. Altitude separation is effective when aircraft can safely remain above or below indirect-fire trajectories. Establishing a temporary informal ACA is one method of maintaining altitude separation, for example, “stay above 3,000 feet mean sea level.” (See figure 8-3.) This technique can be used to support high-level CAS attacks. Altitude separation can also be limited to a specific area to give aircraft more freedom to maneuver, for example, “stay below 500 feet mean sea level in quadrant northeast of grid 6215.” (See figure 8-4 on page 8-10.) MCWP 3-16 discusses computation of altitudes.

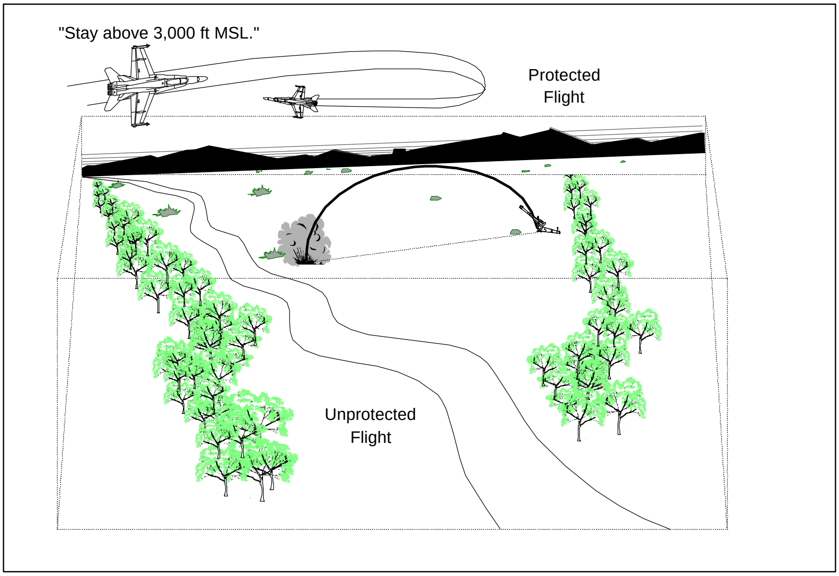


Figure 8-3. Artillery-Unmanned Aerial Vehicle Altitude Separation.

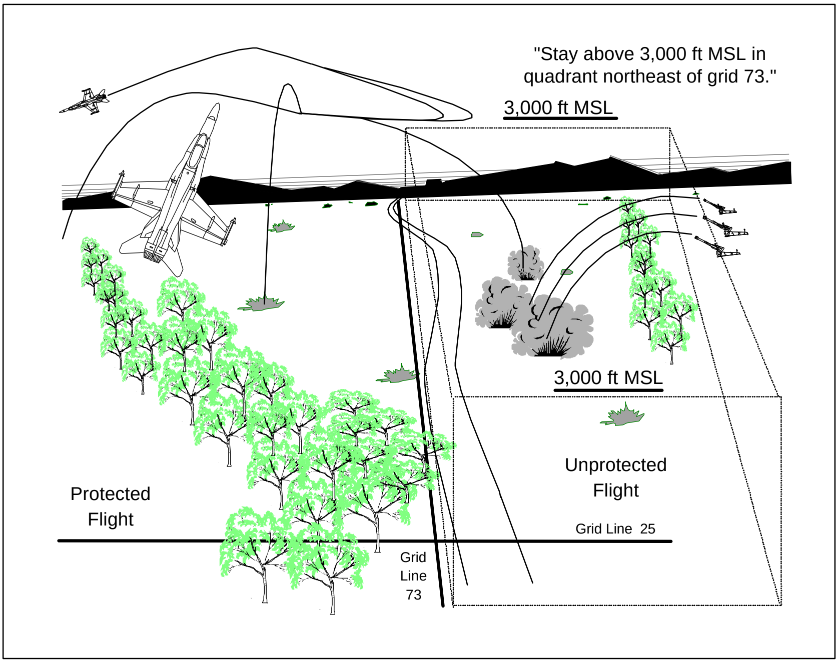


Figure 8-4. Artillery-Close Air Support Aircraft Altitude Separation.

(3) Altitude and Lateral Separation. Altitude and lateral separation is the most restrictive technique for aircraft routing but may be required when aircraft must cross the firing unit's GTL. This technique requires aircraft to remain above or below indirect-fire trajectories at certain points. For low-level CAS attacks, this technique is effective when aircraft and firing units engage safely separated targets but the CAS target requires crossing the GTL. (See figure 8-5.) This technique is also effective in protecting helicopters if they can be routed to fly under SEAD indirect-fire trajectories and away from SEAD targets. (See figure 8-6 on page 8-12.) Separation may be increased by firing high-angle or reduced charge. Establishing a temporary informal ACA is one method of maintaining altitude and lateral separation, for example, “stay below 1,000 feet mean sea level and between north-south grid lines 58 and 62.”

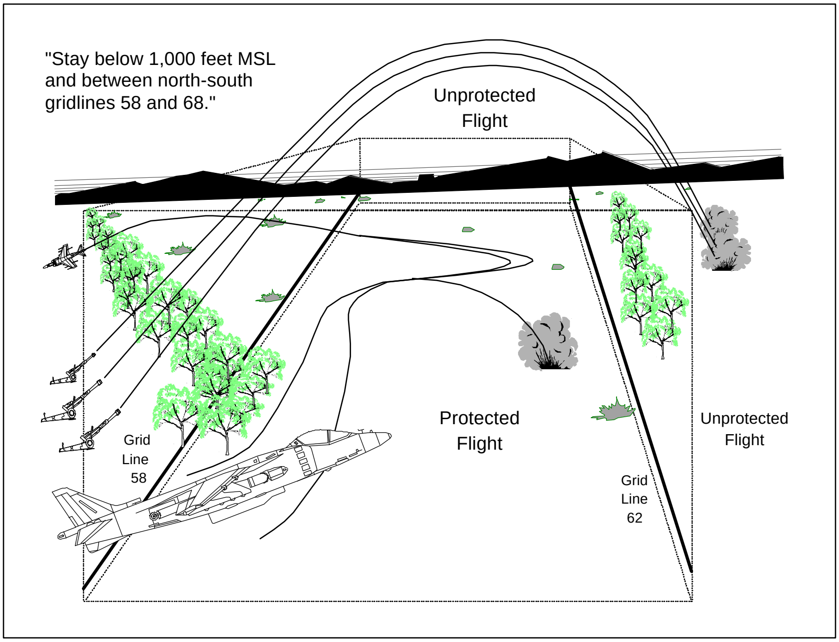


Figure 8-5. Artillery-Close Air Support Aircraft Altitude and Lateral Separation.

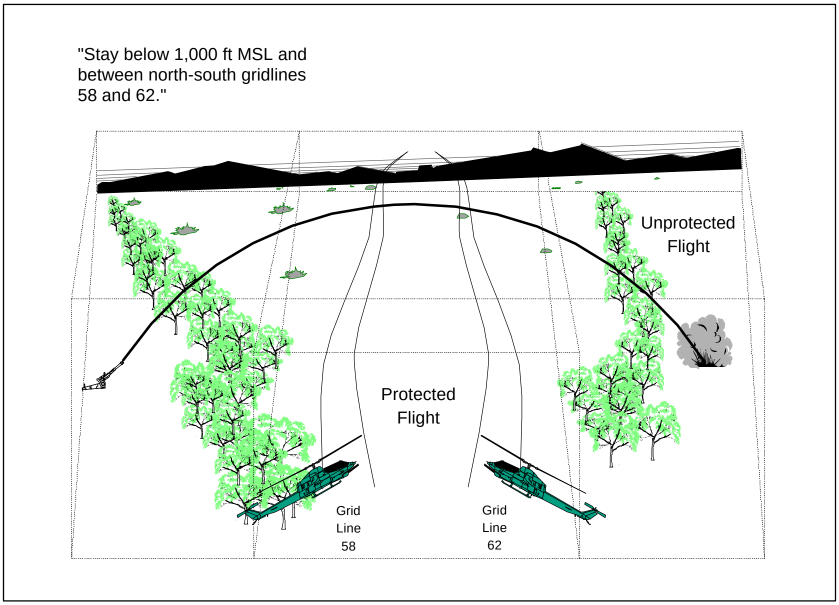


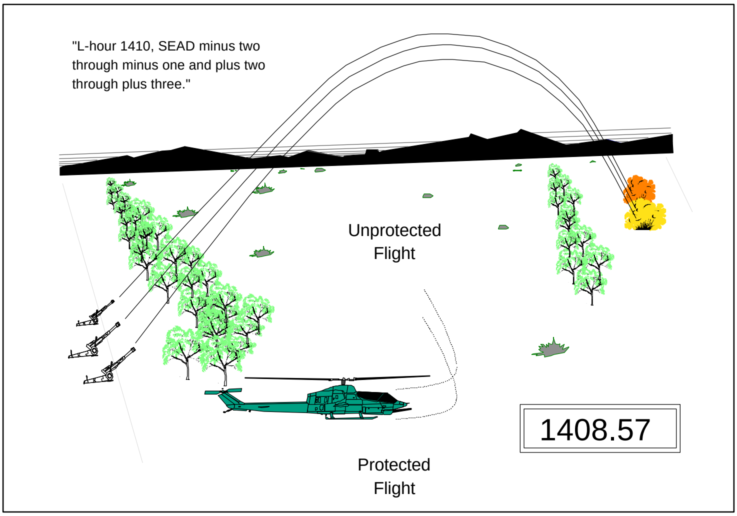
Figure 8-6. Artillery-Assault Support Aircraft Altitude and Lateral Separation.

When CAS and indirect fires engage the same target, a stay-above altitude incorporating the fragmentation effects can be determined. (See MCWP 3-16.) A lateral offset in the form of a final attack heading or cone prevents premature crossing of the GTL.

b. Time Separation. Time separation may be required when aircraft cannot be routed away from indirect-fire trajectories or SEAD targets. This technique requires the timing of SEAD fires to be coordinated with the routing of aircraft so that even though aircraft and SEAD fires may occupy the same space, they do not do so at the same time. (See figure 8-7 on pages 8-14 and 8-15.) For low-level CAS attacks, time separation can be used when aircraft are attacking targets just short of indirect fires along the GTL. (See figure 8-8 on pages 8-15 and 8-16.) All timing for SEAD fires is based on a specific aircraft event time, for example, CAS TOT/TTT, assault support L-hour, UAV mission area arrival time, and so on. In immediate SEAD fire missions, the aircraft event time becomes the zero hour or H-hour for scheduling. The preferred method for coordinating timing is the use of a previously established synchronized clock. If a synchronized clock has not been established or is not universally available, an elapsed time may be used to coordinate timing. See appendix D for instructions on establishing and communicating synchronized and elapsed times.

(1) Interrupted SEAD. The interrupted SEAD program separates aircraft and SEAD fires by halting indirect fires before the aircraft event. Interrupted SEAD fires are delivered during the first critical portion of the aircraft's approach phase, specifically from 1 minute before the CAS TOT/TTT until 30 seconds before the CAS TOT/TTT. This program is requested by stating "interrupted" as a method of fire and control.

(2) Continuous SEAD. The continuous SEAD program is used when providing suppressive fires throughout the aircraft event. Continuous SEAD fires are delivered during the critical portions of the aircraft's approach and egress, specifically from one minute before the CAS TOT/TTT until one minute after the CAS TOT/TTT. This program is requested by stating "continuous" in the method of fire and control.


"L-hour 1410, SEAD minus two
through minus one and plus two
through plus three."
Unprotected
Flight
1408.57
Protected
Flight

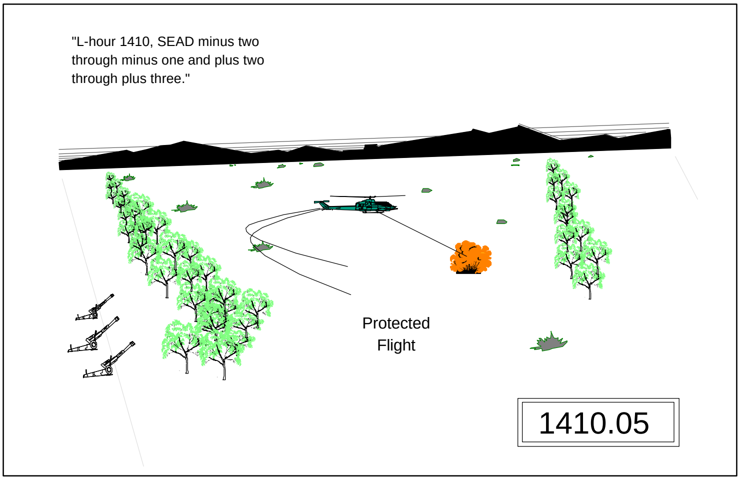

"L-hour 1410, SEAD minus two
through minus one and plus two
through plus three."
Protected
Flight
1410.05

Figure 8-7. Artillery-Tactical Recovery of Aircraft and Personnel (TRAP) Aircraft Timed Separation.

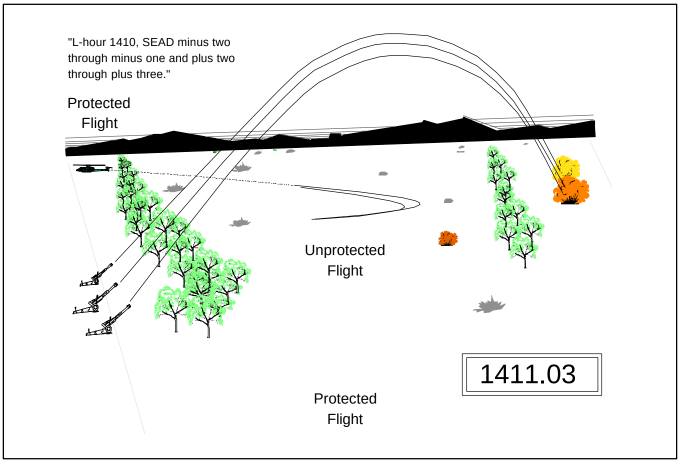


Figure 8-7. Artillery-Tactical Recovery of Aircraft and Personnel Aircraft Timed Separation (continued).

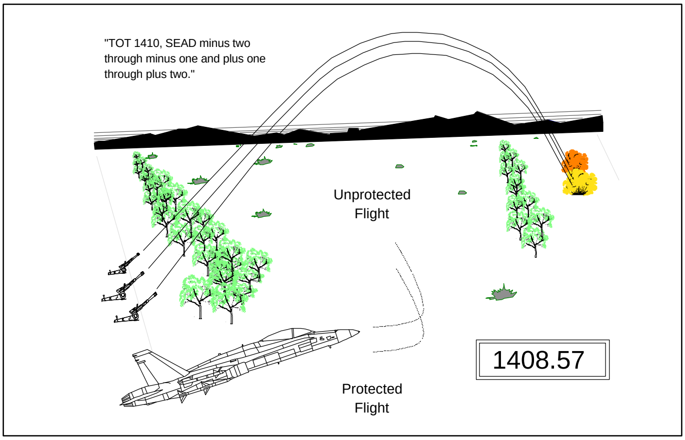


Figure 8-8. Artillery-Close Air Support Aircraft Timed Separation.

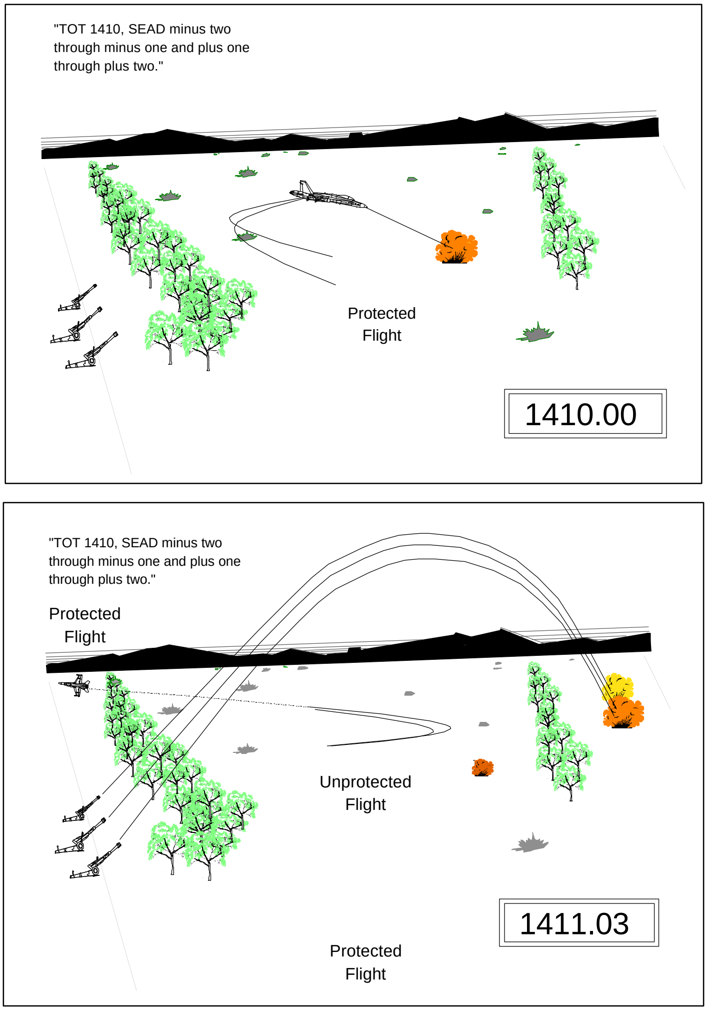


Figure 8-8. Artillery-Close Air Support Aircraft Timed Separation (continued).

(3) Nonstandard SEAD. The nonstandard SEAD program is used when suppressive fires other than interrupted or continuous are desired (specifically, for fires that begin sooner, last longer, or are intermittent). In addition to requesting “nonstandard,” desired times are specified in the method of fire and control.

Example
“Nonstandard, from minus two to plus six, additional mark at plus two.”

c. Separation Techniques. Table 8-2 summarizes appropriate separation techniques for typical CAS scenarios.

Table 8-2. Separation Techniques.

	CAS Target Same as/Near SEAD Target	**CAS Target Distant From SEAD Target**	**CAS Crosses GTL**
High-Level Attack	Altitude separation	Altitude separation	Altitude or time separation
Low-Level Attack	Time separation	Lateral separation	Altitude and lateral separation

8006. Airspace Control Measures

a. Fixed-Wing and Rotary-Wing Close Air Support. Terminal controllers, spotters, and observers must be familiar with the use of contact points, IPs, holding areas, and battle positions when coordinating SEAD fires or target marking for fixed- or rotary-wing CAS aircraft. See paragraph 4003. and MCWP 3-25/ Fleet Marine Force Manual (FMFM) 5-60, *Control of Aircraft and Missiles*, for more information on these airspace control measures.

b. Other Missions. Aircraft and UAVs conducting deep air support, air reconnaissance, assault support, offensive antiair warfare, and electronic warfare missions also use contact points and IPs. IPs are used by air reconnaissance and assault support aircraft to start a run on a reconnaissance target or landing zone. En route points and orbit points are also used by these aircraft. Aircrews use en route points to define routes of flight to and from specific areas. En route points allow specific routing of aircraft for command and control, airspace limitation, and rules of engagement (ROE) requirements. Orbit points represent geographic or electronic positions and are used to station aircraft while they await further routing instructions.

8007. Target Marking for Close Air Support Aircraft. A mark should be provided for CAS aircraft whenever possible. When one of the following marking methods is not possible, the CAS target may be identified by narrative description.

a. Laser Marking. If the CAS aircraft has a laser spot tracker, the preferred method of marking a target is by laser. The laser ensures the accurate engagement of the target by LGW but also assists the CAS aircrew in more accurately delivering unguided ordnance. Laser marks require coordinating the approach of the aircraft to correspond with the direction of the reflected laser energy.

b. Infrared Marking. Infrared pointers and other infrared devices that are now becoming available can be used by terminal controllers to mark targets at night for pilots who are wearing night vision devices. Unlike laser designators, these infrared devices cannot be used to guide or improve the accuracy of aircraft ordnance. Use infrared pointers with caution as they may expose the terminal controller to an enemy with night vision capability. Infrared marks should be initiated 20 to 30 seconds before the CAS TOT/TTT or when requested by the pilot and continue until the pilot transmits "terminate" or the weapon hits the target.

c. Marking by Indirect Fire. Artillery, NGF, and mortar munitions (specifically WP or illumination fuzed to impact on the deck) are excellent means of visually marking targets for CAS aircraft. Munition marking rounds should be delivered as close to the CAS target as possible, with WP marks timed to impact 20 to 30 seconds before the CAS TOT/TTT and illumination marks timed to impact 45 seconds before the CAS TOT/TTT. This lead time ensures that the munition marking round is in position early enough and remains visible long enough for the terminal controller to provide final control instructions and for the pilot of the lead aircraft to acquire the target. On the basis of the CAS aircraft's TOT/TTT given in the SEAD call for fire, the firing unit will determine the time to fire to ensure that the marking round impacts as required. Munition marking rounds delivered within 300 meters of the CAS target are generally considered to be effective enough to direct CAS aircraft. In case the munition marking round is not timely or is inaccurate, terminal controllers should be prepared to use a backup marking technique or rely completely on verbal instructions to identify the target to CAS pilots. If the situation requires precise marks, observers or spotters can adjust marking rounds early to ensure that accurate marks, as well as SEAD fires, are delivered to meet the CAS schedule. This may, however, alert the enemy to an imminent attack.

d. Marking by Direct Fire. Direct-fire weapons, such as the MK-19, can be used to deliver a mark. While this method may provide more responsiveness than indirect-fire marks, its use may be limited by range and the visibility of the burst in the battlespace. The MlA1 tank has no WP round and cannot be used for marking.

e. Marking by Another Aircraft. Another aircraft, such as an F/A-18D or AH-lW, can be used to deliver a marking round.

f. Backup Marks. When firing marks, backup marks should be planned. For example, artillery may be tasked to deliver the primary mark while a mortar or another aircraft may be assigned the backup mark responsibility. One consideration for planning backup marks is the difference between the TOFs of the primary and backup weapons systems. If a mortar is tasked as backup for an artillery mark, it cannot have a longer TOF than the artillery.

g. Other Means. Other means may be used to identify a target. The requesting unit may give a narrative description of the target in relation to their own position, marked by devices such as strobe lights, mirrors, or air panels, or in relation to prominent landmarks.

8008. Artillery SEAD. For artillery SEAD support of air missions, the terminal controller (e.g., FAC) coordinates aircraft routing, required suppression and marking, and timing with the artillery FO. The FO, in turn, determines the artillery firing requirements to protect aircraft from both enemy air defenses and friendly fires and passes this information to the artillery FDC in the form of a call for fire. The FSCC monitors these radio transmissions and ensures that the timing and effects of these SEAD fires are coordinated with other operations of the unit.

a. Call for Fire. The artillery SEAD call for fire is based on the standard artillery call for fire format. (See figures 8-9 through 8-12 on pages 8-22 through 8-26.) Calls for fire may include instructions for marking rounds if required.

(1) Warning Order. SEAD fire requests are identified in the warning order, for example, "SEAD," "SEAD polar," "SEAD laser polar," and "SEAD shift known point." The observer identification and the warning order constitute the first transmission of the call for fire.

(2) Target Location. Use the most accurate method of target location for the situation. The target location element of the call for fire must include the suppression target location(s) and, if required, the location for a munition marking round. Target locations are specified by stating "grid to suppress" followed by the location and "grid to mark" followed by the location. If no mark or suppression is desired, the requisite portions are omitted. The target location constitutes the second transmission of the call for fire.

Grid Example

"Grid to suppress 456 123, grid to mark 462 129, over."

Shift Example

"Suppression direction 6300, right 180, add 600, up 45, over."

Polar Example

"Suppression direction 6300, distance 2400, up 40, mark direction 6340, distance 2500, up 45, over."

Laser Polar Example

"Suppression direction 6300, distance 2413, vertical angle plus 05, over."

Immediate SEAD Decisions

Mission:	UAV high-level flight target damage assessment and reconnaissance
Targets:	One suspected ZSU 23-4; location by shift method
System/unit:	Artillery/battery one (W6T)
Mark:	None
Ordnance:	DPICM
Separation method:	Altitude
Duration/volume:	From one minute before until one minute after mission area arrival time
Timing:	TOT on synchronized clock

Immediate SEAD Call for Fire

FO: "W6T this is D2R, SEAD, shift known point one, over."
FDC: (Reads back.)
FO: "Suppression direction 3500, right 180, up 40, over."
FDC: (Reads back.)
FO: "Suspected ZSU 23-4, DPICM, minus one through plus five, UAV arrival time 1430, over."
FDC: (Reads back.)
FDC: "D2T this is W6T, platoon, 13 rounds, VT, TOF 45, over."
FO: (Reads back.)

Figure 8-9. Example of SEAD Call for Fire Using Altitude Separation and Synchronized Clock.

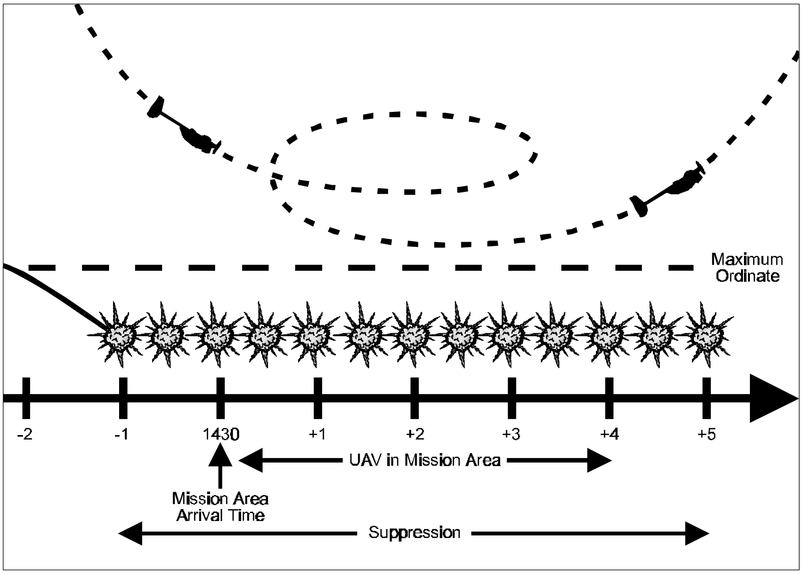


Figure 8-9. Example of SEAD Call for Fire Using Altitude Separation and Synchronized Clock (continued).

(3) Target Description. Target description is provided as in the standard call for fire. Enemy air defense positions should be identified as known or suspected to assist in developing enemy intelligence information. Target description is only given for suppression missions.

Immediate SEAD Decisions

Mission:	CH-46 assault support insert away from GTL
Targets:	One suspected ZPU-4 800 meters from landing zone; location by polar method
System/unit:	Artillery/battery one (W6T)
Mark:	None
Ordnance:	HE/VT and WP/PD
Separation method:	Lateral
Duration/volume:	From two minutes before until two minutes after L-hour
Timing:	L-hour on synchronized clock

Immediate SEAD Call for Fire

FO: "W6T this is D2R, SEAD, polar, over."
FDC: (Reads back.)
FO: "Suppression direction 5640, distance 3600, up 40, over."
FDC: (Reads back.)
FO: "Suspected ZPU-4, VT and WP, minus two through plus two, L-hour 1510, over." (Reads back.)
FDC: (Reads back.)
FDC: "D2T this is W6T, nine rounds, VT and WP, TOF 37, over."
FO: (Reads back.)

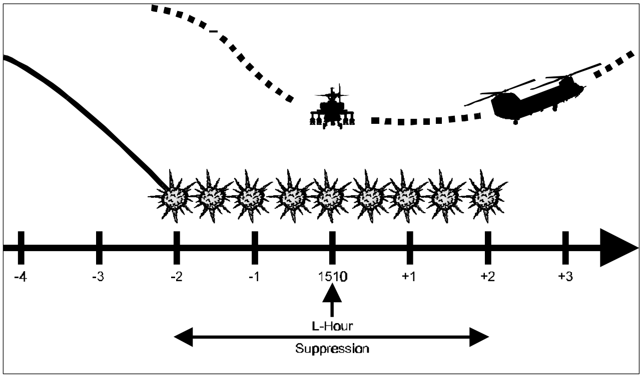


Figure 8-10. Example of SEAD Call for Fire Using Lateral Separation and Synchronized Clock.

	Immediate SEAD Decisions
Mission:	F/A-18 CAS low-level attack
Targets:	Suspected AAA site near CAS target; location by laser polar method
System/unit:	Artillery/battery one (W6T)
Mark:	Artillery
Ordnance:	SEAD HE/VT; Mark WP/PD (SOP)
Separation method:	Timing
Duration/volume:	From one minute before until 30 seconds before CAS TOT (standard interrupted SEAD program)
Timing:	Elapsed time (TTT)
	Immediate SEAD Call for Fire
FO:	"W6T this is D2R, SEAD, laser polar, over."
FDC:	(Reads back.)
FO:	"Suppression direction 4170, distance 2935, vertical angle plus 07, over."
FDC:	(Reads back.)
FO:	"Mark direction 4820, distance 2450, vertical angle plus 02, over."
FDC:	(Reads back.)
FO:	"Suspected AAA site, interrupted, CAS TTT six plus zero, zero . . . stand by . . . hack, over."
FDC:	"Suspected AAA site, interrupted, CAS TTT six plus zero, zero, out."
FDC:	"D2T this is W6T, 92 rounds, VT, TOF 42, over."
FO:	(Reads back.)

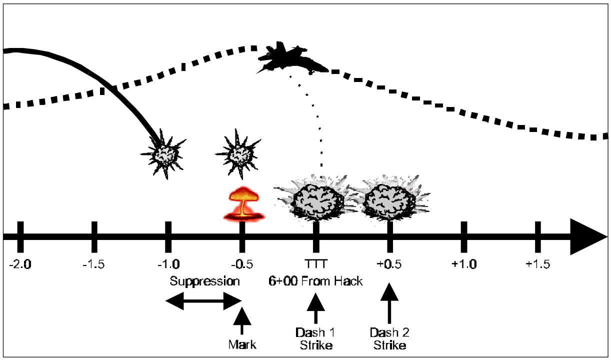


Figure 8-11. Example of SEAD Call for Fire Using Timing Separation and Elapsed Time.

Immediate SEAD Decisions

Mission:	CH-53 TRAP mission low-level flight crossing GTL
Targets:	Two suspected ZU-23s 1,000 meters beyond landing zone; location by grid method
System/unit:	Artillery/battery one (W6T)
Mark:	None
Ordnance:	HE/VT high angle
Separation method:	Altitude and lateral
Duration/volume:	From two minutes before until one minute after L-hour
Timing:	L-hour on synchronized clock

Immediate SEAD Call for Fire

FO:	
FDC:	(Reads back.)
FO:	"Grid to suppress 465 729, over."
FDC:	(Reads back.)
FO:	"Suspected ZU-23, high angle, minus two through plus one, L-hour 1745, over." (Reads back.)
FDC:	(Reads back.)
FDC:	"D2T this is W6T, seven rounds, VT, TOF 67, over."
FO:	(Reads back.)

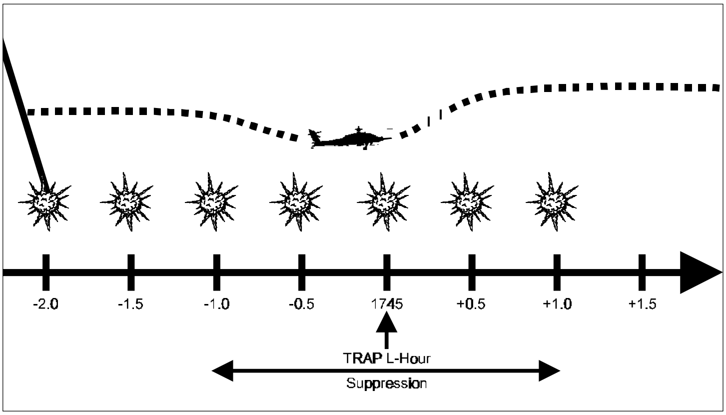


Figure 8-12. Example of SEAD Call for Fire Using Altitude/Lateral Separation and Synchronized Clock.

(4) Method of Engagement. The munition for SEAD suppression will be standardized and fired unless another shell/fuze combination is requested. Depending on the terrain and maneuver requirements, either DPICM or HE/VT will be used. Both are effective against personnel in the open (e.g., air defense gunners) and against air defense fire control and radar devices on antiaircraft artillery (AAA) and surface-to-air missiles (SAMs). DPICM is more effective in terms of size and probability of area coverage. However, HE/VT may be preferable in forested or future maneuver areas. WP/PD (fuzed to impact on the ground) is the standard munition for marking and will be fired unless another shell/fuze combination is requested. WP is a good general-purpose marking munition because it provides a reliable quick-building burst, is distinguishable from HE bursting in the battlespace, and remains visible for many seconds. Other shell/fuze combinations that may be effective in suppressing enemy air defenses and marking CAS targets include the following.

(a) Illumination. Illumination fuzed to burn on the deck is an effective mark. Illumination marks can affect FLIR systems. At night, this light is generally too intense for aircrews operating with night vision devices. Illumination can also be employed for suppression to confuse the acquisition systems of heat-seeking missiles such as the SA-7/14, SA-9/13, and SA-16. It can also produce some confusion for radar guidance systems. Illumination flares in the air during an aircraft’s ordnance delivery can confuse antiair radar and infrared-seeking missiles. The optimum HOB of the illumination flare for suppression is 300 to 400 meters above ground level in between CAS and the suspected ADA position.

(b) Smoke. Smoke can be used to hinder optical acquisition of CAS aircraft by the enemy. The use of smoke will interfere with optical acquisition systems of small arms, machine guns, and most AAA and tactical SAMs. Smoke must be positioned so as not to hinder the pilot's ability to acquire the target or marking round. If an enemy ADA unit is located well enough to obscure, it is preferable to destroy it.

(5) Method of Fire and Control. The method of fire and control includes instructions for timing and duration of SEAD fires. For immediate SEAD fire missions, the aircraft event time (e.g., CAS TOT/TTT, assault support L-hour, UAV mission area arrival time, etc.) serves as the basis, or zero hour, from which artillery fires are scheduled. Fire and control instructions include the starting and ending times for suppression fires and the aircraft event time from which fires are timed. The standard suppression times are expressed as either "interrupted" or "continuous." "Nonstandard" includes plus or minus minutes from zero hour, for example, "minus two through plus one." More than one interval of suppression fires may be specified if SEAD fires are nonstandard, for example, "minus two through minus one, plus one through plus two." Aircraft event times should be expressed as a time on the synchronized clock, for example, "CAS TOT 1305." If a synchronized clock is not available, express aircraft event time as an elapsed time, for example, "CAS TTT six plus zero, zero . . . stand by, hack," or in relation to another event, for example, "H-hour plus 10 minutes."

Refer to appendix D for instructions on establishing and communicating synchronized and elapsed times.

b. Message to Observer. The artillery unit will transmit a normal MTO. In addition, TOF should be requested to allow observers to determine that fires will impact as desired.

8009. Naval Gunfire SEAD. For NGF SEAD support of aircraft missions, the terminal controller (e.g., FAC) coordinates aircraft routing, required suppression and marking, and timing with the NGF spotter. The spotter, in turn, determines the NGF requirements to protect aircraft from both enemy air defenses and friendly fires and passes this information to the naval surface fire support (NSFS) ship in the form of a call for fire (there is no standard call for fire for NGF SEAD; the spotter tailors it for each specific mission). The FSCC monitors these radio transmissions and ensures that the timing and effects of these SEAD fires are coordinated with other operations of the unit. The NGF SEAD call for fire is based on the standard call for fire format. (See figures 8-13 and 8-14 on pages 8-30 through 8-31.) Calls for fire may include instructions for marking rounds if required.

a. Call for Fire

(1) Warning Order and Target Number. SEAD fire requests are identified in the warning order, for example, "SEAD fire mission." The spotter identification, warning order, and target number constitute the first transmission of the call for fire.

Example
"T4R this is E3P, SEAD fire mission, target number NZ 3101, over."

Immediate SEAD Decisions

Mission:	CH-46 assault support inserted away from GTL
Targets:	One suspected ZPU-4 along flight route, one suspected AAA site 800 meters from landing zone; location by grid method
System/unit:	NGF/*USS O'Bannon* DD-987 (V4G)
Mark:	None
Ordnance:	HE/CVT (standard)
Separation method:	Lateral
Duration/volume:	First target: three minutes before to two minutes before L-hour; second target: one minute before to one minute after L-hour
Timing:	L-hour at 1510 on synchronized clock

Immediate SEAD Call for Fire

Spotter:	"V4G this is C5E, SEAD fire mission, target numbers AF 0015 and AF 0016, over."
Ship:	(Reads back.)
Spotter:	"Suppression grid 716 532, altitude 90, suspected ZPU-4, minus three through minus two, suppression grid 765 567, altitude 80, suspected AAA site, minus one through plus one, negative mark, L-hour 1510, over."
Ship:	(Reads back.)
Ship:	"AF 0015 GTL 1140, summit 1000, ready 16, over."
Spotter:	(Reads back.)
Ship:	"AF 0016 GTL 1420, summit 1100, ready 19, over."
Spotter:	(Reads back.)

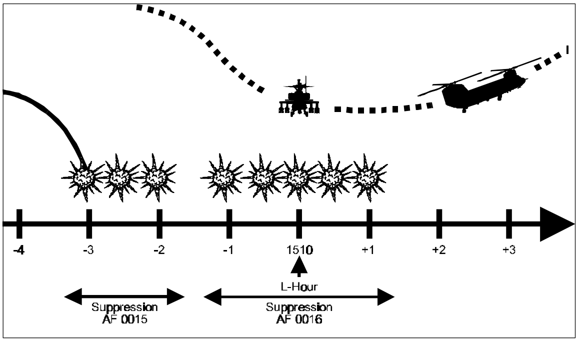


Figure 8-13. Example of SEAD Call for Fire Using Lateral Separation and Synchronized Clock.

Immediate SEAD Decisions

Mission:	F/A-18 CAS low-level attack
Targets:	Suspected AAA site near CAS target; location by polar method
System/unit:	NGF/*USS Leftwich* DD-984 (Y2P)
Mark:	NGF
Ordnance:	SEAD HE/CVT; mark WP/PD (standard)
Separation method:	Timing
Duration/volume:	From one minute before until 30 seconds before CAS TOT (standard interrupted SEAD program)
Timing:	Elapsed time (TTT)

Immediate SEAD Call for Fire

Spotter:	"Y2P this is C5E, SEAD fire mission, target number AF 0017, over."
Ship:	(Reads back.)
Spotter:	"Suppression direction 5640, distance 3600, up 40, suspected AAA site, interrupted, mark direction 5670, distance 3800, over."
Ship:	(Reads back.)
Spotter:	"CAS TTT 10 plus zero, zero . . . stand by . . . . hack, over."
Ship:	"CAS TTT 10 plus zero, zero, out."
Ship:	"Suppression GTL 1310, summit 900 feet, ready 12, over."
Spotter:	(Reads back.)
Ship:	"Mark GTL 1290, summit 900 feet, ready 12, over."
Spotter:	(Reads back.)

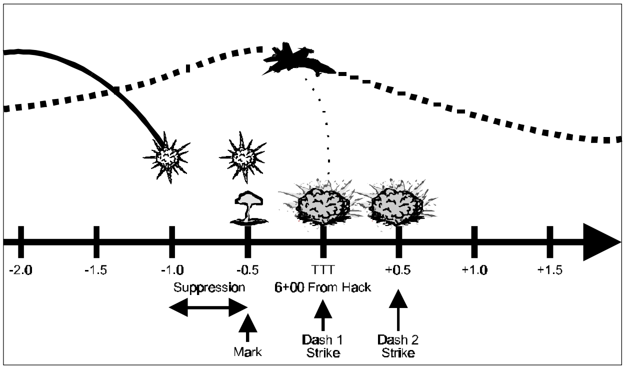


Figure 8-14. Example of SEAD Call for Fire Using Timing Separation and Elapsed Time.

(2) Target Location. Use the most accurate method of target location for the situation at hand. The target location element of the call for fire must include the suppression target location(s) and, if required, the location for a munition marking round. In the call for fire, all suppression target information, that is, target location, target description, method of engagement, and method of control, should be stated before information is given on a second suppression target or the mark target. Target locations are specified by stating "suppression" followed by the location and "mark" followed by the location or "negative mark" if no mark is desired.

(3) Target Description. Target description is provided as in the standard call for fire. Enemy air defense positions should be identified as known or suspected to assist in developing enemy intelligence information.

(4) Method of Engagement. The standard method of engagement for SEAD suppression is HE/CVT, one gun, sustained fire, interval 10 seconds for suppression. For NGF marks, the standard is WP/PD fired to impact at 20 to 30 seconds before the aircraft event time. These standards will be fired unless another method of engagement is specifically requested. The effects of NGF HE/CVT are similar to those of artillery HE/VT. Because some ships may not carry WP, illumination may have to be used as a mark. Illumination marks should be timed to burst 45 seconds before the aircraft event time and fuzed to burn on the deck. The effects of NGF illumination are similar to those of artillery illumination.

The method of engagement includes instructions for timing and duration of SEAD fires. Engagement instructions include the starting and ending times for suppression fires relative to the aircraft event time. The aircraft event time is stated in the method of control element of the call for fire. Suppression times are expressed as plus or minus minutes from zero hour, for example, “minus two through plus one.” More than one sequence of suppression fires may be specified if fires on that target must be interrupted, for example, “minus two through minus one, plus one through plus two.” To abbreviate the SEAD call for fire to support CAS missions, two standard programs are established for typical SEAD scenarios.

(a) Continuous SEAD. The continuous SEAD program may be used when separating aircraft and SEAD fires by distance. This program is generally effective when the SEAD target is in the vicinity of the CAS target and SEAD fires will not endanger CAS aircraft. Continuous SEAD fires are delivered during the critical portion of the CAS aircraft’s attack phase and egress, specifically from one minute before the CAS TOT/TTT until one minute after the CAS TOT/TTT. This program is requested by stating “continuous” instead of desired suppression times.

(b) Interrupted SEAD. The interrupted SEAD program may be used when separating aircraft and SEAD fires by time. This program is generally effective against SEAD targets that are the same as or close to the CAS target and in which SEAD effects or trajectories may endanger CAS aircraft. Interrupted SEAD fires are delivered during the critical portion of the CAS aircraft's attack phase, specifically from one minute before the CAS TOT/TTT until 30 seconds before the CAS TOT/TTT. This program is requested by stating "interrupted" instead of desired suppression times.

(5) Method of Control. For immediate SEAD NGF missions, control instructions must include the aircraft event time (e.g., CAS TOT/TTT, assault support L-hour, UAV mission area arrival time, etc.), which serves as the basis, or zero hour, from which NGF is scheduled. Aircraft event times should be expressed as a time on the synchronized clock, for example, "CAS TOT 1305." If a synchronized clock is not available, express aircraft event time as an elapsed time, for example, "CAS TTT six plus zero, zero . . . stand by, hack," or in relation to another event, for example, "H-hour plus 10 minutes." Refer to appendix D for instructions on establishing and communicating synchronized and elapsed times.

The target location, target description, method of engagement, and method of control constitute the second transmission of the call for fire. Once instructions for a target are begun in this transmission, spotters should complete the location, description, and method of engagement for that target before providing instructions for another suppression target or a mark target, for example, "suppression" first target location, description, and method of engagement; "mark" location and method of engagement. Because of the length of this transmission, information should be transmitted as it is determined, and elapsed times (TTT and hacks) should be sent as a third transmission.

Example
"Suppression grid 765 567, altitude 80, suspected SA-6, minus two through plus two, mark grid 762 575, altitude 50, CAS TOT 1305, over."

b. Message to Observer. The NSFS ship will transmit a normal MTO including the GTL, summit, and TOF. In addition to "shot," "splash" should be transmitted to assure spotters that fires will impact as desired.

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Chapter 9

Laser Designators and Laser-Guided Weapons Systems

An LGW system consists of ground and/or airborne designators used with surface- or air-delivered laser-guided munitions. These systems include laser designators/rangefinders, laser acquisition devices or seekers, laser-guided munitions, and delivery platforms. LGW systems are used by artillery FOs, NGF spotters, reconnaissance personnel, FACs, aerial observers, and aircraft pilots. This chapter will focus on the LGW systems employed by the ground observer, spotter, or terminal controller in support of the MAGTF. Additional discussion is contained in Joint Pub 3-09.1.

9001. Purpose. LGW systems provide combat units with a means of accurately locating and engaging high-priority stationary and moving point targets with first-round hit probability. They also allow for faster location and attack of the target. Artillery, ships, and aircraft can be provided with accurate target data to attack the target effectively with conventional munitions as well. The coded laser beam provides positive control between the air and the ground.

9002. Basic Requirements. The five basic requirements for using laser designators with laser acquisition devices or laser-guided munitions are as follows:

- Line of sight must exist between the designator and the target and between the target and the laser acquisition device.

- A PRF code is used for the laser designator, the laser seeker, and the laser-guided munition. Each must use the same code when operating together.
- An agreement on a direction of attack is necessary. The laser seeker or laser-guided munition must be able to sense the reflected energy from the laser designator.
- The laser designator must be designating the target at the correct time.
- The delivery system must release the munition within the specific munition delivery envelope.

9003. Laser Emission Systems. Laser target ranging and designation systems provide accurate range, azimuth, and elevation information for use in locating enemy targets or other positions. These systems vary from handheld rangefinders and pointers to aircraft-mounted designators. Laser designators provide the energy source that is reflected from a *designated* target to provide terminal guidance for laser-guided munitions. These systems emit discreet pulses of infrared energy that are invisible to the naked eye. The characteristics of these pulses are determined by a PRF code of laser energy, which can be set by a series of switches on the equipment. Laser designators/rangefinders within the Marine Corps include the MULE and the laser infrared observation set (AN/GVS-5).

a. Modular Universal Laser Equipment. The MULE (AN/PAQ-3) is a laser designator/rangefinder that is capable of designating moving targets to a range of 3,500 meters or stationary targets to 5,000 meters. Maximum range-finding capability is 9,990 meters. The MULE system has a north-seeking capability that allows self-orientation for direction, easier self-location, and readout for both grid and true azimuths. It is capable of detecting multitarget reflections. The MULE can be operated during periods of darkness or reduced visibility at slightly reduced ranges by use of the night vision set. It can interoperate directly with the digital message system. It can also be used in conjunction with the PLGR or the Position Location Reporting System (PLRS) to provide accurate observer and target location.

b. Laser Infrared Observation Set (AN/GVS-5). The AN/GVS-5 is a handheld, battery-operated laser rangefinder. It can provide only range to a target. It cannot designate targets for laser-guided munitions. The AN/GVS-5 has a 7 by 50 monocular sighting system. Accuracy is ±10 meters for distances of 200 to 9,990 meters. It can provide a maximum of 100 range readouts per battery charge. It is capable of detecting multiple target reflections.

c. Laser Target Designator/Ranger Pod. The F/A-18C/D is capable of carrying the AN/AAS-38 laser target designator/ranger (LTD/R) pod, which provides two functions. Its laser designator provides terminal weapons guidance for all laser-guided munitions and designates targets for airborne coded laser acquisition/spot trackers. The F-14 is capable of carrying the LANTIRN system. With LANTIRN, the F-14 has an accurate, autonomous designation and targeting capability for delivery of laser-guided bombs. This system is effective during the day or night and at high altitudes.

d. Night Targeting System. The AH-1W attack helicopter contains the Night Targeting System (NTS), which provides LTD/R capability, as well as FLIR visual capability and video capture. It performs the same functions as the LTD/R pod for fixed-wing platforms.

e. Illumination Devices. Handheld lasers emit infrared light for compatibility with NVGs. These devices can either flood infrared light within 1,000 meters to enhance general NVG performance or focus a small beam up to 4 kilometers to pinpoint a specific target with an infrared light beam for any weapons system employing NVGs. They are not capable of designating for a laser-guided munition.

9004. Laser Acquisition Devices. Laser acquisition devices (seekers/spot trackers) are used to acquire reflected laser energy from laser-designated targets. They are installed in aircraft for target acquisition or in laser-guided munitions for terminal guidance. Laser acquisition devices allow visual acquisition of a coded laser-designated target. They must be set to the same PRF code as the laser designator for the user to see the target being lased. There are two types of laser acquisition devices. Note that the AH-1W has the capability to use onboard HELLFIRE munitions as an improvised laser spot tracker before firing. See appendix F for all laser spot tracker-equipped aircraft.

a. Laser Acquisition/Spot Tracker Pod. The coded laser acquisition/spot tracker can be carried on the F/A-18A/C/D. Once it acquires the laser spot (target), it passes necessary ballistic information to allow FLIR or radar acquisition of the target and visual display. Desired PRF codes are in-flight selectable. It then employs LGWs or executes visual deliveries of nonlaser ordnance.

b. Angle Rate Bombing System. The angle rate bombing system (ARBS) is used on the AV-8B. It consists of a three-axis gimbaled television/laser spot tracker, which enables a view of the laser spot. It provides day or night attack and reattack information for either LGWs or nonguided bombs. The system allows in-flight selection of PRF codes but is affected by smoke or obscurants.

9005. Laser-Guided Munitions. These munitions home in on reflected laser energy during the terminal portion of the attack. Such munitions are part of the precision-guided munitions (PGM) family, which includes Copperhead, HELLFIRE, Maverick, and laser-guided bombs.

a. Copperhead. Ground or airborne designators can designate Copperhead targets. The best use of the Copperhead is against high-payoff targets outside the range of maneuver direct-fire weapons (more than 5,000 meters from the ground observer). Single or multiple targets may be engaged within a Copperhead engagement area. The Copperhead is a 155-mm cannon-launched, antitank, laser-guided projectile. The body of the projectile contains fins and wings, which deploy in flight to allow the projectile to maneuver. The Copperhead is fired in either the ballistic or shaped-trajectory mode. Upon reaching a point on its descending trajectory, the projectile acquires the reflected laser energy from the designator and maneuvers to the designated target. It has a maximum range of 16,800 meters and a minimum range of 3,000 meters. It requires at least 13 seconds of laser designation to acquire and maneuver to the target.

b. Maverick. The Maverick is an air-launched, air-to-ground missile that is available in a laser-guided variant and an infrared-seeker variant. It can be employed on the AV-8B, A-10, F-15, F-16, and F/A-18 aircraft. It can be used against field fortifications, SAM sites, and armored vehicles. The missile requires lock on before launch and continual designation during flight. Once the Maverick is launched, the aircraft can break away or launch another missile. The PRF code is cockpit selectable.

c. Helicopterborne Fire and Forget Missile. HELLFIRE is an air-launched, laser-guided, antiarmor missile launched from the AH-lW, AH-64, and OH-58D aircraft. It can be employed in indirect (lock-on after launch) or direct (lock-on before launch) fire methods. HELLFIRE can be launched in four firing modes: one missile (single), two or more missiles on the same code (rapid), two or more missiles launched on different codes using multiple laser designators (ripple), or multiple codes and designators used in a combination of rapid and ripple fire. The PRF code is cockpit selectable.

d. Laser-Guided Bombs. The MK-82, MK-83, and MK-84 are designations for the 500-, 1,000-, and 2,000-lb bombs that can be converted to the GBU-12, GBU-16, GBU-10, GBU-22, GBU-23, and GBU-24 laser-guided bombs. These bombs use common laser guidance and control subassemblies with only the aerodynamic surfaces changed to match the particular size of warhead. They can be employed in a standoff capacity. The PRF codes must be set before aircraft launch.

9006. Laser Energy Reflectivity. Laser energy is reflected in various ways, depending on the nature of the reflecting surface, the angle at which the laser energy strikes the target surface, and the laser beam divergence. This information is important in determining where the laser acquisition/tracking device or seeker needs to be to acquire and home in on the reflected energy spot.

a. Laser Spot Size. The laser energy or beam increases in size at a constant rate from its source. This spreading is a function of the designator itself and the distance to the target being designated. This is called beam divergence. Figure 9-1 on page 9-8 shows the effect of distance on spot size. For the MULE, the laser energy spot size can be estimated for any distance by using the following rule of thumb: spot size is equal to three inches plus eight times the OT distance (in thousands of meters).

Example
OT distance = 3,000 m
MULE spot size = 27 in (3 in + (8 x 3) = 27 in)

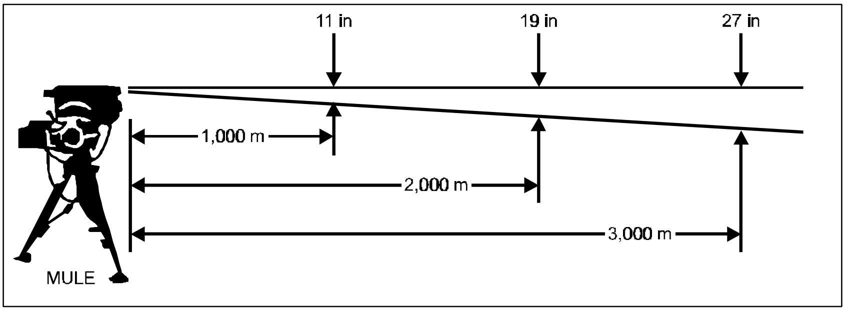

Figure 9-1. Modular Universal Laser Equipment Spot Size.

b. Target Surface Reflectivity. Targets contain a combination of mirrorlike (e.g., windshields, windows, and shiny metal) and low-reflectivity surfaces. Mirrorlike surfaces should not generally be designated because the reflective energy does not spread sufficiently to allow the seeker to acquire it. Certain materials are better reflectors of laser energy than others. Targets with greater reflectivity increase the probability of a laser seeker picking up the laser spot. Attack headings for air-delivered munitions should be outside the safety zone—the area 10 degrees (180 mils) on either side of the laser designator. LGWs launched within the 20-degree (360-mil) safety zone could receive false target indications and acquire the designator. The safest acquisition area for an LGW is more than 10 degrees (20 mils) but less than 60 degrees (1,100 mils) off the laser target line. This provides a 50-degree (900-mil) cone to either side of the laser target line for an ideal attack heading as shown in figure 9-2 on page 9-9. Terminal controllers employing laser designators must provide aircrews with an attack heading within that cone.

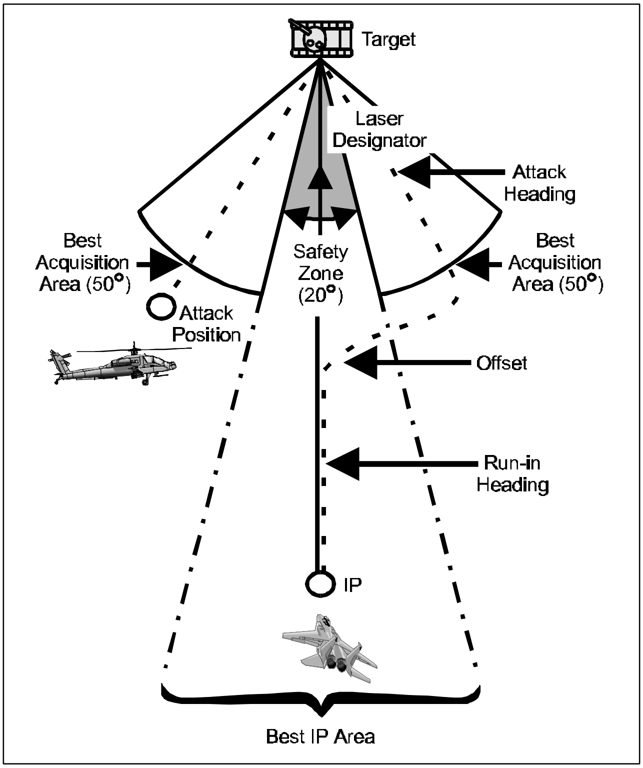

Figure 9-2. Safety Zone and Optimal Acquisition Area for Delivery of Laser-Guided Weapons.

The best results are normally obtained when designated targets reflect the beam upward and toward the incoming seeker or munition. The amount of laser energy that is reflected from a target is difficult to determine and is material dependent. (See table 9-1 on page 9-10.)

Table 9-1. Energy Reflection.

Material	Reflectivity Percentage
Brick	55 - 90
Vegetation	30 - 70
Unpolished aluminum	55
Olive drab metal (dirty)	2 - 30
Asphalt	10 - 25
Concrete	10 - 15
Water	2

c. Energy Reflection on Various Surfaces. A brief description of how the energy is reflected from various types of surfaces follows.

(1) Mirrorlike Reflections. The laser energy reflects in a narrow path from flat, bare, shiny metal as well as glass surfaces as shown in figure 9-3 on page 9-11. Any seeker looking for this laser energy would have to be in this narrow area of reflection to acquire the spot. These surfaces are not suitable for laser designation.

(2) Scattered Reflections. Laser energy scatters in a large spherical arc from flat, low-reflectivity surfaces. (See figure 9-4 on page 9-11.) These surfaces are suitable for laser designation.

(3) Spillover. Laser energy spillover occurs when the laser spot is larger than the target. It is usually caused by beam divergence but may be caused by a careless designator operator. Reflections from objects near the target may occur. (See figure 9-5 on page 9-12.) When this happens, the seeker may acquire the wrong spot.

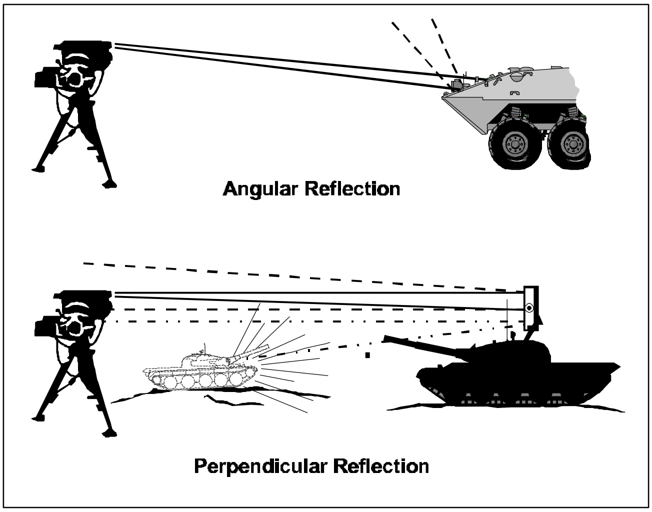

Figure 9-3. Mirrorlike Reflections.

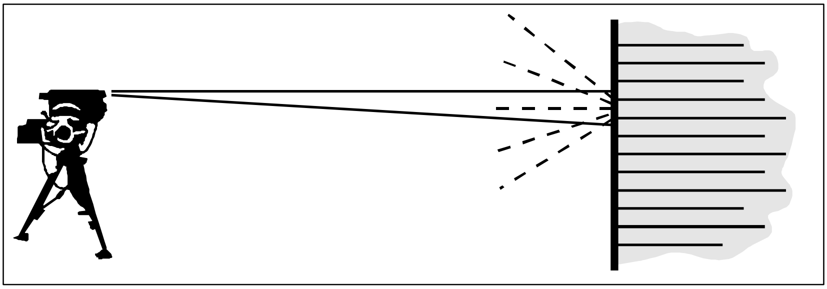

Figure 9-4. Scattered Reflections.

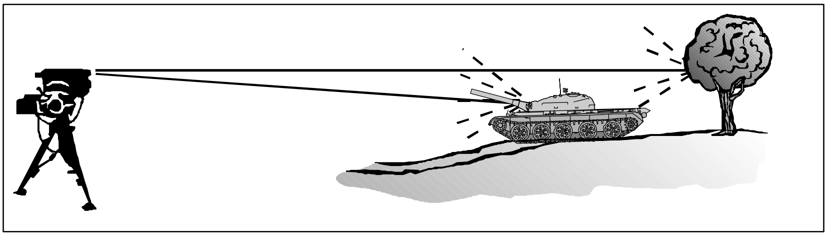

Figure 9-5. Laser Spillover.

(4) Blocked. If the seeker is not in the proper position, laser energy reflections from the target can be blocked from the seeker by intervening objects or by the target itself. (See figure 9-6.)

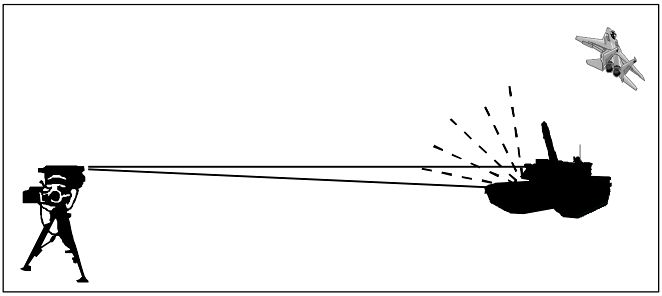

Figure 9-6. Blocked Reflection.

(5) Absorbed. Aiming the designator into tunnels and other targets causes laser energy to be absorbed. Instead, the operator must aim the designator slightly above a tunnel opening; this would allow a munition to impact at that critical point. For munitions like laser-guided bombs that tend to impact short of the point being designated, this type of designation could guide the bomb into the tunnel opening. (See figure 9-7.)

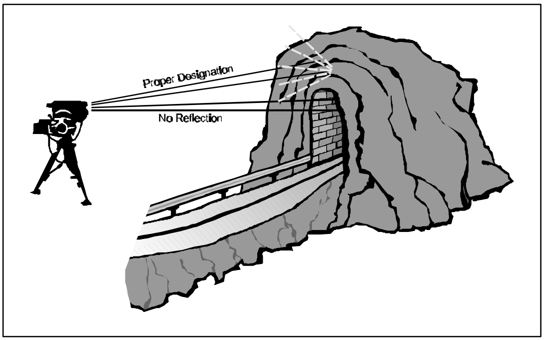

Figure 9-7. Concave Targets.

9007. Laser-Guided-Munition Planning

a. Laser Designator Planning Factors. Based on the commander's guidance, the observer must consider the following factors when employing the MULE:

- Environmental conditions
- Designator location relative to target and delivery system
- Laser designator aiming points
- Communications
- Mobility.

b. Mission Execution/Employment Factors. In addition to the five basic requirements established in paragraph 9002., the observer must also consider the following key factors when employing laser-guided munitions.

(1) Enemy Countermeasures. Judicious use of laser target designators will limit the enemy's countermeasures capability.

(2) Battlespace Obscuration. The effects of smoke, dust, and debris can impair the use of laser-guided munitions. The reflective scattering of laser light by smoke particles may present false targets. The operator can use night sight, alternate positions on higher ground, and alternate designators to reduce smoke effects.

(3) Terrain/Vegetation. Irregular terrain and vegetation will affect line of sight.

(4) Weather. Rain, snow, fog, and low clouds can prevent effective use of laser-guided munitions. Heavy precipitation can limit the use of laser designators by affecting line of sight. Snow on the ground can produce a negative effect on the accuracy of laser-guided munitions. Extreme temperatures (below 32 degrees) can affect MULE battery life and may require the use of an external power adapter. In low temperatures, placing the battery close to the body under heavy clothing will help to preserve its life. Fog and low clouds will block the laser-guided-munition seeker's field of view, reducing the guidance time. This reduction may affect the hit probability.

(5) Darkness. Targets are more difficult to locate, range, and designate during periods of poor visibility.

(6) Target Shape. Poorly defined targets such as caves and tunnels may absorb the laser spots.

(7) Seeker/Laser Designator Alignment. The direction of attack/GTL must be within the allowable mission attack angle. Laser-guided, air-launched munitions should attack the target within 60 degrees (1,100 mils) to either side of the designator target azimuth. (Some munitions may require a smaller angle.) The closer the weapon approach angle is to the designator target azimuth (provided it is at least 10 degrees (180 mils)), the greater the probability of target acquisition and hit. Copperheads require an angle of no greater than 45 degrees on either side but do not require an exclusion, or safety, zone.

(8) Communications. Positive communications between the terminal controller/observer and the delivery aircraft/unit are required to coordinate the proper PRF code, the seeker/laser designator alignment, and target designation timing.

(9) Safety. The invisible laser beam is intense infrared radiation, which can cause serious eye damage and blindness.

(a) During *peacetime*, the use of laser-guided munitions imposes strict safety requirements during training exercises. Operators must adhere to range and unit safety SOPs when employing laser-guided munitions.

b) During *combat*, the operator must take care to avoid friendly casualties from indiscriminate laser designation. Caution should also be taken in designating specular surfaces, which can cause dangerous reflected beams. The use of binoculars and similar optical devices during airborne or ground lasing greatly increases the possibility of eye damage. Ground troops in the target area should use safety goggles when working with aircraft that can designate targets. The terminal controllers must be aware of friendly front lines when planning the attack heading for aircraft ordnance delivery.

c. Seeker Lock-on to Designator. Laser seekers may occasionally lock on to the designator instead of the target. Intervening grass or leaves, for example, could reflect sufficient laser energy to cause seeker lock-on. To prevent seeker lock-on to the designator position, the designator should be masked from the seeker's field of view by terrain, vegetation, or a temporary screen such as blankets or a tarp. When the seeker's progress indicates a seeker lock-on to the designator, it may be possible to prevent a mishap by aborting the aircraft's bombing run or by turning off the designator.

d. Pulse Repetition Frequency Codes. Laser coding permits the simultaneous use of multiple laser designators and laser-guided seekers/weapons. Laser designators and seekers use a PRF coding system to ensure that a specific seeker and designator combination works in harmony. By setting the same code in both the designator and the seeker, the seeker will track only the target that is designated with that code.

(1) Code Description. The system uses either a three- or four-digit numeral system, depending on the type of laser equipment. Three-digit settings range from 111 to 788, and four-digit settings range from 1111 to 1788. All three- and four-digit designators/seekers are compatible. When employing three- and four-digit designators/seekers, the first digit of the four-digit code must always be set to one. The remaining digits of the two systems must then match. For example, a four-digit code of 1657 would be compatible with a three-digit code of 657.

(2) Code Allocation and Assignment. LGW system codes are controlled and coordinated. At the MAGTF level, different blocks of codes are assigned to artillery, air, and NGF to prevent interference between supporting arms activities. Each supporting arm then assigns codes to its subordinate units for individual missions. It also changes codes periodically as the situation requires. Subordinate FSCCs provide positive coordination of the code settings through the various fire support representatives. For individual missions, the munition delivery system (artillery, ships, aircraft) employs the codes. For CAS, codes are ultimately assigned to each flight so that no two flights are in the air at the same time with the same code. When an aircraft is on station, the pilot passes the code to the terminal controller. The terminal controller then coordinates with the MULE operator to ensure that the MULE is set to the same code as the aircraft. Individual aircraft may carry LGWs with different preset codes to accommodate multiple aircraft attacks or multiple weapon releases or to allow variation in codes used on consecutive attacks.

(3) Security. PRF codes are handled in the same manner as other classified material. Secure means should be used, if available, when the codes are passed between laser designators and the munition delivery unit/aircraft. However, the absence of compatible secure means should not normally dictate the termination of a laser-guided munition attack. In certain situations, codes will be prebriefed.

e. Effect on Mission. The adverse effects of the mission execution/employment factors can often be overcome by skillful employment of the designators. Enemy countermeasures can be minimized by aiming the laser designator at an object near the target instead of directly on target (offset designation). Laser-guided munitions can be employed against high-priority targets early in the battle before smoke and dust obscure the battlespace. Targets downwind can be attacked first if priorities permit. Use of preplanned aiming points and laser-guided munition *footprints* can help to overcome effects of obscuration, weather, vegetation, and terrain. Use of a night sight on the designator will overcome the effects of darkness and can assist during periods of poor visibility and inclement weather.

9008. Methods of Employment. Laser-guided munitions are employed in the ground and airborne modes.

a. Ground Mode. Ground laser designators identify targets for artillery, NGF, and aircraft-delivered munitions. MULE-equipped teams can employ laser-guided munitions from all delivery means requiring laser designation. Standard calls for fire are used, but the laser code must be exchanged between the ground designator and the firing unit or the aircraft.

b. Airborne Mode. Airborne laser designators identify targets for artillery, NGF, and aircraft-delivered munitions. Airborne designator systems operating in support of ground maneuver forces have the ability to employ all types of laser-guided munitions. Standard calls for fire or requests for air support are used, but the code being used must be exchanged.

9009. Employment Considerations

a. Designator Aiming Point Considerations. The range, size, shape, reflectivity characteristics, location, and motion of a target all have a bearing on the technique of employing a laser designator. When lasing a target by using a night sight device, the operator must be trained. As an example, the operator should know that the infrared signature of a target will be at the highest concentration of heat. In the case of a moving vehicle, this heat concentration will be slightly behind the designated lasing point of the target. Generally speaking, a flat surface is the most favorable surface for designation because it is perpendicular to the direction of the incoming ordnance. If there is not a flat surface, then a curved or irregular surface facing the direction of the incoming ordnance will generally be a satisfactory aiming point.

b. Technique. The distance from the laser to the target determines the size of the laser spot. To reduce spillover, the MULE should be aimed so that the spot projects partially in front of the target with the remainder on the target.

(1) Target and Laser Spot Size. If the target is larger in size than the laser spot, a point on the target should be selected at which to place the spot. The point selected should optimize conditions for spot tracking and weapon guidance. The direction from which the attack will be made and the shape, angular relationship, and reflectivity of the target surface must be considered. In situations where the laser spot is quite small, care must be taken not to aim the laser into an opening because the opening will absorb the reflected energy.

(2) Masked or Obscured Targets. If the operator suspects that the target may be partially masked from the view of the incoming seeker, he should aim the laser at a point on the target that he believes will be within line of sight of the seeker. In situations where the target is concealed, it may be necessary to aim the laser spot at some overhead or nearby object. For example, in designating a vehicle under a tree, the laser spot can be positioned in the foliage overhead.

(3) Moving Targets. In tracking a moving target, the operator may have to designate a point near the target and wait until the target moves into the designated spot. If the target moves out of sight during lasing, the laser spot may be shifted to another target in the vicinity. If the laser spot tracker or laser-guided ordnance has already locked on, the spot should be moved slowly to the new location to avoid interrupting the laser output.

(4) Survivability. For observer survivability, designation time should be minimized. Minimizing the designation time will reduce the time available for the enemy to detect, locate, and suppress the designator. The operator may lase a spot a distance away from the target and walk the spot to the target for the terminal portion of the attack. This technique is called offset laser designation. It minimizes laser on-target time and requires that the operator be advised of the progress of the attack to ensure that the spot is on target at the proper time. The operator must not move the spot through any location that is masked from view by the attacking aircraft or guided ordnance.

(5) Power Sources. Designation time should also be minimized to conserve MULE battery life. The life span of recharged batteries is variable and often short. A fresh battery should be installed when preparing to designate targets. Likewise, even under vehicular power, it is possible to damage MULE components by continuous lasing; the duration of continuous designation should not exceed one minute.

c. Designator Operator Positioning Considerations. The MULE operator selects his position based on line of sight, cover and concealment, maximum coverage of operations, and communications requirements. Next, the MULE operator determines the standoff distance. Standoff distance must be properly used when observing enemy avenues of approach and chokepoints. The vulnerability of the designators must be considered when designating point targets such as tanks, BMPs, and guns. Although standoff may increase survivability of the designator, the operator must be aware that the beam divergence at long standoff ranges could preclude effective point-target designation. The operator should select positions that are near expected locations of high-priority targets while minimizing risks to friendly forces. The site(s) must be coordinated with the positioning of other antiarmor weapons, such as the tube launched, optically tracked, wire command link guided missile (TOW) and Dragon. All antiarmor weapons, including the MULE, must be deployed to ensure mutual support and coordination. To increase survivability of the MULE, the observer should consider hardening the site, for example, with a pit similar to a machine gun horseshoe pit. Deployment of the MULE can be accomplished by manpack, vehicle, or helicopter.

9010. Copperhead Engagement Characteristics. The capabilities of the Copperhead are coupled with certain delivery requirements. These do not negate the effectiveness of the Copperhead, but are important in planning Copperhead engagements. Factors that must be considered for a successful Copperhead mission include:

- Visibility requirements
- Engagement footprint
- Target mobility.

a. Minimum Visibility Requirements. Visibility requirements include the observer's laser visibility of the target and the Copperhead's visibility of the reflected laser energy. The maximum effective range for designating stationary targets with the MULE is

5,000 meters; for moving targets, the range is 3,500 meters. Airborne platforms can designate from greater distances; however, the munition itself has a minimum visibility requirement of 5,000 meters. The operator can use the MULE to range the farthest visible terrain feature and determine its distance. If the distance measured is 5,000 meters or greater, the minimum visibility requirement is met. Minimum visibility should be updated periodically and transmitted to the FDC.

b. Time of Flight/Angle T. The Copperhead's additional visibility requirements are based on the TOF, angle T, and cloud height. During the last 13 seconds of the Copperhead's flight, the round acquires the laser energy reflected from the target and begins maneuvering toward it. The target, or offset aim point, must be continuously lased during this period. The minimum range from gun to target of 3,000 meters guarantees the minimum 13-second TOF needed to acquire and maneuver to the target. The angle T between the observer and GTL must be 800 mils or less. This ensures an adequate angle for the Copperhead to acquire reflected laser energy. There is *no* requirement for a 20-degree exclusion zone with the Copperhead. TOF and angle T are provided in the MTO for Copperhead missions. The other factor affecting Copperhead visibility is cloud height.

c. Observer Cloud Height. Target cloud height significantly affects the performance of the Copperhead round. Cloud ceilings that are too low will not allow the Copperhead round enough time to lock on and maneuver to the designated target. Besides reporting his location to the FDC, the operator must report the cloud height from his position whenever Copperhead munitions are available. The FDC uses the reported observer cloud height to compute the best trajectory for acquiring the target. If the observer believes that the cloud coverage has changed significantly, he should update the FDC. The following procedures are used to determine operator cloud height.

(1) Elevate the MULE to a vertical angle of +300 mils toward the area of responsibility. Select the range mode on the rangefinder and measure the slant range to the cloud base.

(2) Express the slant range to the nearest 100 meters (for example, 2,570 meters = 2,600). If the slant range is greater than 6,300 meters, the operator reports "operator cloud height greater than 1,890 meters." (1,890 meters cloud height corresponds to a range of 6,300 meters.) If the slant range is equal to or less than 6,300 meters, the operator uses the cloud height table in table 9-2 on page 9-25 to determine the cloud height.

(3) Enter the table on the left side with the nearest listed value less than or equal to the slant range. Note the difference between the entry range and the expressed range. For example, for an expressed range of 2,600, enter the table on the left side at 2,500. The difference is 100 meters.

(4) Enter the table from the top, using the difference between the entry range and the expressed range resulting from step 3. Using the example in step 3, the table would be entered in the column labeled "100."

Table 9-2. Operator Cloud Height.

Range (m)	0	100	200	300	400
1,500	450	480	510	540	570
2,000	600	630	660	690	720
2,500	750	780	810	840	870
3,000	900	930	960	990	1,020
3,500	1,050	1,080	1,110	1,140	1,170
4,000	1,200	1,230	1,260	1,290	1,320
4,500	1,350	1,380	1,410	1,440	1,470
5,000	1,500	1,530	1,560	1,590	1,620
5,500	1,650	1,680	1,710	1,740	1,770
6,000	1,800	1,830	1,860	1,890	1,920

Notes:

1. A similar table is on the cover card of the Copperhead footprint template set. Do not use that table because it was designed for the ground/vehicle laser locator designator's maximum elevation of +350 mils, which the MULE cannot reach.
2. The operator should report cloud height as soon as possible after occupying a position. He should then report changes only when the change in operator cloud height exceeds 100 meters.
3. An increase or decrease of 300 meters in measured slant range corresponds to an approximate 100-meter increase or decrease in cloud height.

(5) Extract the operator cloud height. Using the example in step 3, the operator cloud height would be 780. The operator would report the observer cloud height as "operator cloud height 780 meters, over."

d. Engagement Footprint. The ground surface area in which the round can successfully maneuver is limited. The optimal limit of engagement of the Copperhead round is called a footprint. The outer boundary of the footprint represents 50 percent of the hit probability, whereas the center of the footprint has a probability substantially higher than 50 percent. Footprints are roughly oval in shape and form around the target location sent in by the operator. Although a round can maneuver to the outside limits of the footprint, the greatest chance of hitting the target is when it is at or near the target location sent to the FDC. The greater the target location error, the lower the probability that the round will hit the target. The size and shape of the footprint are affected by the type of trajectory flown by the round, the target cloud height, and the gun-target range. Knowing the limits of the Copperhead maneuverability (footprint), the observer can determine which target to lase within the footprint boundary while the projectile still has time to maneuver.

e. Copperhead Footprint Template. The operator can use a Copperhead footprint template to map out or visualize the Copperhead footprint. (See figure 9-8 on page 9-27.) The template consists of a cover card and 13 template cards. The cover card contains an operator cloud height table on one side and minimum cloud height information on the other. The template cards are clear plastic graphical devices (1:50,000 scale). Each card has the shape of the footprint partially cut into the card. Also, each card is marked with the footprint letter code, the type of trajectory, the gun-target range, the interval, the average TOF, a center line, a target location pinhole, and an angle T scale. This information is automatically provided in the digital MTO.

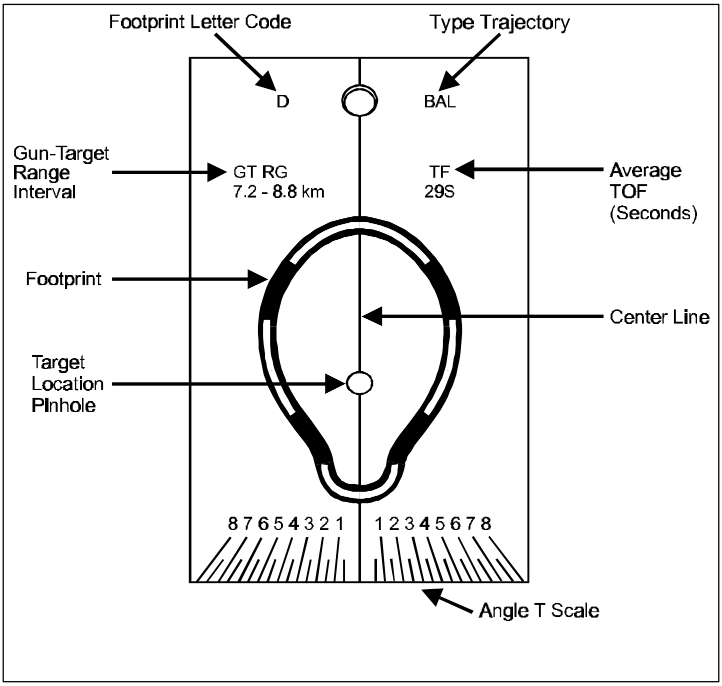

Figure 9-8. Example of Copperhead Footprint Template Card.

(1) Footprints A - D. Footprints A - D are ballistic-mode footprints. The blue color code on these sets indicates that the minimum target cloud height requirement is 10 percent of the actual gun-target range.

(2) Footprints E - I. Footprints E - I are glide-mode footprints. The blue color code indicates that the minimum cloud height requirement is 600 meters. The green color code indicates a 750-meter minimum target cloud height, and the black color code indicates a 900-meter minimum. Footprints F and H show two footprints. The smaller (blue) footprint is for a target cloud height of 600 meters. The larger (green) footprint is for a target cloud height of 750 meters or greater. For target cloud heights between 600 and 750 meters, the operator should draw both footprints and visually interpolate the size of the footprint between these two target cloud heights.

(3) Footprint L. Footprint L is a high-angle footprint. The red color code indicates a minimum cloud height requirement of 2,120 meters.

f. Selecting and Orienting the Template Card. During target planning, the operator selects the appropriate footprint on the basis of the expected gun-target range and location of the battery with which he habitually operates. For refinement, if the operator does not have the required information to orient the footprint on occupation of the OP, he should contact the battery FDC and request the needed information or the MTO for the target.

(1) Orienting the Template. To orient the template card, the pinhole appearing within the footprint is centered over the planned target location. The center line is aligned with the OTL. Using the OTL as an index, the angle T is set off to the right or left by using the angle T scale at the bottom of the template card. The center line should now be aligned with the GTL. If the operator does not have the battery location or the angle T and guns left or right of his location, he may request the Copperhead MTO from the FDC. After the template card has been properly oriented, the footprint can be drawn by inserting a pencil or other marking device into the openings on the card. The drawing is completed by removing the card and connecting the broken lines.

(2) Visualizing the Footprint. The operator can use the MULE to help him visualize the footprints on the ground. Once the operator has drawn the footprints on his map, he selects several points around the edges of the footprints and determines the direction and distance to them. He then locates these points on the ground by using the MULE. By visually connecting the points, the operator can determine the shape of the footprints on the ground. The ability of the operator to visualize Copperhead footprints on existing terrain is essential to effective Copperhead target planning. The operator uses the Copperhead footprint template and his ability to construct a visibility diagram for the areas of likely enemy activity to help him in fire planning.

(3) Estimation. Visualizing the Copperhead footprint is as important to the successful engagement of targets of opportunity as it is for planned targets. However, visualizing targets of opportunity is more difficult because of the lack of time to draw a footprint on the map. Instead, the operator estimates the dimensions of the footprint in the general vicinity of the target of opportunity. If planned target footprints have not been established, the operator selects an average footprint based on the gun-target range or TOF and visualizes it on the ground.

(4) Target Mobility. Although static targets such as command posts are not a concern, vehicles, when attacked or lased, will attempt to maneuver out of the Copperhead engagement area. The mobility of the vehicles, whether or not they have laser countermeasures, the terrain, and other factors (obstacles, etc.) will affect the amount of time and the number of targets that will be available within the desired Copperhead engagement area. Trigger selection criteria also depend on target mobility and are discussed below.

9011. Copperhead Call for Fire. The following call for fire formats are used for Copperheads. Priority planned targets provide the greatest responsiveness from the FDC, followed by planned targets and, last of all, targets of opportunity. The FDC must have the observer's PRF code, as well as visibility and cloud height of the target area, to determine accurate firing data. This information should be reported regularly, as when reporting position. Copperhead missions, like conventional missions, can be fired on either planned targets or targets of opportunity.

a. Planned Targets. Planned targets are either priority targets or on-call targets with firing data already computed. Because of its relatively short response time, the Copperhead planned target is the preferred method for employing Copperheads.

(1) Number of Rounds. The criteria for determining the number of rounds include the planned number of targets (to a maximum of six rounds), Copperhead footprint size, target mobility, and the longevity of the laser designator. Unless otherwise requested, the FDC plans two rounds per Copperhead target. The second round is prepared as “do not load” and available by requesting “repeat.” The number of rounds fired may vary from the planned request depending on the situation. Based on target mobility, the number of rounds does not have to equal the number of target elements. If the target is expected to remain in the engagement area, the observer may request one or more rounds to be fired sequentially.

(2) Planned Target Call for Fire. The observer requests “Copperhead” in the target’s initial call for fire or target list worksheet. When a target is detected and is predicted to move within one of the preplanned footprints, the observer calls for fire on his predetermined aim point. The observer may request up to six rounds to be fired at intervals (30 seconds unless otherwise specified). On notification from the FDC, the observer lases the first element until the round impacts. If the FO obtains a kill, he realigns the MULE on another target and lases the next round. When longer firing intervals are employed (e.g., 30 seconds or more), the observer should not continually designate while acquiring the next target. If a target is missed, it can be redesignated for the next round. (See figure 9-9 on page 9-32.)

b. Targets of Opportunity. When planned target locations are not available, the operator engages the target as a target of opportunity.Calls for fire for Copperhead targets of opportunity follow the same format as the standard call for fire. Normally, the observer uses “at my command” or “by round at my command.”

“A58 this is A71, fire target AY 4781, over.”
“Three tanks, three rounds, at my command, over.”

or

“This is A71, fire target AY 4781, over.”

Figure 9-9. Copperhead Calls for Fire on Planned Target.

Example
“A57 this is A71, fire for effect, laser polar, over.”
“Direction 1800, distance 3450, vertical angle plus five, over.”
“Two tanks, Copperhead, two rounds, by round at my command, over.”

If a moving target is detected outside a preplanned footprint but is within engagement range, the observer uses the MULE to estimate its speed and direction and predicts an intercept point. The intercept point is reported to the FDC by using polar plot data from the MULE (preferred), shifting from the target or a known point, or using grid coordinates. At my command is the recommended method of control when attacking moving targets of opportunity. When requested, the battery fires the Copperhead rounds at intervals of 30 seconds after the operator gives the command to fire the first round. When by round at my command is requested, the operator controls the firing of each round.

9012. Message to Observer. After the call for fire is received by the FDC and the mission processing is started, the MTO is sent. For single-element targets with one round planned and one round "do not load," the number of rounds is announced as one. The elements of the Copperhead MTO, in addition to normal elements, include the PRF code, angle T, gun-target range, TOF, and howitzer right or left of OT line. This allows for template orientation. When planning targets, this information will not be available until both battery and observer are in position.

Example
"QUEBEC, three rounds, code 241, angle T 400, range 7000, TOF 25, right of OT line, over."

9013. Trigger Points. To ensure that a moving target and a Copperhead round arrive at the planned target location/intercept point at the same time, the operator determines a trigger point. (See figure 9-10 on page 9-34.) A trigger point is a point on the ground at which the operator will command the battery to fire when the target passes over or near it.

In choosing a trigger point, the operator must consider the intended path of the target, the target speed, the Copperhead TOF, the transmission time, and the size and shape of the footprint. His first step is to determine the distance from the planned target location/intercept point to the trigger point. This is done by adding the transmission time (an average of five seconds) to the TOF received in the MTO. Multiplying this sum by the speed of the target gives the distance to the trigger point.

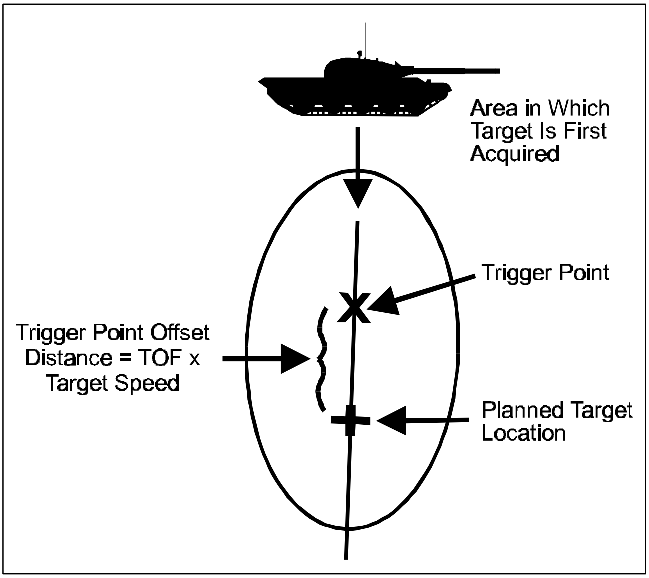

Figure 9-10. Trigger Point for Planned Target.

After acquiring the target, the operator follows it until he is sure of the direction in which it is moving. As the target moves, the operator can use one of two methods to determine its speed. First, he can estimate the speed as "slow" (three meters per second/seven miles per hour), "medium" (five meters per second/11 miles per hour), or "fast" (eight meters per second/18 miles per hour). Second, he can use the MULE to measure the distance that the target moves during a certain time interval. As the target moves, the operator lases it and converts the polar data to grid locations. By using the two locations, he determines how far the target has moved. He divides this number by the time interval between those locations to determine the target's speed (in meters per second) and the direction in which it is moving.

Example
Transmission time = 5 sec
TOF = 25 sec
Target speed = 5 m/sec
(5 sec + 25 sec) x 5 m/sec = 150 m (distance from trigger point to target)

The trigger point is determined by setting off the distance to the trigger point from the planned target location/intercept point along the intended path of the target.

With a planned target, the target may not travel over the initial planned target location. Therefore, the operator should select his trigger point so that the target will be as near as possible to the planned target location when the Copperhead round arrives.

If the target passes the trigger point before the battery reports "ready" but is still within the footprint when "ready" is received, assess the situation. The footprint represents a 50-percent probability of a hit. Determine how far the target will travel out of the footprint should the operator fire the round immediately. (See figure 9-11 on page 9-36.)

If the target has passed through the footprint before the battery reports "ready" or will have by the time the round arrives, the operator should make a bold shift to a new target location. Data for the new target location should be sent to the FDC immediately. When the operator does not intend to request "by round at my command," the trigger point becomes the point at which he initiates his call for fire. Therefore, mission reaction time must be included when determining the distance to the trigger point. Normal mission reaction times are as follows:

- Priority targets—30 seconds plus TOF
- On-call targets—90 to 120 seconds plus TOF
- Targets of opportunity—180 seconds plus TOF.

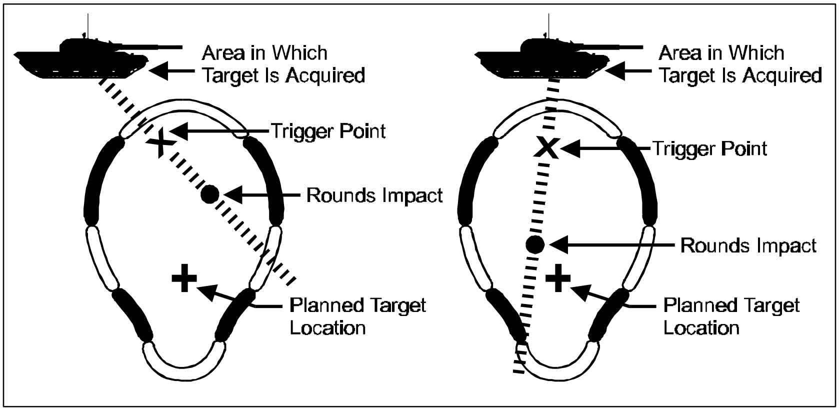

Figure 9-11. Trigger Points for Target Not in Center of Footprint.

9014. Copperhead Engagement Commands

a. Shot. As soon as the first Copperhead round is fired in a mission, the operator receives “shot” from the FDC. If he specified “at my command” or omitted the method of control in the call for fire (battery fires when ready), he receives “shot” only once. The subsequent rounds will be fired at intervals of 30 seconds without notification (the exact interval will be set by unit SOP). If the operator specified “by round, at my command,” he receives “shot” for each round fired. If an operator fails to acknowledge “shot” for a given round, it will not be retransmitted because the operator’s timing will be affected.

b. Designate. The next and most critical engagement command is “designate.” When the operator receives the command “designate” from the FDC, he begins designating the target with the MULE. The command is sent 20 seconds before impact. If the TOF is 20 seconds or less, “shot” and “designate” are sent in the same transmission. “Laser on” is used for voice transmissions.

(1) The operator must designate the target during the last 13 seconds of the TOF. Once the operator has received “shot,” he should begin his own countdown by using the TOF received in the MTO. If for some reason he has not received a “designate” message, he should begin designation when 13 seconds are left in his countdown.

(2) If the battery is firing the Copperhead rounds automatically at 30-second intervals, the command “designate” is sent only for the first round. The operator either continues designating for the subsequent round or, if designating for more than two rounds, releases the trigger while moving the laser spot to the next target.

(3) If “shot” is given for each round or if the firing interval is greater than 30 seconds, “designate” is given for each round.

c. Designate Now. If an operator fails to acknowledge the “designate” command, the command “designate now” is sent by the FDC until the operator acknowledges or until the TOF of the round elapses. If the operator fails to acknowledge the “designate now” command, “shot” and “designate” are sent on the next round fired, regardless of the method of control.

d. Rounds Complete. The FDC reports “rounds complete” after the engagement commands for the last round are transmitted and acknowledged. If the operator wants to terminate firing before the last round is fired and the FDC is controlling the firing of subsequent rounds, he sends either “cease loading” or “check firing, cancel check firing, end of mission.” If the operator is controlling the firing of subsequent rounds, he sends “cease loading” then “end of mission” to terminate the mission.

e. Requests for Additional Rounds. If additional rounds are required to engage the target array, the operator may request them in one of two ways. For single-round missions, the observer simply requests “repeat” for the remaining round in “do not load” status or, after the last Copperhead round is fired, he may send, “(number) rounds repeat.”

9015. Survey Control. If elements of survey (grid location, direction, and altitude) are not available, laser designators and rangefinders can be used in conjunction with the digital message system or BCS to provide the observer, or other observers, with accurate grid location and direction. The same procedures can be used during position improvement to improve firing accuracy and to extend accuracy into the target area. The most important factor in considering the accuracy of observer location and direction is the source. The ideal source for all survey is the supporting artillery battalion (common survey). The following self-location procedures are predominantly based on using known points or the observer's own directional control. If a known point is a burst or is located by map spot or if direction is obtained by compass, errors exist and will be passed on to the observer's grid and direction. Always use the most accurate means available to obtain survey control.

a. MULE North-Finding Module. The MULE's north-finding module provides the ability to locate true north and/or grid north with an accuracy of ±2 mils. The north-finding module is also capable of calculating grid convergence when location has been entered. The north-finding module has a 6,400-mil capability and can find north in less than two minutes from positions of up to 66.5 degrees latitude and in less than four minutes from positions between 66.5 degrees and 75 degrees latitude. The north-finding module will store the location even with the power off and has a built-in test for the electronics and display. For further information and procedures for the north-finding module and the MULE, see TM 08579A-12/1, *Operators Manual for AN/PAQ-3 MULE*.

b. Self-Location. The procedures for self-location use different elements of survey to orient the observer. Self-location can also be employed during position improvement to improve firing accuracy. Once established, these accuracies can be passed to other observers in the area of operations. The different procedures have different requirements and provide different elements of survey. Either a digital message system or BCS can perform all computations. Likewise, a BC scope with a laser rangefinder can be used to perform the same procedures as a MULE without a north-finding module.

(1) Trilateration. Trilateration requires the distances and vertical angles to two known points. The known points should be at least 300 mils apart and accurately located. Trilateration provides grid location and direction to the observer. It can be performed with a MULE or laser rangefinder. The observer locates himself by determining accurate distances to two known points. The observer can report these distances to the FDC or enter them into his digital message system, which, in turn, computes his location. The observer always specifies the point on his left (lase and announce first). (See figure 9-12 on page 9-41.)

(2) Resection. Resection requires the direction, distance, and vertical angle to one known point. A back azimuth is determined from the polar information to provide a grid location to the observer. Because he is using only one point, the observer must have accurate directional control and common survey with the FDC for the known point, if desired. If not, these errors will be translated into location error. (See figure 9-13 on page 9-42.)

Observer:	"A16 this is A23, perform trilateration, known points one and two."
FDC:	(Reads back.)
Observer:	"Known point two on left: distance 3180, vertical angle +10. Known point one: distance 1230, vertical angle -10."
FDC:	(Reads back.)
FDC:	"Grid 45867 32339, altitude 422. Direction to known point two: 3,095 mils."
Observer:	(Reads back.)

Figure 9-12. Self-Location by Using Trilateration.

(3) Triangulation. Triangulation requires directions to two known points (known points should be at least 300 mils apart) and provides a grid location without the altitude. If vertical angle is included in the data, the determined altitude must be verified (at least by map spot). It can be performed by a BC scope. In this procedure, the observer sends the directions and vertical angles (optional) for two known points to the FDC or enters them into his digital message system. The FDC determines the observer location and provides an altitude. (See figure 9-14 on page 9-43.)

c. Self-Location by Using One Known Point and One Burst. If only one known point is available, the second prearranged point may be established by a planned burst of an HE or WP round. The natural dispersion in terms of probable errors in range and deflection for the projectile will transfer survey errors to the observer's location. The operator should plan the location of the burst so that it is separated from the known point by at least 300 mils. Graze bursts should be used. By using the MULE, the operator ranges the known point and the burst to determine the required direction, distance, or vertical angle for each of the two points. He reports these to the FDC or enters them into his digital message system. The FDC computes the MULE location and corrected azimuth to the known point and sends the information to the operator. The accuracy of the computed MULE location and reference azimuth are affected by the accuracy of the firing data and must include accurate altitude to the burst point. The FDC should use the most accurate data available.

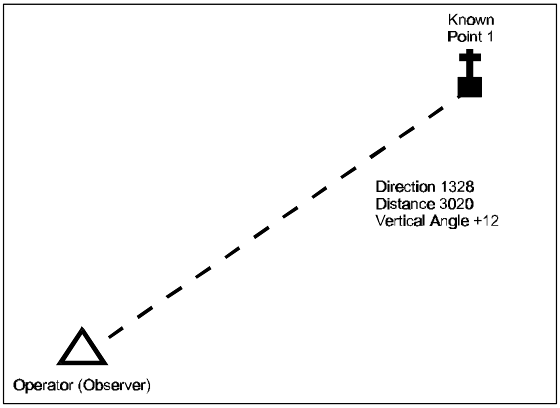

Figure 9-13. Self-Location by Using Resection.

d. Second-Observer Assistance. An observer who has been accurately located and oriented through survey or through self-location can help other observers to locate themselves. This second MULE operator can establish known points for another operator to use in self-location or can perform a simultaneous observation with the other MULE operator on two illumination rounds. FDC(s) can refer observers requiring self-location to observers with survey control to coordinate assistance.

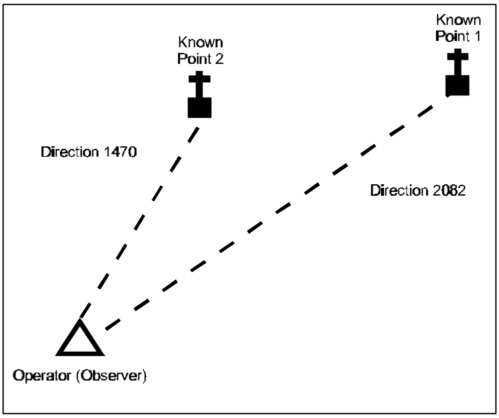

Figure 9-14. Self-Location by Using Triangulation.

e. Establishing Known Points for Other Operators. There will be times when an operator emplacing a MULE or BC scope will have no preestablished known points and no readily identifiable terrain feature that can be measured from a map. A second operator with an accurately located and oriented MULE can use it to establish known points for the other operator. To do this, both operators must be able to see a common area well enough to identify and locate objects to serve as known points for self-location. These points should be separated from each other by at least 300 mils as observed from the observer position being located. Once mutually agreeable points have been identified, they can be established as known points as outlined below.

Example

An observer (A23) has no survey control or known points in his area. The FDC (A16) instructs a nearby observer with a MULE (A47) that is accurately located and oriented to assist in establishing known points in his area. Mutually agreeable points have been identified.

FDC: "A47 this is A16, establish known points for A23, over."
Observer: "Known point four tower at grid 45627 78953, direction 0832, distance 5740, vertical angle minus nine. Known point five burned tank at grid 45752 74452, direction 0947, distance 6370, vertical angle minus 11, over."

With two known points established, the observer can now locate himself by using self-location techniques. Any error in the oriented observer's survey will be transferred to the obtaining observer's survey.

f. Location by Simultaneous Observation. An operator with an accurately located and oriented MULE can help to determine the location of another observer by performing a simultaneous observation on two illumination rounds with that observer. (See figure 9-15 on page 9-45.) The accuracy of survey obtained by the observer is based on the accuracy of the contributing observer's survey. This technique is especially useful during periods of limited visibility (darkness). Both operators must be able to see and lase the illumination rounds. Also, these illumination rounds should be separated by at least 300 mils as seen by the observer position being located. Thorough prior coordination between the two operators must take place for effective use of this technique. The observer of the accurately located MULE acts as the controlling station and initiates the illumination call for fire as outlined in the example.

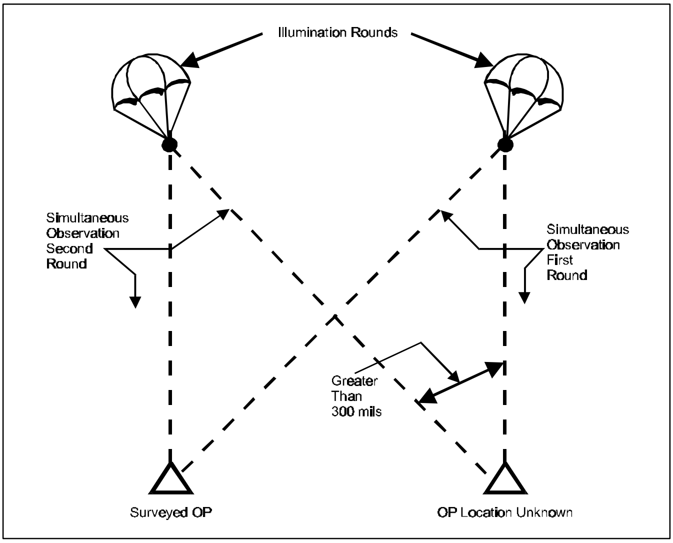

Figure 9-15. Locating Second Observation Point by Simultaneous Observation.

Example

A47 is the operator of the accurately located MULE. A23 is the operator of the MULE being located. A16 is the battery FDC. Coordination between A47 and A23 has already taken place.

"A16 this is A47, simultaneous observation with A23, over."
"One round, grid 391 516, one round, grid 374 522, over."
"Illumination, by round at my command, over."
"A47 this is A23, ready to observe, over."
"A47 this is A16, ready, over."
"A16 this is A47, fire, over."

As the illumination round descends, the operator with the accurately located MULE coordinates simultaneous lasing on the flare. He begins tracking the descending flare and has his radio operator transmit "tracking, tracking, tracking . . . lase." Once the command "lase" is given, both operators lase/range the flare's parachute simultaneously, record the data, then repeat the process with the second illumination round. The operators must use their judgment to determine whether they have received an accurate return from the flare's parachute. If one of the operators feels that he has an inaccurate return, the tracking phase should be immediately repeated before any data is sent to the FDC. The controlling observer sends his data to the FDC either as polar data or a converted grid. The FDC establishes the data as grid locations. The obtaining observer then sends his data to the FDC by using one of the self-location techniques. He can also use a digital message system once he has been provided with the grid locations from the controlling observer's data.

"A16 this is A47, point one, direction 6377, distance 4120, vertical angle plus 23, over."
"Point two, direction 6205, distance 2090, vertical angle plus 45, over."
"A16 this is A23, conduct triangulation, points one and two, over."
"Point one, direction 4095, point two, direction 4835, over."
"A23 this is A16, location 3751 4832, over."

(continued)

g. Directional Control. If the obtaining observer does not have directional control, he can still perform the procedure by trilateration. He must establish a reference point before the procedure and record the number of mils indicated on his device to that point. When conducting the simultaneous observation, he must record the number of mils to the left-most illumination round at the time of lasing. When the FDC provides direction to the left-most illumination point, he compares the two numbers, obtains a correction factor, applies it to his reference point, and reorients his observation device.

Example
Observer reference point: direction 2010 Observer direction to left-most illumination point: direction 4095 FDC direction to left-most illumination point: direction 4090 FDC direction minus observer direction: 4090-4095 = -5 (correction factor) Correction factor applied to reference point: 2010 + (-5) = 2005 Mule or BC scope reorientation to reference point: direction 2005

h. Observer Actions After Being Located. As soon as the operator knows his accurate location, he should record his location on the map and, if provided with direction, adjust the azimuth to his reference point as described in the procedures above. He should then determine polar plot data to several prominent points around his position for future use. (See figure 9-16 on page 9-48.) The digital message system or BCS can determine the grids to these points for the operator, and they can be established as known points. The MULE can also assist the observer in preparing a visibility diagram by ranging objects along selected azimuths. Defilade areas can then be marked on the map. Once the observer's position is known to the FDC and he has accurate directional control, the observer can fire for effect on targets from his location. This assumes that the firing-unit FDC is firing accurately.

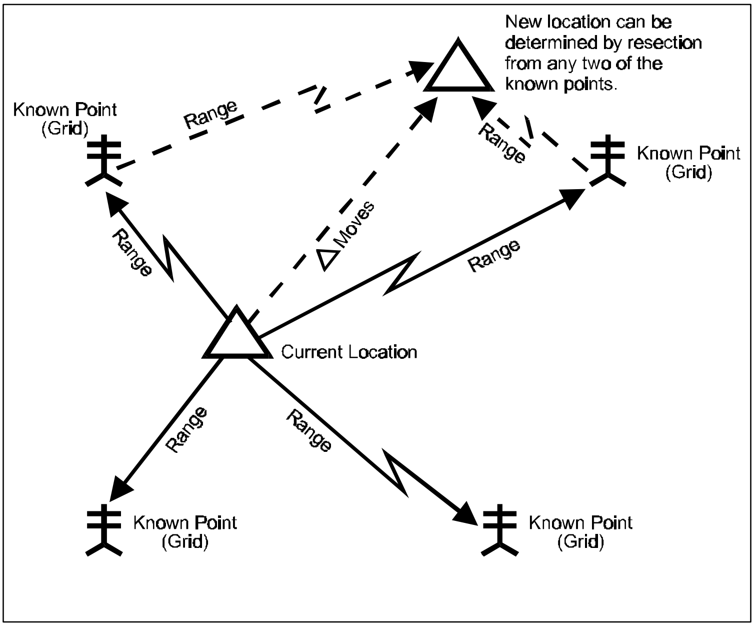

Figure 9-16. Using a Laser To Determine Known Points and New Location.

9016. Laser Polar Missions. An accurately located and properly oriented MULE, or oriented BC scope with laser rangefinder, has accurate enough target location for the first-round fire-for-effect missions. However, some of the requirements for accurate first-round fire for effect may be lacking at the battery. If the operator is not sure that he can achieve first-round fire for effect on the target, he should adjust fire by using laser polar data. If the MULE is correctly oriented, then it gives him the capability to fire for effect on the subsequent round. The laser polar adjust-fire mission is processed differently from other missions.

a. Fire Direction Center-Computed Shift. The operator sends the laser polar plot data of the burst (equivalent to a spotting) to the FDC, which computes the shift (equivalent to a correction) and, normally, fires for effect. The observer's data is transmitted as direction, distance, and vertical angle or is converted to grid coordinates. If the burst dissipates before it can be lased, the observer transmits "lost burst" to the FDC.

Example
"Burst direction 5872, distance 4350, vertical angle minus 11, fire for effect, over."

b. Observer-Computed Shift. If the supporting FDC is not automated, then the operator can compute his own subsequent correction or have the FDC process it manually. (See table 9-3 on page 9-50.)

Table 9-3. Calculation of Shift by Observer.

Procedure	Example
Compute the operator-burst (OB) distance factor. Express to the nearest 1,000 meters.	OB distance 3,480 OB factor 3
Determine the deviation shift. Multiply the angular deviation by the OB factor.	25 x 3 = 75 (left 80)
Determine the range shift (OT range - OB range). Express to the nearest ten meters.	Distance to target 3,680 Distance to burst - 3,480 Difference 200
Compute a vertical shift (if it exceeds 30 meters). Determine the vertical angle difference between the burst and the target, then multiply by the OB factor. Express to the nearest ten meters.	Vertical angle to target +2 Vertical angle to burst (-) -1 Vertical angle difference +3 3 x 3 = 9 m (10 m)
Note: The observer's correction would be "left 80, add 200, fire for effect, over."	

Example

"H24 this is H58, new target, direction 0220, distance 3680, vertical angle plus two, over."

"Battalion assembly area, ICM in effect, over."

9017. Target Shifts. Laser polar missions have the capability to conduct large shifts much like an NGF fresh target. If a new target is located, or a shift from an auxiliary adjusting point is employed, the observer prevents the FDC from applying the new location as a correction to the previous round by announcing "new target." If this is not announced, the FDC will apply the difference between the previous burst and new location in the opposite direction.

9018. Registrations with MULEs. The MULE may be used to accurately determine data for HB, MPI, or precision registrations. When the accuracy of the operator's location meets the standards for an HB or MPI registration, the HB/MPI is the preferred method of conducting a registration. If the location or direction for the MULE is doubtful, it may still be used to help conduct a precision registration. Use of a MULE in conducting registrations does not lessen the number of fired rounds required for the FDO to achieve assurance of validity.

a. High-Burst/Mean Point of Impact Registration. The FDC either requests that the observer lase an orienting point or provides the operator with orienting data through an MTO. The operator uses the MULE to determine laser polar plot data for the burst of each round fired during the registration and sends the data to the FDC. If operating with a digital message system, the observer should convert the polar data to grid. Before conducting an HB registration, the operator should ensure that safety restrictions do not prevent lasing the burst if it is above the skyline.

b. Precision Registration. In a precision registration, the operator uses the MULE to determine accurate burst locations and transmits them to the FDC for subsequent corrections. The observer is still responsible for controlling the phases and number of rounds and for recording registration points. During the time phase, the observer uses the MULE to spot all bursts but determines and transmits subsequent corrections and refinements.

c. Abbreviated Registration. In an abbreviated registration, the registration is conducted with less than the optimal number of rounds. The operator lases the burst of the first adjusting round as outlined for adjusting fire by using the MULE. The FDC computes new firing data and fires a second adjusting round. The operator lases the burst of the second round as well. This process is continued until the lased burst is within 50 meters of the designated registration point. If a time portion has also been requested, two air bursts are fired to establish the mean HOB. The operator sends corrections to adjust the mean HOB to 20 meters.

Example

"A23 this is A16, message to observer, abbreviated registration, known point quick and time, over."

"A16 this is A23, direction 6216, over." (First adjusting round is fired.)

"Direction 6327, distance 3140, vertical angle minus 11, over." (Second adjusting round is fired.)

"Left 30, add 50, record as registration point, time repeat, over." (One HE/time round is fired.)

"Down 25, two rounds, repeat, over." (Two time rounds are fired. Note that an air burst must be achieved.)

"Up five, record as time registration point, end of mission, over."

9019. MULE Employment by the Naval Gunfire Spot Team. The spot team in each SFCP is equipped with a MULE. However, there are no laser-guided munitions presently available for NSFS ships. The spot teams employ their MULEs for purposes of range finding, target location, and self-location.

9020. AN/GVS-5 Laser Rangefinder Employment. The AN/GVS-5 is a lightweight, handheld laser rangefinder that can determine the range of a target quickly and accurately. The device emits a laser burst and detects its return when the burst is reflected from a distant object. The time lapse between the emission of the beam and its return is converted to meters and displayed in the eyepiece on the range-to-target display. When accurately aimed, the AN/GVS-5 provides a range that is accurate to within 10 meters of the target. However, clutter in front of or behind the target may cause false readings in the AN/GVS-5. To ensure accurate data, the observer should associate the displayed range with a terrain-map analysis and his own range estimate to decide whether the reading is accurate. When, in the observer's opinion, all of these figures do not correlate, he should consider the following.

a. Multiple Firings. Three consistent readings generally indicate that the observer has aimed in the same place each time.

b. Minimum Range Set. Although the emitted laser beam is relatively narrow, it is wide enough to reflect from more than one target or object. The AN/GVS-5 is equipped with a multiple target warning light inside the eyepiece that illuminates when more than one return signal is received. When multiple target readings are indicated, the range displayed is the range to the first object from which the beam is reflected.

(1) To prevent false readings from an intermediate object between the observer and the target, the AN/GVS-5 is equipped with a minimum range set. Ranges to the nearest 10 meters and up to 5,000 meters may be set on the minimum range set. The range set indicates the range within which the AN/GVS-5 will not register a return. This option eliminates receiving false readings from intermediate objects.

(2) The observer adjusts the minimum range set by correlating the range displayed and his own range estimate based on map and terrain analysis. On the minimum range set, the observer can save time by establishing the maximum range beyond which he is certain the target lies before he begins ranging a target. On completion of a mission, the minimum range set should always be set back to zero.

c. Adjustment of Fire. Lateral and vertical shifts in the adjustment of fire are computed by using the mil relation in the same way as for adjustment of fire using binoculars. Range adjustments are made by using the difference in range between the target and the burst and making the correction in the appropriate direction.

d. Target Location. The distance provided by the AN/GVS-5 should always be used with the most accurate available direction to the target and a quick, but thorough, map analysis. The observer should remember that the AN/GVS-5 is designed to help him refine distances. Therefore, the distances determined by the device should always be correlated with known information before target location is produced.

Appendix A

Target Analysis and Munitions Effects

1. Observer Responsibilities. As the eyes of indirect-fire supporting arms, artillery FOs, mortar FOs, and NGF spotters must properly describe the target to the firing unit. Additionally, FOs must recommend and NGF spotters must decide on the best method of attack based on the size, type, and posture of the target.

2. Target Analysis. A target must be analyzed to determine its weak points. The decision as to where the target is most vulnerable and what fires will best exploit its weaknesses is influenced by the degree of damage desired. On the basis of the commander's guidance, the observer must determine the degree of effects needed. In analyzing a target, the observer should consider the following. (See tables A-1 and A-2 on pages A-2 through A-4.)

3. Effects Sought. In analyzing the target, the observer must consider the effects sought. The three categories of target effects sought are suppression, neutralization, and destruction.

a. Suppression. Suppression of a target limits the ability of enemy personnel to perform their mission. This type of fire is used against likely, suspected, or inaccurately located enemy units where time is essential. It can be delivered by small delivery units. Various munitions can be used to cause suppressive results, such as HE or smoke. The effect of suppressive fires lasts only as long as the duration of fires and does not damage the target.

Table A-1. Target Characteristics and Considerations.

Target Characteristics	Considerations
Composition	Indicates achievable destructive or incendiary effects.
Size and shape	May require special sheaf, multiple aim points.
Vulnerability	Affects weapon selection.
Mobility	May affect weapon/ammunition selection because of required response time.
Resiliency	May affect decision to engage.
Location	May affect weapon selection because of proximity to friendly forces; accuracy will affect volume of fire to achieve desired effects.

Table A-2. Environmental Characteristics and Considerations.

Environmental Characteristics	Considerations
Weather	Restricts/prohibits use of some weapons/munitions. For example, clouds and fog may affect the use of lasers and some aircraft/ordnance. Wind affects attacking targets with smoke, ICM, FASCAM, or illumination projectiles.
Terrain	Rugged terrain reduces vulnerability of targets and increases volume of fire for desired effects. Overhead vegetation reduces effectiveness of some munitions and requires delay fuze action. Orientation of terrain features in the target area may require repositioning of firing units or high-angle fires.

Urbanized areas	ICM and HE/VT should be reserved for firing at personnel on rooftops and targets in the open. High-angle fires should be employed for targets in defilade. HE/Q or concrete piercing (CP) is effective for rubbling and covered targets. HE/delay is not effective for mortar or brick penetration. (Use HE/Q or CP.) Are conducive to illumination and incendiary munitions. Allow use of FASCAM to close routes.
Mountainous areas	Require high-angle fires to attack defilade targets. Increase lethality of HE in hard, rocky surfaces. Reduce effectiveness of WP, ICM, and FASCAM in deep snow and wooded areas. Make unobserved fires less accurate in changing atmospheric conditions.
	Enhance air bursts on reverse slopes. Allow use of FASCAM to compartmentalize or close routes. Are conducive to rock slides. Offer opportunity for CAS to attack targets on reverse slopes and steep slopes.

Jungle areas	Reduce effects of most munitions because of vegetation. Restrict employment of bomblet submunitions (ICM, CBUs) because of overhead cover. Promote fires in proximity to friendly forces.
Desert areas	Reduce effectiveness of unobserved fires due to target dispersion. Increase use of smoke for screening; however, atmospheric conditions reduce duration of smoke screens.
Arctic areas	Slow rates of fire. Cause ICM, FASCAM, and HE/Q to be less effective because of deep snow and mud. Allow the best results for air bursts. Reduce smoke effectiveness. Cause resupply of ammunition expenditure to be controlled because of difficulty of resupply.

b. Neutralization. Neutralization of a target, in addition to suppressing it, knocks the target out of the battle temporarily. Personnel casualties or weapons systems damages of 10 percent or more are considered to neutralize a unit. A damaged weapons system has significantly degraded performance until repairs are made. Examples include a firepower kill, such as a destroyed main sight or gun, or a mobility kill from a damaged engine or tread. The unit or target can become effective again when the casualties are replaced and the damage is repaired. The assets required to neutralize a target vary according to the type and size of the target and the weapon/ammunition combination used.

c. Destruction. Destruction requires a target to be completely reconstituted or replaced. It is defined differently for units and individual weapons systems. In terms of units, it is a larger amount of casualties or damage. Casualties or system damages of 30 percent (as defined in mobility, firepower, and crew-kill neutralization) inflicted during a short time span are considered to render a unit destroyed. Destruction of an individual weapons system occurs when it suffers both a firepower and mobility kill, a crew kill, or a catastrophic kill. With precision destruction missions, direct hits are used to destroy hard materiel targets.

4. Ammunition and Its Effects. This paragraph discusses ammunition for indirect-fire weapons. (Ammunition for CAS is discussed in chapter 4.)

a. Projectiles

(1) High Explosive. The HE projectile is a hollow shell filled with trinitrotoluene (TNT) or Composition B. When detonated by a PD, delay, VT, or mechanical time fuze, bursts cause fragmentation and blast over a wide area. It is most often used by the observer in adjustment. Shell HE is effective against personnel, vehicles, and material. HE/VT from artillery and NGF is also effective against stationary armored vehicles. Shell HE is fired by mortars, artillery, and NGF.

(2) White Phosphorus. The WP shell is a burster-chemical-type projectile. Its hollow shell bursts on impact by an internal charge that expels burning WP over a limited area. This shell is used for marking, screening, obscuring, and incendiary effects. It is used against vehicles; petroleum, oils, and lubricants (POL) and ammunition storage areas; and enemy observers. The WP shell is most commonly fired with an impact fuze. However, it may be fired with fuze time to obtain an air burst. It cannot be fired with fuze VT. The WP shell can be fired by mortars, artillery, and NGF.

(3) Illumination. This is a base-ejecting-type projectile. A canister containing burning illuminant is ignited and expelled in a small parachute. This projectile is used for battlespace illumination or marking. Illumination can be fired by mortars, artillery, and NGF.

(4) Hexachloroethane Smoke. Shell smoke is a base-ejection projectile that is filled with canisters that emit smoke. The smoke projectile is more effective than WP in screening because it has less of a tendency to pillar. This projectile can be fired from all artillery weapons except the eight-inch howitzer.

(5) Felt-Wedge Smoke. The HC smoke projectile has been replaced with the M825 improved smoke round. The M825 is a base-ejection projectile that uses felt wedges impregnated with WP to create uniform dispersion of smoke over an area. The M825 provides 5 to 10 minutes of smoke over a large area. Unburned wedges can cause a hazard to friendly forces; therefore, caution must be exercised when operating in these areas. The M825 is delivered by 155-mm artillery weapons.

(6) Family of Scatterable Mines. FASCAM artillery shells are used to deliver antipersonnel (ADAM) or antitank mines (RAAMS) against an enemy force. The FASCAM shells are delivered by 155-mm artillery weapons.

(7) Copperhead. The Copperhead is a cannon-launched guided projectile. It consists of a 14.5-pound shaped charge that is capable of penetrating most armor and destroying point targets. (See chapter 9.)

(8) Improved Conventional Munitions. The ICM shell is a base-ejection projectile that consists of a mechanical time fuze and a body assembly containing grenades. When the fuze functions, the grenades are dispersed over a large area. There are two types of ICM: dual purpose and antipersonnel. APICM is no longer in production. The DPICM is produced in two artillery munitions, M483A1, called ICM, and M864, called base burn ICM. It is very effective against exposed troops and vehicles. It is also effective against armored vehicles. ICM projectiles can be fired by artillery and rocket systems.

(9) High Capacity. The high-capacity projectile is a fragmenting round that can also produce penetration effects. The projectile may have multiple fuzes, including a nose fuze. The fuzes are a nose plug; a PD or mechanical time fuze; an auxiliary detonating fuze, which is an intermediate detonating device to magnify the explosion of the nose fuze; and a base detonating fuze with a delay arming action. The high-capacity projectile is fired by the five-inch naval gun.

b. Fuzes. See figure A-1 on page A-9 for examples of fuze actions.

(1) Fuze Quick. Fuze quick is a PD fuze that functions on impact. It is fired from all indirect-fire weapons (artillery, mortars, NGF) with the HE projectile (most commonly in adjustment) or WP projectile. Fuze quick loses its effect if troops are in trenches, on uneven ground, or on earthworks. It is used against personnel who are standing, personnel who are prone on the ground, armored vehicles, and light material.

(2) Fuze Delay. A fuze delay is a 0.05-second delay that can be set on the quick fuze to allow either ricochet fire or penetration. The observer should use fuze delay for penetration if he wants to fire into dense woods or against light earthworks or nonmasonry buildings. Fuze delay is not effective against concrete or brick (use CP or quick). Fuze delay can be used in conjunction with a ricochet. A ricochet causes a low air burst when there is a small angle of impact on a hard surface. Ricochets are particularly common when firing high charges in artillery or when firing NGF.

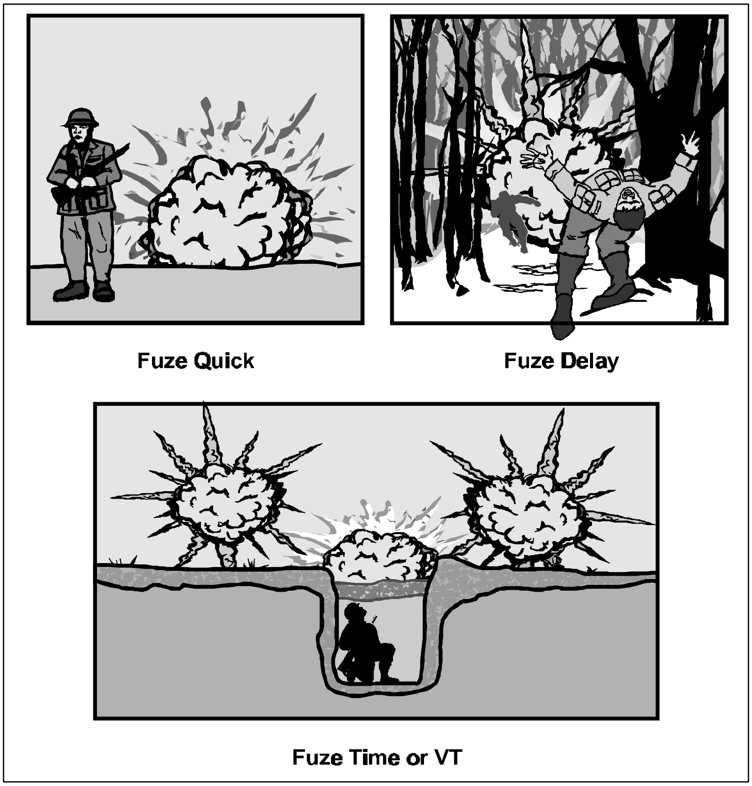

Figure A-1. Fuze Actions.

(3) Mechanical Time Fuzes. The time fuze functions in the air at a given time along the trajectory. It requires adjustment to achieve the proper 20-meter HOB when used with HE or WP. Therefore, another shell/fuze combination should be considered if time is critical and air bursts are desired. Fuze time should never be used for high-angle missions. Time fuzes are used with HE and WP against troops in the open, in trenches, or in fighting holes; vehicles; and materiel. It can be fired by all artillery weapons and NGF. Time fuzes are also used for payload munitions such as illumination, smoke, M825 smoke, and ICM projectiles.

(4) Proximity Variable Time Fuzes. Proximity VT fuzes are radio activated for detonation at a seven-meter HOB. A VT fuze provides a more effective air burst than fuze time and does not have to be adjusted. It is an excellent fuze to fire with shell HE for fire-for-effect missions, unobserved fires, or high-angle fires. It should be used in missions conducted by an aerial observer when an air burst is desired. It is used against all targets that can be attacked with fuze time. Fuze VT can be fired with HE projectiles by all artillery weapons, mortars, and the five-inch naval gun. Various proximity fuzes exist in the NGF inventory.

(5) Controlled Variable Time. CVT fuzes have an adjustable arming feature that prevents the fuze from arming until the set time has elapsed. Therefore, it provides more safety when firing over friendly troops. The CVT fuze is available for NGF HE projectiles. It is the preferred proximity fuze for NGF.

(6) Other Variable Time Fuzes. Other versions of the VT fuze exist in the NGF inventory, for example, variable time-radio frequency (VT-RF) and variable time-infrared (VT-IR).

(7) Concrete-Piercing Fuze. CP fuzes are used with artillery and NGF HE projectiles for attack of concrete structures or earth- and log-reinforced emplacements. The two types of CP fuzes are nondelay and delay. Nondelay is used primarily for spotting or for clearing rubble and shattering concrete. Delay is used to destroy the concrete target.

Table A-3 provides a guide for selecting weapons to attack various targets.

Table A-3. Guide for the Attack of Targets.

Target	Weapon/Ordnance
Personnel: In the open	Mortar—HE/Q or VT Artillery—HE/Q, VT, or time; DPICM NGF—HE/Q, time, or VT Air—general purpose, fuel air explosive, cluster, firebombs, guns
In fighting holes	Mortar—HE/VT Artillery—HE/VT or time NGF—HE/VT or time Air—fuel air explosive, general purpose, cluster
Under light cover	Mortar—HE-delay Artillery—HE-delay or HE/Q/VT mix NGF—HE-delay Air—general purpose, rockets, guns, cluster
Under heavy cover (concrete bunkers)	Artillery—HE-CP, HE/Q, Copperhead NGF—armor piercing or HE-delay Air—general purpose, guided weapons
Armored vehicles:	Mortar—HE/Q or VT Artillery—HE/Q, VT, or time; DPICM; Copperhead NGF—HE/Q or delay Air—guided weapons, general purpose, rockets, guns, cluster

Field artillery:	Artillery—DPICM, HE/VT, WP, FASCAM NGF—HE/Q or VT, WP Air—cluster, guided weapons, general-purpose bombs
Antiaircraft artillery: Automatic	 Mortar—HE/VT, WP Artillery—DPICM, HE/VT, WP, smoke NGF—HE/Q or VT, WP Air—cluster, guided weapons, general-purpose bombs, firebombs, guns
Self-propelled	Same as armored vehicles
Missile launchers:	Mortar—HE/VT Artillery—DPICM, HE/VT NGF—HE/Q or VT Air—missiles, guided and cluster weapons, general purpose, firebombs
Radar installations:	Mortar—HE/Q or VT Artillery—DPICM, HE/Q or VT NGF—HE/Q or VT Air—missiles, guided/cluster weapons, general purpose, fuel air explosive, guns, rockets
Field fortifications:	Mortar—HE-delay, WP Artillery—HE-CP or delay, DPICM, WP NGF—HE-CP or delay, HE/Q, WP Air—general purpose, guided bombs, rockets
Supply depots/dumps:	Mortar—HE/VT, WP Artillery—HE/VT or time, DPICM, WP NGF—HE/VT or time, WP Air—cluster, firebombs, general purpose, guided bombs, rockets
Land transportation: Roads	 Mortar—HE-delay Artillery—HE-delay or CP, FASCAM NGF—HE-delay or CP Air—general-purpose bombs

Trucks	Mortar—HE/Q or VT, WP Artillery—HE/Q or VT, DPICM, WP NGF—HE/Q or VT, WP Air—guided missiles and cluster weapons, general purpose, guns, rockets
Buildings:	Mortar—HE-delay, HE/Q or VT, WP Artillery—HE-CP or delay, HE/Q, WP NGF—HE-CP or delay, HE/Q, WP Air—guided bombs and missiles, general purpose

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Appendix B

Crater Analysis

1. General. Whenever and wherever hostile cannon, missile, or mortar shelling is detected, it must be reported without delay to the appropriate S-2. The S-2 can then evaluate and act on such information. When counterfire agencies are provided with sufficient information, they can implement immediate operational objectives to ensure the successful attack of hostile weapons. Observers and liaison personnel should be capable of conducting crater analysis.

Shelling reports (SHELREPs) form the basis for effective counterfire action. The most reliable, accurate, and informative SHELREPs are visual or electronic observation supplemented by crater analysis and fragment identification.

2. Procedures for Crater Analysis. The observer can determine the direction of fire of an enemy projectile with reasonable accuracy by analyzing its crater or ricochet furrow. The observer can obtain weapon location by plotting the intersection of the back-azimuth rays from two or more widely separated craters caused by projectiles fired from the same weapon. Essentially, crater analysis involves determining the axis of the crater, marking the axis, and measuring the azimuth of the axis to the weapon.

The initial step in crater analysis is to locate a suitable crater for use in determining the direction to the hostile weapon. The crater should be clearly defined on the ground and should be reasonably fresh.

Because the crater is the beginning point for plotting direction to the enemy weapon, the observer should determine grid coordinates of the crater as precisely as the time and the method used will allow. The observer must collect shell fragments to identify the type and caliber of the weapon. The observer must determine direction to the firing weapon by using one of the methods described below.

3. Artillery Shell Craters

a. Fuze Quick Craters. The detonation of a projectile causes an inner crater. The burst and momentum of the shell carry the effect forward and to the sides, forming an arrow that points to the rear (toward the weapon from which the round was fired). The fuze continues along the line of flight, creating a fuze furrow (groove in the ground). There are two methods of obtaining a direction to a hostile weapon from this type of crater. The observer can obtain the best results by determining a mean or average of several directions from both methods.

(1) Fuze Tunnel and Center of Crater Method. In this method, one stake is placed in the center of the crater and another is placed in the furrow at the point where the fuze was blown forward to the front of the crater. (See figure B-1 on page B-3.) A direction-measuring instrument is set up in line with the two stakes, and the direction is measured to the hostile weapon. There are five steps of the fuze tunnel and center of crater method:

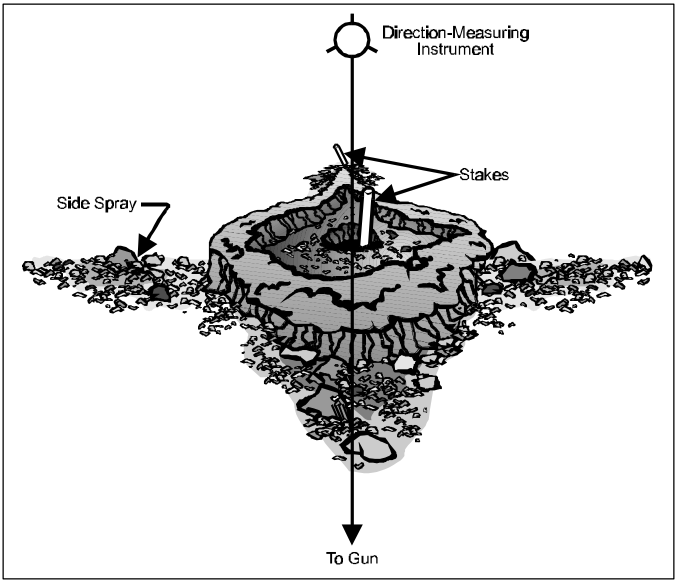

Figure B-1. Fuze Tunnel and Center of Crater Method.

- Step one—Place a stake in the center of the crater.
- Step two—Place a second stake in the fuze furrow.
- Step three—Set up a direction-measuring instrument (i.e., compass, aiming circle) in line with the stakes and away from fragments.
- Step four—Orient the instrument.
- Step five—Measure the direction to the hostile weapon.

(2) Variation of the Fuze Tunnel and Center of Crater Method. A variation of this method is to place a stake where the shell entered the ground instead of in the center of the crater and determine the direction in the same manner. However, this is rarely possible because indications of the point of entry are usually destroyed by the explosion of the shell.

(3) Side Spray Method. The side spray method involves bisecting the angle formed by the lines of the side spray by striking arcs. (See figure B-2.) The seven steps in measuring the direction of a fuze quick crater by the side spray method are as follows:

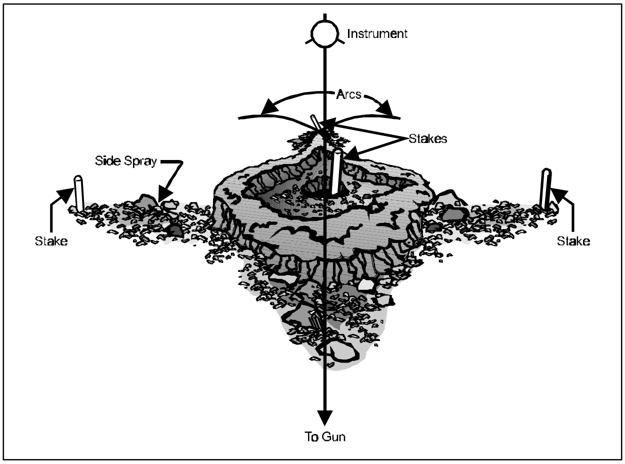

Figure B-2. Side Spray Method.

- Step one—Place a stake in the center of the crater.

- Step two—Place two stakes, one at the end of each line of side spray, equidistant from the center stake.

- Step three—Hold a length of WD-1 wire to each side-spray stake, and strike an arc forward of the fuze furrow.

- Step four—Place a stake where these arcs intersect.

- Step five—Set up a direction-measuring instrument in line with the stake at the intersection of the arcs and the center stake.

- Step six—Orient the instrument.

- Step seven—Measure the direction to the firing weapon.

b. Fuze Delay Craters. There are two types of fuze delay craters—ricochet and mine action.

(1) Ricochet. The projectile enters the ground in a line following the trajectory and continues in a straight line for a few feet, causing a ricochet furrow. The projectile normally deflects upward and at the same time changes direction. The change in direction usually is to the right as a result of the spin or rotation of the projectile. The effect of the air burst can be noted on the ground. (See figure B-3 on page B-6.) Directions obtained from ricochet craters are considered to be most reliable. The five steps in determining direction from a ricochet furrow are as follows:

- Step one—Clean out the furrow.

- Step two—Place stakes at each end of a usable straight section of the furrow.

- Step three—Set up an instrument in line with the stakes and away from the fragments.
- Step four—Orient the instrument.
- Step five—Measure the direction to the weapon.

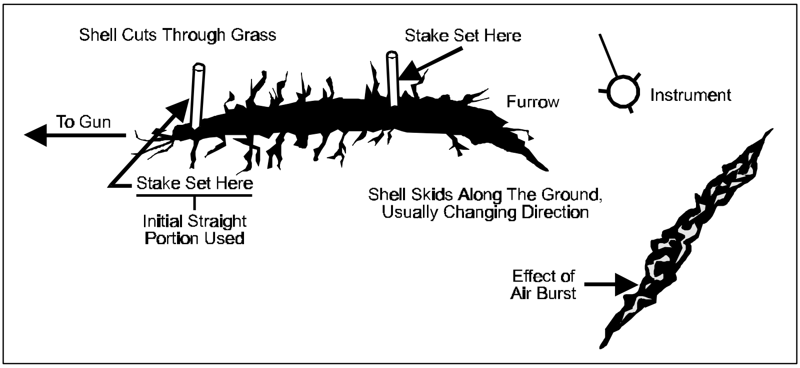

Figure B-3. Ricochet Furrow Method.

(2) Mine Action. Mine action occurs when a shell bursts beneath the ground. Occasionally, such a burst will leave a furrow that can be analyzed in the same manner as the ricochet furrow. A mine action crater that does not have a furrow cannot be used to determine the direction to the weapon.

4. Mortar Shell Craters. In a typical mortar crater, the turf at the forward edge (the direction away from the hostile mortar) is undercut (cut beneath with a portion left overhanging). The rear edge of the crater is rid of vegetation and grooved with splinters.

(See figure B-4.) When fresh, the crater is covered with loose earth that must be carefully removed to disclose the burnt inner crater. The ground surrounding the crater is streaked by splinter grooves that radiate from the point of detonation. The ends of the splinter grooves on the rearward side are on an approximately straight line. This line is perpendicular to the line of flight when on level ground or on slopes with contours perpendicular to the plane of fire. (See figure B-5 on page B-8.) A fuze tunnel is caused by the fuze burying itself at the bottom of the crater in front of the point of detonation. Three methods may be used to determine direction from a mortar shell crater—main axis, splinter groove, and fuze tunnel.

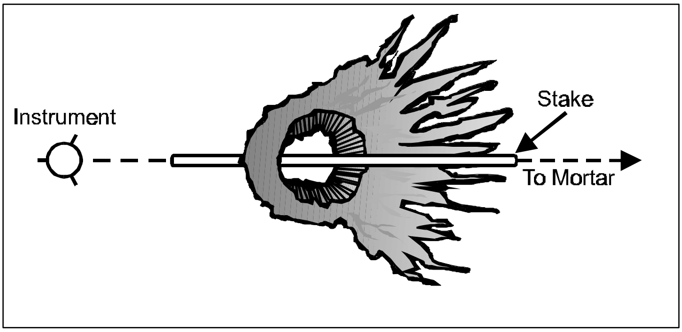

Figure B-4. Main Axis Method.

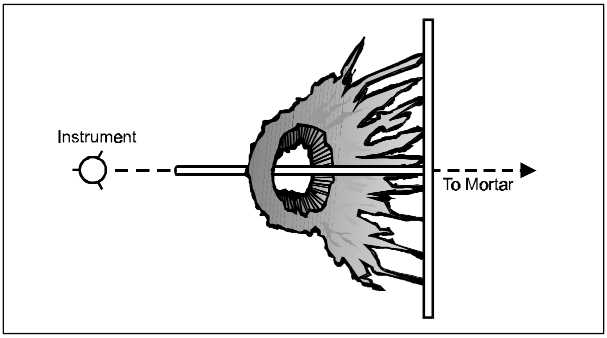

Figure B-5. Splinter Groove Method.

a. Main Axis Method. There are four steps used in determining direction by the main axis method when a definite and regular crater is formed:

- Step one—Lay a stake along the main axis of the crater, dividing the crater into symmetrical halves. The stake points in the direction of the mortar.
- Step two—Set up an instrument in line with the stake and away from fragments.
- Step three—Orient the instrument.
- Step four—Measure the direction to the weapon.

b. Splinter Groove Method. The five steps in determining direction by the splinter groove method are as follows:

- Step one—Lay a stake along the ends of the splinter grooves that extend from the crater.
- Step two—Lay a second stake perpendicular to the first stake through the axis of the fuze tunnel.
- Step three—Set up an instrument in line with the second stake and away from fragments.
- Step four—Orient the instrument.
- Step five—Measure the direction to the weapon.

c. Fuze Tunnel Method. The four steps in determining direction by the fuze tunnel method are as follows (see figure B-6 on page B-10):

- Step one—Place a stake in the fuze tunnel.
- Step two—Set up an instrument in line with the stake and away from fragments.
- Step three—Orient the instrument.
- Step four—Measure the direction to the weapon.

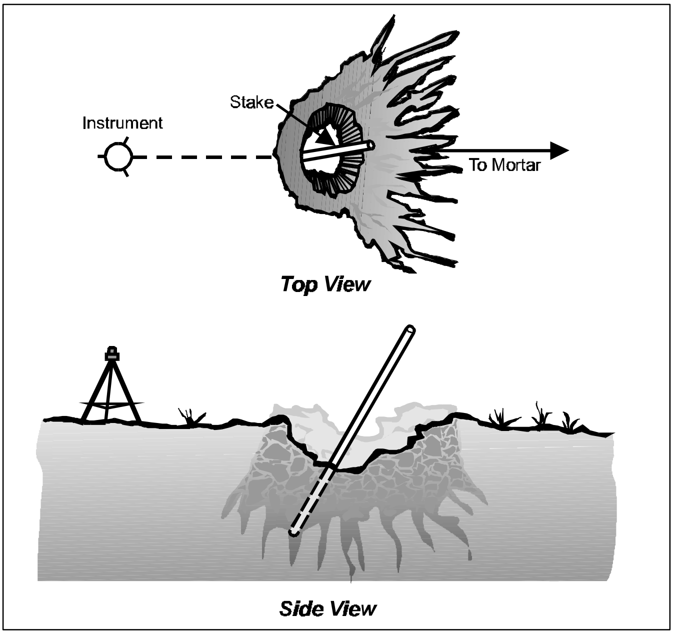

Figure B-6. Fuze Tunnel Method.

5. Rocket Craters. A crater resulting from a rocket impacting with a low or medium angle of fall is analyzed in the same manner as an artillery crater resulting from a projectile armed with fuze quick. However, if the rocket impacts with a high angle of fall, the crater is analyzed in the same manner as a crater resulting from a mortar round. The tail fins, rocket motor, body, and other parts of the rocket may be used to determine caliber and type of rocket fired.

6. Shell Fragment Analysis. The type and caliber of a hostile weapon can be determined by analysis of shell fragments. Dimensions of the parts, as well as of the complete shell, vary according to the caliber and type of shell. (See figure B-7 on page B-12.) The fragments must contain one or more features that can be matched with technical specifications of the shell. Such features are mortar fin assemblies, rotating bands, and fuze wells. Also, the curvature and thickness of large shell fragments can aid in identification. The observer should make sure that the data on munitions suspected to be in the area are disseminated through intelligence channels. Fragments from hostile shells that cannot be identified should be tagged and sent to the S-2 concerned. To be of maximum value, the tag for the fragment should show the following:

- The date and time at which the shell impacted
- The accurate location of the crater
- The direction from which the shell came and the method used in determining this direction (survey of crater, sound, flash, etc.)
- The name and organization of the person reporting
- A reference to a previously submitted SHELREP, if appropriate.

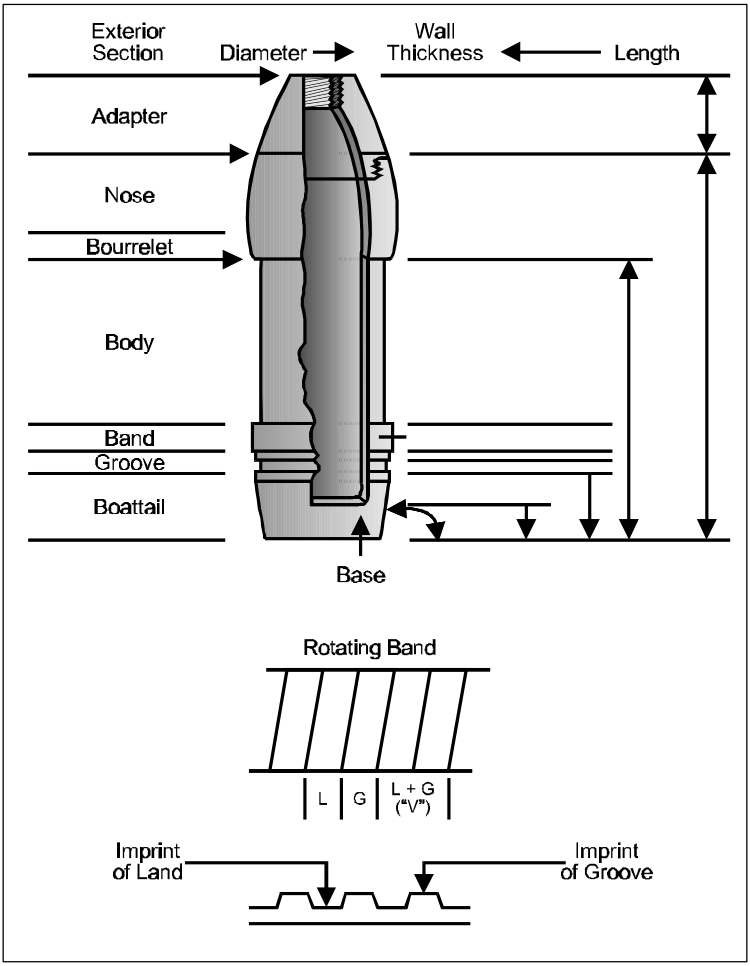

Figure B-7. Typical Shell Showing Critical Measurements.

a. Duds and Low-Order Bursts. Logically, a dud would provide the best identification of the caliber of a weapon. However, because a dud may not always be available (or, if available, may be too dangerous to handle), a low-order burst would provide the next best means of identification. When the explosive filler is incompletely detonated, a low-order burst occurs and large shell fragments result. The observer can use these large pieces to identify thread count, curvature, wall thickness, and so on.

b. High-Order Bursts. A high-order burst will normally form into small, deformed fragments. These fragments are useless for identification purposes unless they include a section of either the *rotating band* or the *rotating band seat*. Fragments of either of these sections positively identify the shell because each shell has its own distinctive rotating markings. (See figure B-8 on page B-14.)

c. Rotating Bands and Band Seats. The observer may identify a shell as to caliber, type, and nation or other place of origin from the following:

- Pattern or rifling imprints
- Width, number, and size of rotating bands
- Dimensions and pattern of keying or knurling (ridges) on the band seat
- Dimensions and pattern of keying and knurling impressed on the rotating bands.

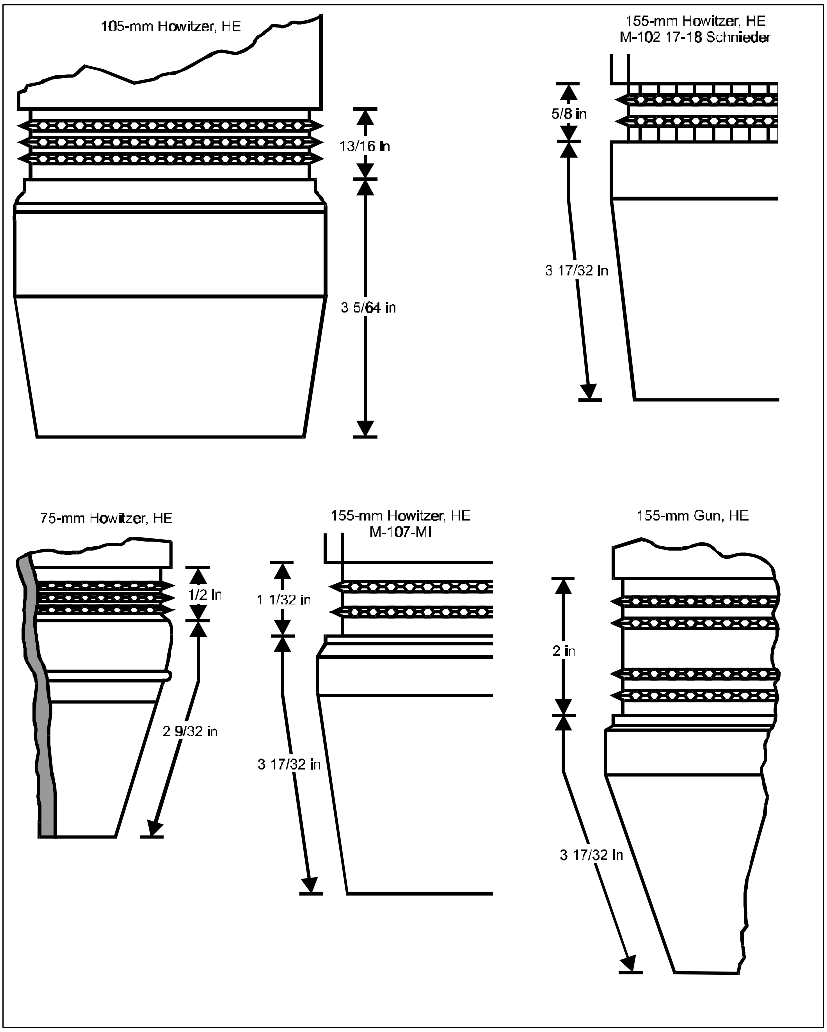

Figure B-8. Shell Fragment Identification, U.S. Ammunition.

d. Tail Fins. The observer may identify a mortar from the mortar shell fragments and tail fins; the latter is the best indication of the type and caliber. (See figure B-9 on page B-16.) A mortar that is not fin stabilized may be identified from pieces of the projectile on which rifling is imprinted. Tail fins are often found in the fuze hole of the crater.

> **Note**
> With the exception of rotating bands and band seats on the tail fins, different types of shells may be identical in one dimension, such as wall thickness, but seldom will be alike in two or more dimensions. Therefore, it is possible to make positive identification from two or more dimensions.

e. Fuzes. Because the same type of fuze may be used with several types of projectiles, it is impossible to establish the type and caliber of a weapon by examination of the fuze.

f. Other Common Artillery and Mortar Rounds. Some other common artillery and mortar rounds are shown in figures B-10 through B-13 on pages B-17 through B-19.

7. Determination of Caliber by Geometric Analysis of Fragments. The geometric method of determining projectile caliber is based on the problem of circumscribing a circle about a triangle. For accurate results, the following considerations apply:

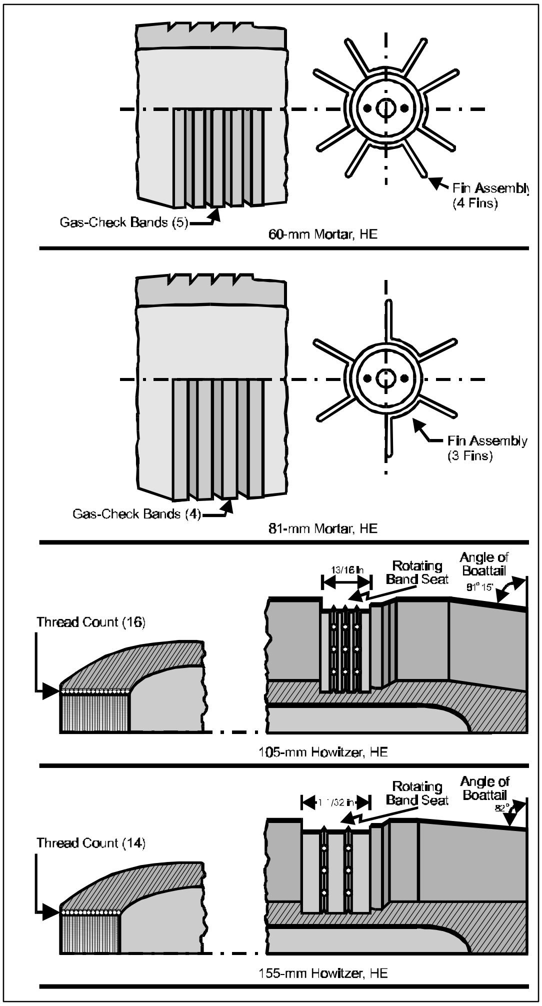

Figure B-9. Shell Fragment and Tail Fin Identification, U.S. Ammunition.

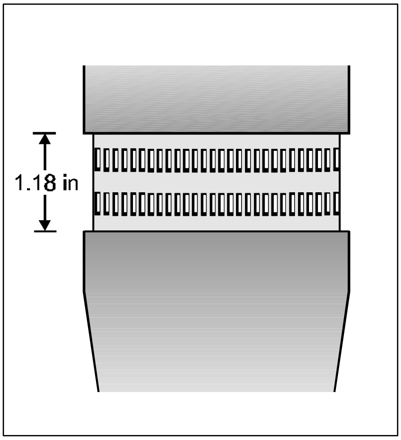

Figure B-10. 122-mm-Gun Projectile.

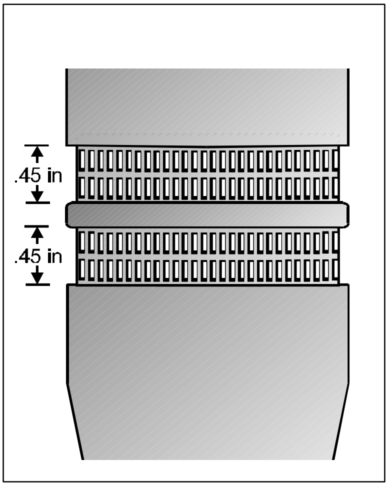

Figure B-11. 85-mm Projectile.

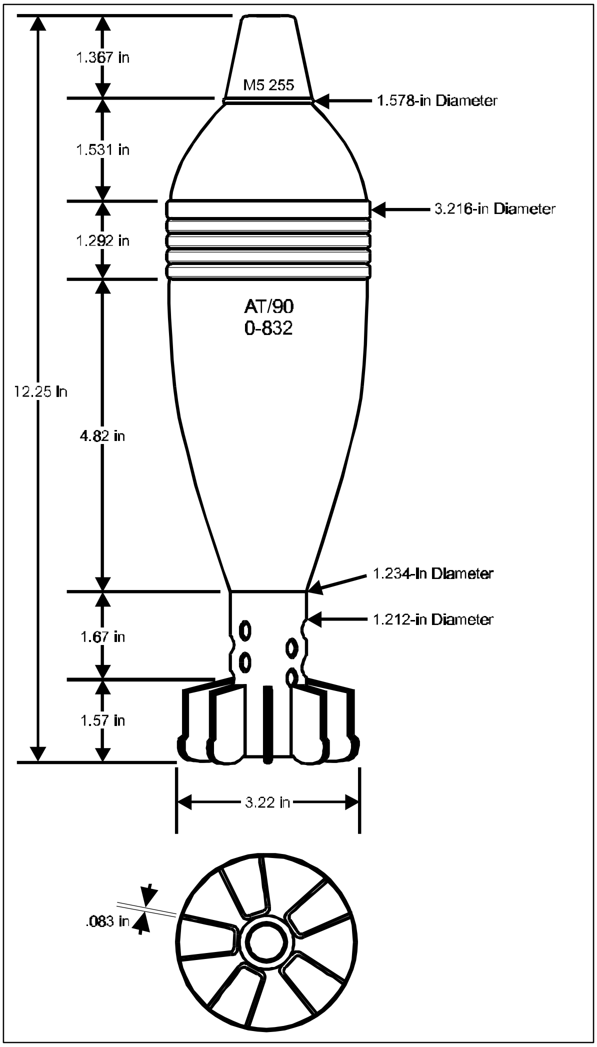

Figure B-12. 82-mm Mortar Round, 5 Fins.

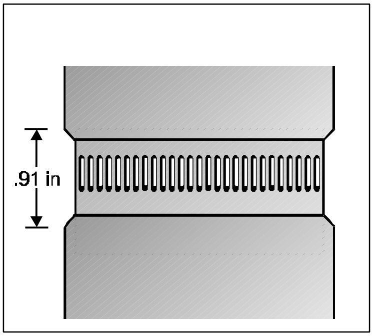

Figure B-13. 152-mm Projectile.

- The fragment selected for use should be the largest available. It should include an arc of the projectile circumference ranging in size from a minimum of one-half inch for a small-caliber weapon (37 mm) to a minimum of two inches for a large-caliber weapon (10 in).

- The fragment must be from that portion of the projectile located between the rotating band and the bourrelet. In the case of a nonboat tail (square base) projectile, the fragment may be from any portion located between the bourrelet and the base.

- The fragment should not be distorted. However, if the fragment is only slightly distorted, the results will be fairly accurate and will give a close approximation of the caliber.

The approximate caliber of a suitable fragment that meets the above conditions can be determined by using the following procedures (see figure B-14 on page B-20):

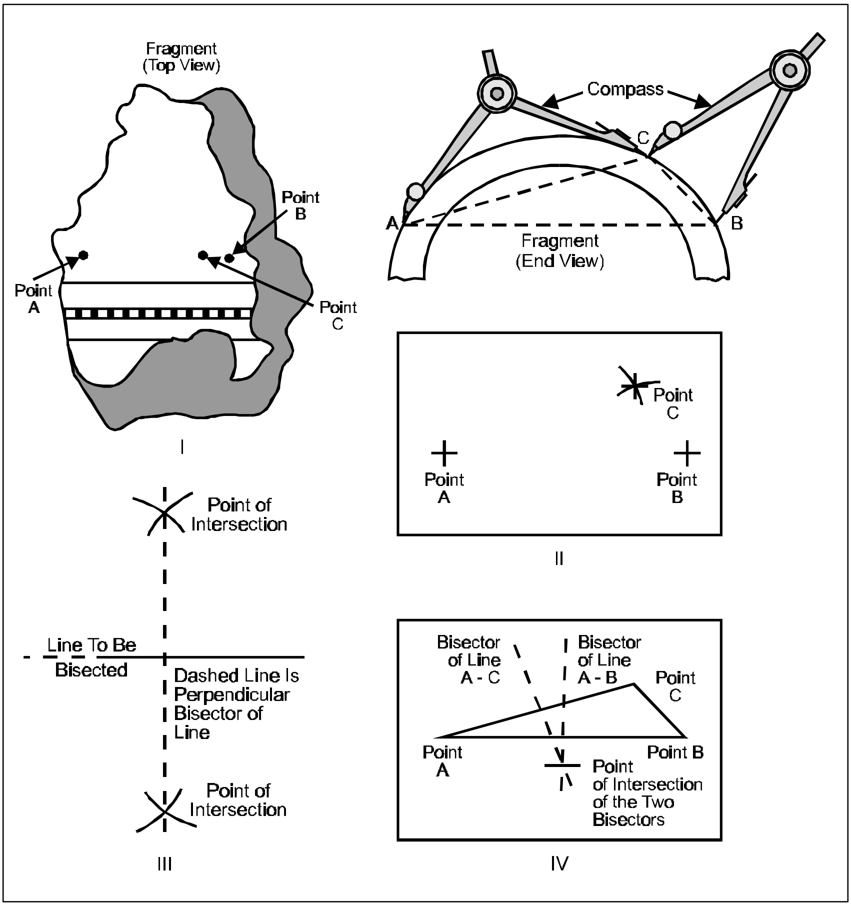

Figure B-14. Determination of Projectile Caliber by Geometric Analysis of a Fragment.

- Select two points (in this case, A and B as illustrated in the "I" portion of the figure), and place them as far apart as possible on the circumference of the projectile fragment.

- Measure the chord (straight line segment) distance between points A and B with dividers or any other suitable instrument, and plot this measurement on paper (I and II).

- Select a third point C, on the arc fixed by A and B, and measure the distance from point A to point C. Using this distance as the radius, strike an arc about point A on the paper (II).

- Measure the distance on the fragment from point B to point C. Using this distance as the radius, strike an arc about point B on the paper. Mark the intersection of the two arcs. This is the plot of point C.

- Draw a triangle, using points A, B, and C as the vertexes. Erect perpendicular bisectors to the sides of the triangle (IV). To construct a perpendicular bisector of a line, set off a radius greater than one-half the length of the line. Using this radius, strike arcs (one on each side of the line) from each end of the line and draw a line connecting the two points of intersection of the arcs. This line is the perpendicular bisector (III).

- Measure the distance from the point of intersection of the perpendicular bisectors to one of the vertexes of the triangle, and multiply this distance by two. The result is the diameter of the projectile that produced the fragment.

8. Shelling Reports. A SHELREP is “any report of enemy shelling containing information on caliber, direction, time, density, and area shelled.” (Joint Pub 1-02) The information obtained from a crater should be forwarded by the most rapid means available. The information is transmitted by using the standard SHELREP, which corresponds to lines a through k of the form depicted in figure B-15 (Department of the Army (DA) Form 2185-R, *Artillery Counterfire Information Form (ACIF)*). Regardless of how little information has been obtained, do not hesitate to forward the information. Fragmentary or incomplete information is often of value in supplementing or confirming existing information.

Items a, b, and k—unit of origin, position of the observer, and friendly damage incurred—are encoded for security reasons. The current call sign or code name for the unit is in item a, and codes used to transmit the information are included in items b and k. Item b is not applicable when this form is used for crater analysis.

Because three elements—direction, dimensions, and curvature—must be measured for crater analysis, the following equipment is required:

- Measuring instrument—an aiming circle or compass
- Dividers and a ruler
- Curvature template—used to measure the curvature of the fragment and so determine the caliber of the shell (See figure B-15 on page B-23.) (The template can be constructed of heavy cardboard, acetate, wood, or other appropriate material.)
- Ammunition data sheets on commonly encountered munitions.

ARTILLERY COUNTERFIRE INFORMATION (FM 6-121)										
RECEIVED BY R			FROM D/1/10			TIME 260605		NUMBER 1		
SECTION I - BOMREP, SHELREP, MORTREP (Cross out items not applicable.)										
UNIT OF ORIGIN	POSITION OF OBSERVER	DIRECTION	TIME FROM	TIME TO	AREA BOMBED, SHELLED, OR MORTARED	NO. AND NATURE OF GUNS	NATURE OF FIRE	NO., TYPE, AND CAL.	TIME OF FLASH TO BANG	DAMAGE
(Current call sign, address, group, or code name.)	(Encode if headquarters or important OP or column F gives information on location.)	Measured clockwise from GRID NORTH in degrees or mils (state which) of FLASH, SOUND, or GROOVE of SHELL (state which). (Omit for aircraft.)			(Grid reference in CLEAR) or (direction to impact in degrees or mils, distance in meters).	(Mortar, rocket launchers, aircraft, or other methods of delivery.)	(Registration, bombardment, harassing, etc.)	(State whether measured or assumed) of SHELLS, ROCKETS, MISSILES, or BOMBS.	(Omit for aircraft.)	(Encode if required.)
a	b	c	d	e	f	g	h	i	j	k
PINE BOX 25	NA	4,810 MILS (GROOVE)	260545	206547	3932 8401	1/122/H	HARASSING	4 HE	—	WIA

Figure B-15. Artillery Counterfire Information Form.

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Appendix C

Observation Post

An OP is “a position from which military observations are made, or fire directed and adjusted, and which possesses appropriate communications; may be airborne.” (Joint Pub 1-02) The selection of an OP is critical to the ability of the observer or spotter to effectively call for and adjust fire, as well as to his survivability. This appendix will discuss considerations for the selection and preparation of the OP.

1. Selection of Observation Posts. Above all, when the observer selects an OP, the OP must permit observation of the area of operation of the supported unit. The observer must coordinate the selection of his OP with other observers’ OPs and maneuver OPs to prevent/minimize gaps or dead spaces. Visibility diagrams should be constructed, as time permits. The following should be taken into consideration when selecting OPs:

- The observer must make sure that the OP is not vulnerable. OPs may be identified by aerial observers or in aerial photographs by loose dirt, wire lines, paths and approaches to the position, and communications (excessive radio traffic or detection of antennas).

- The observer should select an OP that can accommodate the establishment and maintenance of communications.

- When practical, the selection of the OP should facilitate the adjustment of fire, for example, angle T.
- The OP can enhance survivability through concealment. Concealment is practically the only protection available in the early stages of occupation. As time permits, the observer should improve the OP because the observer must be able to function in the most violent of situations.
- The OP should have routes of entry and exit without arousing the suspicion of the enemy. The edges of woods and villages can be used as entries and exits.
- The observer can use elevated points for OPs, such as crests, trees, and so on. The observer should avoid landmarks and prominent terrain features because these are probably targeted. When selecting an OP, the observer must consider the characteristics of the forward slope versus those of the reverse slope.

a. Forward Slope Position (Military Crest). The following characteristics of forward slope position should be taken into consideration:

- This position affords a better view of the front and flanks.
- Fires impacting on the topographical crest will not neutralize the position.
- This position aids in concealment because the hillside provides background.

- Occupation during daylight is difficult without risking disclosure of the position.

- Radio communications may be difficult. It may be necessary to remote antennas to the reverse slope.

- This position does not provide cover from direct fire.

b. Reverse Slope Position. The following characteristics of reverse slope position should be taken into consideration:

- This position may be occupied in daylight.

- It allows greater freedom of movement.

- The position facilitates installation, maintenance, and concealment of communications equipment.

- The position affords protection from direct fire.

- It often affords only a limited field of view to the front.

- This position causes the OP to be neutralized when enemy fire is adjusted on the topographical crest.

2. Preparation of the Observation Post. The preparation and improvement of the OP must allow sufficient space for the observer/team and his equipment, for example, the MULE. If the OP is on the ground, a trench usually is the first means of protection. Later, the OP may be improved by emplacing a cover of logs and earth. As time permits, the OP can be fortified with sandbags. Care must be taken to conceal the work by using both the natural cover afforded by the ground and camouflage. The observer must remove the signs of fresh digging. Special precautions must be taken to camouflage cover and openings. Figures C-1 through C-3 on pages C-5 through C-7 provide illustrations of improved OPs.

3. Tactical Occupation of an Observation Post. When conducting a deliberate occupation of an OP, the observer's defensive posture will be relatively permanent and will allow the use of many procedures that would normally be omitted during offensive operations. Many of the procedures used below are time intensive but are extremely valuable techniques that are only possible during static operations, such as establishing a deliberate OP. One technique that the observer may use is represented by the acronym SLoCTOP, which stands for *s*ecurity, *lo*cation, *c*ommunications, *t*argeting, *o*bservation, and *p*osition improvement.

a. Security. The following steps should be taken during the security phase:

- Before occupying the OP, establish a security patrol around the surrounding area.

- Ensure that the security patrol covers a 6,400-mil area with a 500-meter radius around the tentative OP location.

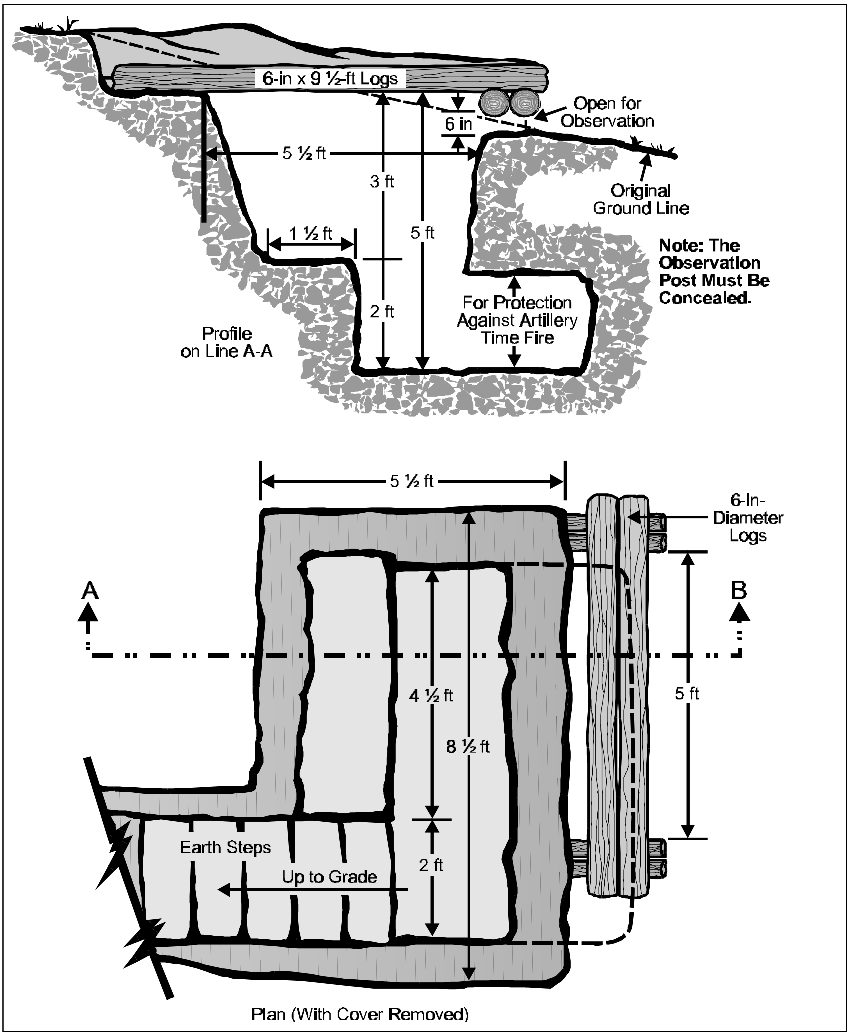

Figure C-1. Observation Post with Cover.

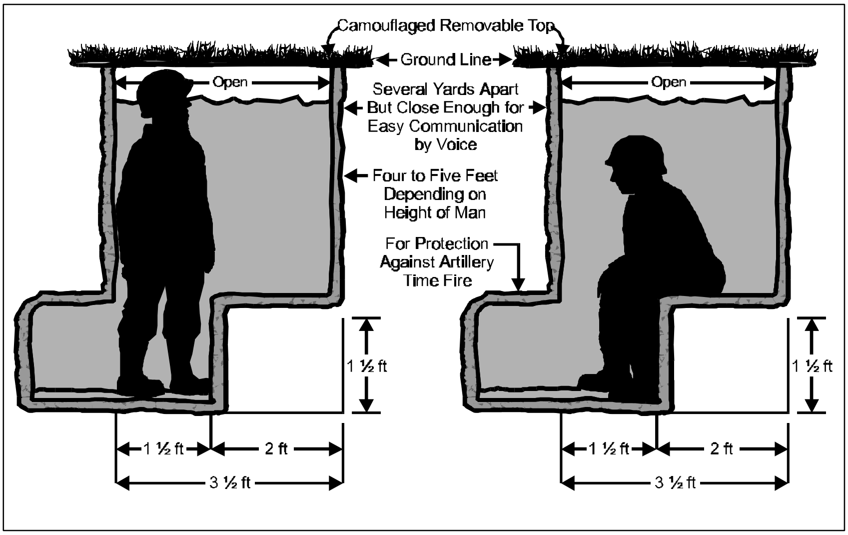

Figure C-2. Observation Post Using One-Man Fighting Holes.

- The security patrol should consist of one portion of the FO team (task oriented), with the remainder of the team remaining in a holding position to monitor radio nets.

- Scouts must ensure that they do not silhouette themselves during the patrol. They should exercise camouflage and noise and light discipline during all phases of the OP occupation.

b. Location. The following steps should be taken during the location phase:

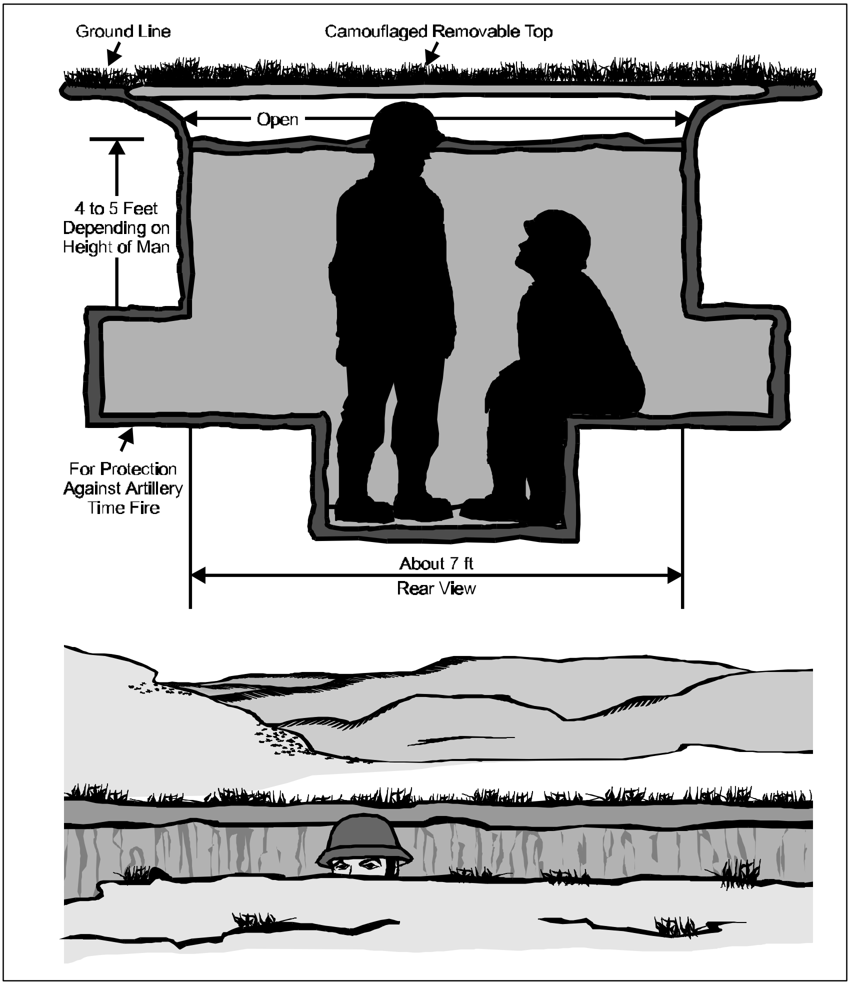

Figure C-3. Observation Post Using a Two-Man Fighting Hole.

- While the security patrol is being conducted, the FO should be finalizing the exact observation site. Degree of accuracy for self-location is 100 meters.

- The position should not be skylined or easily identifiable as an OP (military crest, i.e., 2/3 up, on nondescript high ground).

- The location should offer sufficient observation into the enemy operational area or likely enemy avenues of approach.

- The FO should prepare an OF fan for use, begin a terrain sketch by using reference points that are easily identifiable, and develop a visibility diagram in accordance with appendix E of this publication.

- The FO should ensure that the current situation map is accurate and contains all current friendly units, known/suspected enemy positions, and graphical control measures.

c. Communications. The following steps should be taken during the communications phase:

- Communication is the number one priority for the FO team. Communications *must* be established with all required stations during the security and location phases of SLoCTOP.

- Communication is the most valuable resource for developing situational awareness during occupation. It is critical for the radio/telephone operator (RTO) to record all information that is transmitted (i.e., other missions, position updates, SALUTE reports, etc.) to assist in the smooth transition from a mobile to a static observation posture.

- If communications cannot be established or are distorted, measures must be taken to establish/improve them (e.g., change location, check batteries, improve antenna, etc.). Because of this necessity, the FO should include procedures for field-expedient antennas in his handbook.

- Ensure that higher headquarters (both maneuver and supporting arms agencies) are updated with the most current observer location and other relevant information, such as enemy situation.

d. Targeting. The following steps should be taken during the targeting phase:

- The FO should always locate targets by using the most accurate and expedient means available. Furthermore, he should include these target locations in his terrain sketch.

- Ensure that the MULE is well concealed and that both the MULE and AN/GVS-5 are operated within safety parameters.

e. Observation. The following steps should be taken during the observation phase:

- Ensure that all team members are proficient in friendly/enemy forces recognition.

- The FO should constantly refine company targets and those assigned by higher headquarters.

- The FO should identify trigger points and target reference points (TRPs), review engagement criteria, and ensure that information is understood by all team members.

- The FO should ensure that there is a well-implemented plan to sustain 24-hour operations.

f. Position Improvement. The following steps should be taken during the position improvement phase:

- As time permits, the FO should dig in his position, including a parapet. Through the use of foliage and items organic to the area, he should ensure that there is a natural look to his position. (A good technique to ensure that the position is concealed is by viewing it from the enemy's point of view.)

- The FO should continually improve camouflaging (erect a net if available).

- Units should have an SOP established for the conduct of an OP, including a rotation schedule, placement of the head, and eating procedures.

- Position improvement is continuous. Specific areas for concentration are security, communications, noise and light discipline, camouflage, and weapons and equipment maintenance.

Appendix D

Timing the Delivery of Fire Support

An important aspect in requesting (and coordinating) fire support is the ability to time the delivery of fires. The intent of this appendix is to provide a description of each of the techniques to time the delivery of fires that are used in Marine Corps operations. The techniques are synchronization (PLGR/synchronized clock), elapsed time, and event. Other techniques and terminology for timing the delivery of fire support (e.g., the running clock) should be avoided because they are difficult to establish and often create confusion.

1. Synchronization (Using the AN/PSN-11 PLGR). Synchronization is a technique of placing all units on a common time. The AN/PSN-11 PLGR is the preferable device for synchronizing because it is the easiest and most accurate electronic device available to establish common time. The PLGR must be able to track at least one satellite. An unencrypted PLGR, encrypted PLGR, and time cube will all display the exact same time expressed in seconds.

2. Synchronization (Synchronized Clock). The synchronized clock uses a specific hour/minute based on either local or the universal (ZULU) time zone (as dictated by OPORD or unit SOP, for example, "1505.") The synchronized clock requires all units to be placed on an established time and requires periodic time checks. Once established, the synchronized clock significantly streamlines the coordination of timing. The synchronized clock is established by the senior command element/headquarters and is disseminated to all units. It is most easily disseminated electronically by automated communications systems but can also be disseminated from unit to unit by voice time checks or be acquired as needed from the Naval Observatory. The voice transmissions for establishing a synchronized clock are as follows.

Example

Sender: "T7Y (unit or collective call sign) this is V8P, stand by for time check in two minutes, time will be 1505, over."

Receiver: "V8P this is T7Y, roger, out." (If collective call sign, each unit responds.)

Sender: "T7Y this is V8P, stand by for time check . . . five-four-three-two-one-hack, time is 1505, over."

Receiver: "V8P, this is T7Y, time 1505, out."

Note

Specify time zone if different from SOP/OPORD, for example, "time 1505 SIERRA."

a. Local Time. A local time zone (e.g., "ROMEO time zone") may be used to establish the synchronized clock. The use of the local time zone on the synchronized clock may cause confusion if the unit or supporting forces (e.g., aircraft) are operating over more than one time zone.

b. Universal Time. Universal time is based on the ZULU time zone. Use of universal time facilitates timing of actions across time zones and is the preferred basis for establishing a synchronized clock. If required, units/agencies can independently access the Naval Observatory, which provides an automated, continuous broadcast of time. Units/agencies can acquire universal time from the Naval Observatory on HF radio frequencies of 5.000, 10.000, 15.000, 20.000, or 25.000 MHz or by telephone at DSN 762-1401/1069 or commercial 202-762-1401/1069. Universal time is particularly advantageous when operations involve joint forces and/or aircraft operating from remotely located airfields.

c. Definition of Universal Time. Universal time is "a measure of time that conforms, within a close approximation, to the mean diurnal rotation of the Earth and serves as the basis of civil timekeeping. Universal Time (UT1) is determined from observations of the stars, radio sources, and also from ranging observations of the Moon and artificial Earth satellites. The scale determined directly from such observations is designated Universal Time Observed (UTO); it is slightly dependent on the place of observation. When UTO is corrected for the shift in longitude of the observing station caused by polar motion, the time scale UT1 is obtained. When an accuracy better than one second is not required, Universal Time can be used to mean Coordinated Universal Time (UTC). Also called **ZULU time.** Formerly called Greenwich Mean Time." (Joint Pub 1-02)

3. Elapsed Time. The delivery of fires may be timed by specifying a number of minutes (and seconds as required) to elapse from a stated countdown reference or "hack." Elapsed time is best used when timing the delivery of fires in an immediate or time-critical situation, when a synchronized clock has not been established, or when a synchronized clock's accuracy is doubtful. Elapsed time is difficult to disseminate when several units/agencies are involved, for example, during a coordinated attack of a target by aircraft, artillery, and NGF.

Elapsed time is expressed in relation to the transmission of "hack." In starting an elapsed time, hack is always transmitted by specifying the number of minutes and seconds to elapse before ordnance is to impact on the target. The hack is used in transmitting the TTT for immediate or on-call CAS.

Example
"Eight (minutes understood) plus zero, zero (seconds understood) . . . hack."

The term "hack" is now used for all supporting arms and replaces "mark" for use in initiating or establishing time.

4. Event. The timing of fires may be in relation to a specific event, for example, H-hour or H-5. However, precautions should be taken to ensure that all concerned agencies know the correct H- or L-hour.

Appendix E

Construction of the Visibility Diagram

The observer constructs the visibility diagram in overlay form and drawn to map scale. The completed visibility diagram is formed by the systematic alignment of terrain profiles. A terrain profile is an exaggerated view of a portion of the Earth's surface along a line between two points, such as the line between the OP and point A in figure E-1. The observer can construct a terrain profile from any contour-lined map.

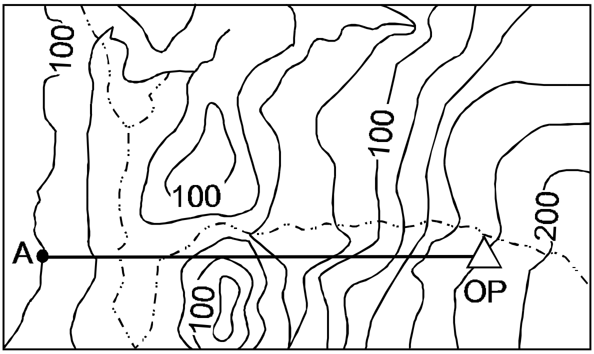

Figure E-1. A Profile (Line OP-A) Constructed on a Contour Map.

1. Step One—Drawing Radial Lines from the Observer's Location. The observer does the following:

- Locates and plots his position on the map

- Constructs radial lines from the OP to the limits of his visibility. Each adjacent pair of radial lines should form an angle of no more than 100 mils. (See figure E-2.) Each radial line from the OP represents a line of vision. The OF fan fulfills this function when placed on the map and oriented.

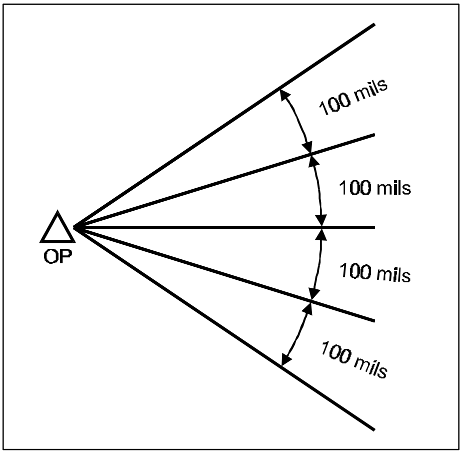

Figure E-2. Radial Lines (Lines of Vision) Ranging Out From the Observation Post.

2. Step Two—Constructing the Profile. The basic element of the visibility diagram is a terrain profile. A terrain profile is an exaggerated side view of a portion of the Earth's surface along a line between two points. Each of the radial lines represents a terrain profile, and each profile must be constructed. For example, the most common way of indicating elevation and relief on maps is by contour lines. A contour line is a line representing an imaginary line on the ground along which all points are at the same elevation. Starting at sea level, normally at zero contour, each contour line is the contour interval, and the value of this interval is listed in the marginal data on a map.

Starting at zero elevation, every fifth contour line is drawn so that it is heavier than the other contour lines. These heavier lines are index contours, and at some place along each index contour the line is broken and the elevation listed. The contour lines falling between index contours are called intermediate contours. The observer can determine the elevation of any point by doing the following:

- Determining the contour interval (from the map or marginal data)
- Finding the numbered contour line nearest to the point for which elevation is sought
- Determining the direction of slope from the numbered contour line to the desired point
- Counting the number of contour lines that must be crossed to go from the numbered line to the desired point and noting the direction (up or down). The number of lines crossed multiplied by the contour interval is the distance above or below the starting value.

Along a radial line, determine the value of the highest contour line and the value of the lowest contour line. (See figure E-3.) On a blank sheet of paper, draw equally spaced horizontal lines. Draw the lines so that there will be one line representing each contour value crossed by the profile line from the OP. Number each line on the paper by assigning the top line a value equal to one contour interval higher than the highest contour line determined along the radial line. Number the rest of the lines in sequence down by contour interval to the bottom line. Give the bottom line a value of one contour interval lower than the lowest contour line determined. A sheet of lined tablet or notebook paper will be suitable in most cases for this purpose.

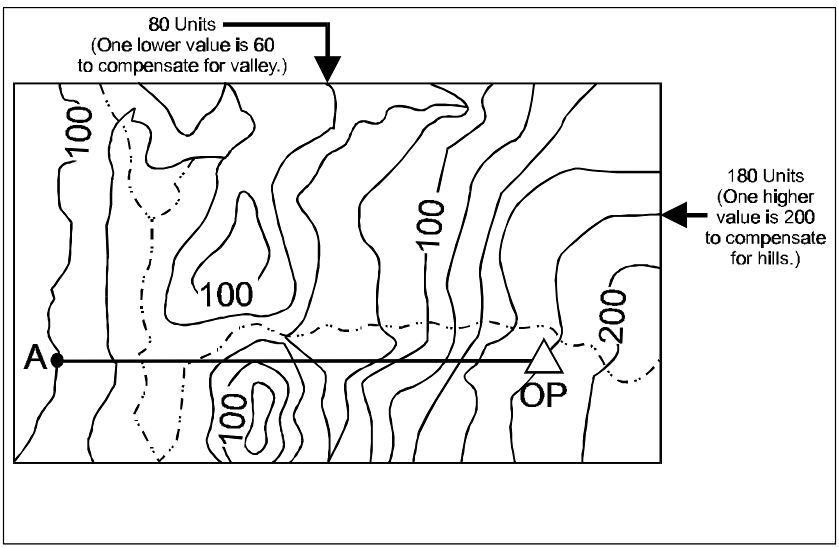

Figure E-3. Contour Interval.

Draw a vertical line from each contour line intersecting the radial line (profile line). Extend the vertical line to the (horizontal) line corresponding to the elevation of a contour line. Continue this procedure until all contour lines have been connected with their corresponding elevations. The result will appear as a series of perpendicular lines connecting points of a contour line with a horizontal line of a specified elevation. After all vertical lines have been dropped for contour lines, drop the vertical lines from hilltops, ridgetops, stream lines, and valleys. (See broken lines in figure E-4 on page E-6.) Then determine the end points of these perpendicular lines by interpolation. If the diagram is being drawn at the OP, make allowances for buildings, new construction, newly grown vegetation, and other changes to the map.

The next step is to connect the end points of all perpendicular lines with a smooth, curved line. When the points are connected, the relief of the terrain along the profile line becomes apparent.

To determine visibility from the terrain profile, draw straight lines from the OP to the lowest points of visibility along the entire length of the terrain profile. Those areas that are not visible from the OP are below the straight lines and may be shaded. (See figure E-5 on page E-7.)

After the areas that are not visible from the OP have been identified as in figure E-5, show them on the profile line. Do this by extending perpendicular lines from the left and right limits of the defilade areas as shown in figure E-5. The defilade is shown as a heavy shaded portion of the profile line.

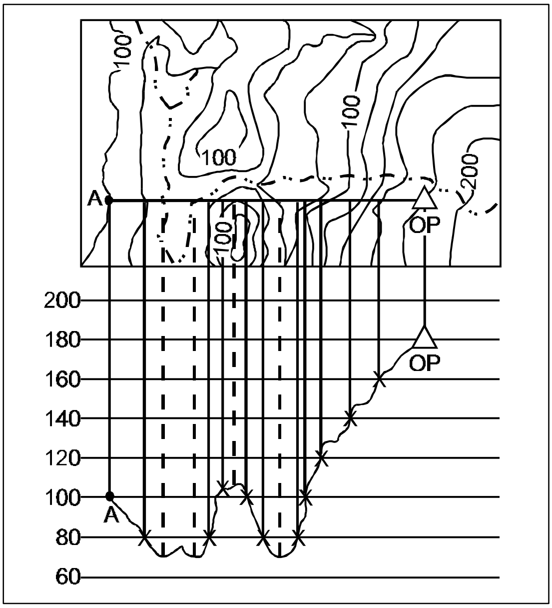

Figure E-4. Transferring Points from Profile to Profile Line.

3. Step Three—The Completed Visibility Diagram. After the nonvisible areas have been transferred to the first profile line, repeat the procedures described in step two for each profile line in the zone of observation. (See figure E-6 on page E-7.)

As defilade areas along each line of vision are identified and shaded, connect the nonvisible portions. (See figure E-7 on page E-8.)

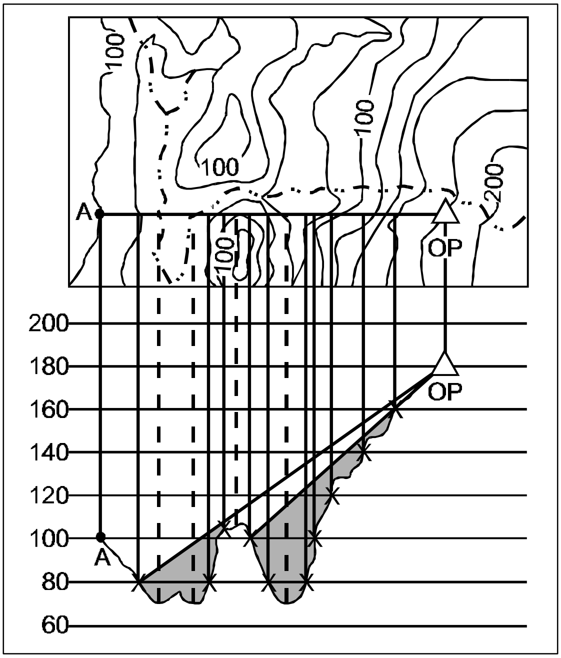

Figure E-5. Nonvisible Areas (Defilade).

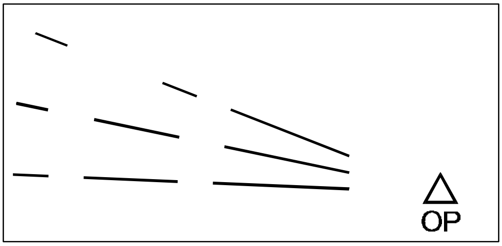

Figure E-6. Nonvisible Areas on Profile Lines.

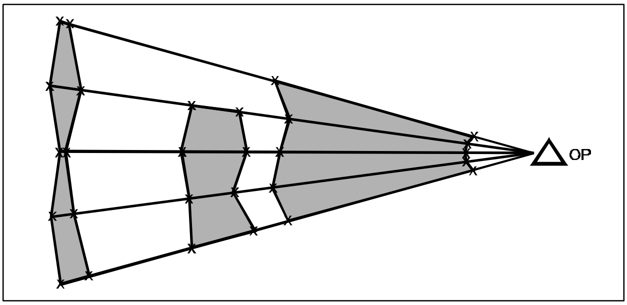

Figure E-7. Areas of Visibility and Nonvisibility.

After adjacent profile lines have been analyzed and the areas that are not visible have been revealed, the finished product appears as shown in figure E-8 on page E-9. The observer highlights nonvisible areas by shading or crosshatching the defilade areas.

The visibility diagram normally is completed in overlay form. As a minimum, the marginal data listed in table E-1 should be placed on the overlay. (See figure E-8 on page E-9.)

Table E-1. Marginal Data.

Item	Example
OP grid	5138 2925
Primary azimuth of observation	0700 mils
Grid register marks	Register marks
Map sheet/scale	Podunk, 1:50,000
Map series/date	V793, sheet 2345 III, 1975
Name of observer	2dLt Cannon
Unit	3/10
Date-time group	251300 Feb
Left and right limits	200 mils, 1,200 mils

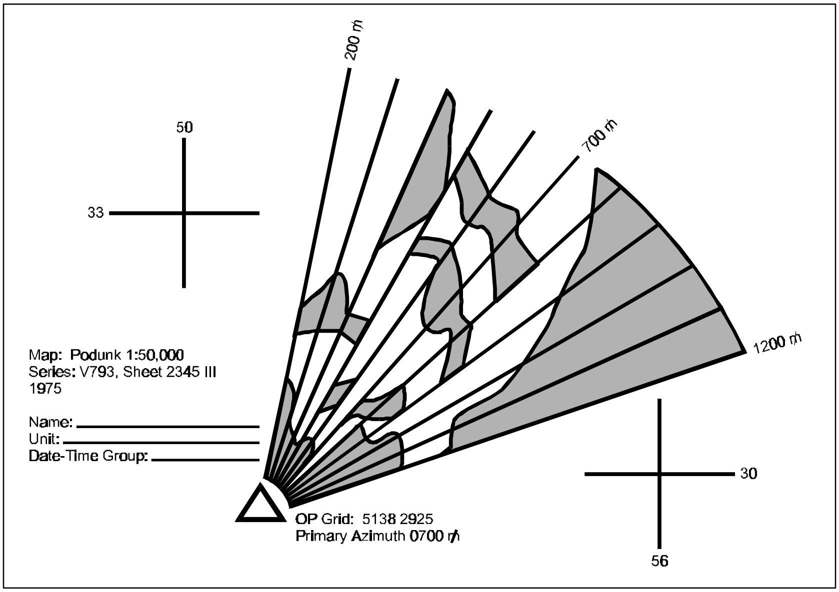

Figure E-8. Completed Visibility Diagram Overlay With Marginal Data.

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Appendix F

Weapons Reference Data

Table F-1. Naval Gunfire Platforms.

Hull Number	Name	Armament	GFCS	Hull Number	Name	Armament	GFCS
California Class (CGN), 2 Ships							
CGN 36	California	2 - 5“/54	MK-86	CGN 37	South Carolina	2 - 5”/54	MK-86
Ticonderoga Class (CG), 27 Ships							
CG 47	Ticonderoga	2 - 5“/54	MK-86	CG 61	Monterey	2 - 5“/54	MK-86
CG 48	Yorktown	2 - 5”/54	MK-86	CG 62	Chancellorsville	2 - 5“/54	MK-86
CG 49	Vincennes	2 - 5“/54	MK-86	CG 63	Cowpens	2 - 5“/54	MK-86
CG 50	Valley Forge	2 - 5”/54	MK-86	CG 64	Gettysburg	2 - 5“/54	MK-86
CG 51	Thomas S. Gates	2 - 5”/54	MK-86	CG 65	Chosin	2 - 5“/54	MK-86
CG 52	Bunker Hill	2 - 5”/54	MK-86	CG 66	Hue City	2 - 5“/54	MK-86
CG 53	Mobile Bay	2 - 5”/54	MK-86	CG 67	Shiloh	2 - 5“/54	MK-86
CG 54	Antietam	2 - 5”/54	MK-86	CG 68	Anzio	2 - 5“/54	MK-86
CG 55	Leyte Gulf	2 - 5“/54	MK-86	CG 69	Vicksburg	2 - 5“/54	MK-86
CG 56	San Jacinto	2 - 5“/54	MK-86	CG 70	Lake Erie	2 - 5“/54	MK-86
CG 57	Lake Champlain	2 - 5“/54	MK-86	CG 71	Cape St. George	2 - 5“/54	MK-86
CG 58	Philippine Sea	2 - 5“/54	MK-86	CG 72	Vella Gulf	2 - 5“/54	MK-86
CG 59	Princeton	2 - 5“/54	MK-86	CG 73	Port Royal	2 - 5“/54	MK-86
CG 60	Normandy	2 - 5”/54	MK-86				
Arleigh Burke Class (DDG), 23 Ships Active, 8 Under Construction							
DDG 51	Arleigh Burke	1 - 5”/54	MK-34	DDG 63	Stethem	1 - 5”/54	MK-34
DDG 52	Barry	1 - 5”/54	MK-34	DDG 64	Carney	1 - 5”/54	MK-34
DDG 53	John Paul Jones	1 - 5”/54	MK-34	DDG 65	Benfold	1 - 5“/54	MK-34
DDG 54	Curtis Wilbur	1 - 5”/54	MK-34	DDG 66	Gonzalez	1 - 5“/54	MK-34
DDG 55	Stout	1 - 5“/54	MK-34	DDG 67	Cole	1 - 5“/54	MK-34
DDG 56	John S. McCain	1 - 5”/54	MK-34	DDG 68	The Sullivans	1 - 5“/54	MK-34
DDG 57	Mitscher	1 - 5”/54	MK-34	DDG 69	Milius	1 - 5“/54	MK-34
DDG 58	Laboon	1 - 5”/54	MK-34	DDG 70	Hopper	1 - 5“/54	MK-34
DDG 59	Russell	1 - 5”/54	MK-34	DDG 71	Ross	1 - 5“/54	MK-34
DDG 60	Paul Hamilton	1 - 5”/54	MK-34	DDG 72	Mahan	1 - 5“/54	MK-34
DDG 61	Ramage	1 - 5“/54	MK-34	DDG 74	McFaul	1 - 5“/54	MK-34
DDG 62	Fitzgerald	1 - 5“/54	MK-34				
Kidd Class (DDG), 2 Ships							
DDG 995	Scott	2 - 5“/54	MK-86	DDG 996	Chandler	2 - 5”/54	MK-86
Spruance Class (DD), 27 Ships							

DD 963	Spruance	2 - 5“/54	MK-86	DD 978	Stump	2 - 5”/54	MK-86
DD 964	Paul F. Foster	2 - 5”/54	MK-86	DD 979	Conolly	2 - 5“/54	MK-86
DD 965	Kinkaid	2 - 5“/54	MK-86	DD 980	Moosbrugger	2 - 5“/54	MK-86
DD 966	Hewitt	2 - 5“/54	MK-86	DD 981	John Hancock	2 - 5“/54	MK-86
DD 967	Elliot	2 - 5“/54	MK-86	DD 982	Nicholson	2 - 5“/54	MK-86
DD 968	Arthur W. Radford	2 - 5”/54	MK-86	DD 983	John Rogers	2 - 5“/54	MK-86
	Peterson			DD 985	Cushing	2 - 5“/54	MK-86
DD 969	Caron	2 - 5”/54	MK-86	DD 987	O’Bannon	2 - 5“/54	MK-86
DD 970	David R. Ray	2 - 5”/54	MK-86	DD 988	Thorn	2 - 5“/54	MK-86
DD 971	Oldendorf	2 - 5“/54	MK-86	DD 989	Deyo	2 - 5“/54	MK-86
DD 972	John Young	2 - 5“/54	MK-86	DD 990	Ingersoll	2 - 5“/54	MK-86
DD 973	O’Brien	2 - 5“/54	MK-86	DD 991	Fife	2 - 5“/54	MK-86
DD 975	Briscoe	2 - 5“/54	MK-86	DD 992	Fletcher	2 - 5“/54	MK-86
DD 977		2 - 5“/54	MK-86	DD 997	Hayler	2 - 5“/54	MK-86

Note: Active ships as of June 1998.

Legend: CG = guided missile cruiser
CGN = guided missile cruiser (nuclear)
DD = destroyer
DDG = guided missile destroyer
GFCS = gunfire control system

Table F-2. Characteristics of U.S. Mortars, Artillery, and Rockets.

Caliber	60 mm	81 mm	105 mm[1]	105 mm[1]	155 mm	155 mm[1]	227 mm[1]	607 mm[1]
Model	M224	M252	M102	M119A1	M198	M109A5/A6	MLRS	ATACMS
Maximum Range (m)	3,500[2]	5,600[3]	11,400	11,500	18,300 22,000[4]	18,200 21,700[4]	32,000 45,000[5]	165,000 300,000[6]
Ammuni-tion	HE, WP, ILLUM	HE, WP, RP, ILLUM	HE, HC, WP, ILLUM, APICM	HE, HC, WP, ILLUM, APICM	HE, HC, WP, ILLUM, APICM, DPICM, M825 smoke, FASCAM, Copperhead	HE, HC, WP, ILLUM, APICM, DPICM, M825 smoke, FASCAM, Copperhead	DPICM	APAM
Maximum Rate of Fire (Rounds/ min)	30	35	10	10	4	4	12/40 sec	2/20 sec
Sustained Rate of Fire (Rounds/ min)	20	15	3	3	2	1	N/A	N/A
Range of RAP (m)	N/A	N/A	15,300	19,500	30,100	30,000	N/A	N/A
Range of DPICM (m)	N/A	N/A	10,500	14,100	18,000 28,200[7]	17,900 28,100[7]	N/A	N/A
Minimum Range (m)	75	70	N/A	N/A	N/A	N/A	10,000 13,000	25,000 70,000
Fuzes	MO	MO	PD, VT, MT, MTSQ, CP, delay	PD, VT, MT, MTSQ, CP, delay	PD, VT, MT, MTSQ, delay	PD, VT, MT, MTSQ, delay	ET	ET

Illumination Time (sec)	25	60	75	75	120	120	N/A	N/A
HE Burst Width (1 Round)	28	35	35	35	50	50	100	N/A
FPF	90 3 tubes	35 1 tube	210 6 guns	210 6 guns	300 6 guns	300 6 guns 150 3 guns	N/A	N/A
Notes:	1. U.S. Marine Corps units do not possess these weapons systems. However, Marine Corps units may operate with Army units equipped with these weapons. 2. With M720 ammunition. 3. With M821 ammunition. 4. With M795 HE, M825 smoke ammunition. 5. Extended-range MLRS to be fielded in Fiscal Year 99. 6. Block 1A ATACMS to be fielded in Fiscal Year 98. 7. BBDPICM M864.							
Legend:	ATACMS = Army Tactical Missile System ET = electronic time HC = high capacity ILLUM = illumination MO = multioption fuze, VT, PD, delay					MT = mechanical time MTSQ = mechanical time superquick RAP = rocket-assisted projectile		

Table F-3. U.S. Aircraft Capabilities Guide.

Type of Aircraft	Communications Package	Navigation	Guns	Conventional Ordnance		Laser Equipment	
				External	Maximum Load	Tracker	Designator
AV-8B	2 UHF	TACAN INS Radar[2]	25 mm 300 rounds	All	8,000 lb	No	No
AH-1W[4]	2 UHF[1] 2 VHF-AM[1] 2 VHF-FM[1]	TACAN ADF FM homer Radar beacon	20 mm 750 rounds or 20-mm pod	2.75-in rockets 5-in rockets TOW missile HELLFIRE Sidearm	2,500 lb	No	Yes
F/A-18A/C[5]	2 UHF[1] 2 VHF-AM[1] 2 VHF-FM[1]	TACAN ADF INS Radar FLIR	20 mm 580 rounds	All	13,700 lb	Yes (pod)	Yes
F/A-18D[5]	2 UHF[1] 2 VHF-AM[1] 2 VHF-FM[1]	TACAN ADF INS Radar FLIR	20 mm 515 rounds	All	13,500 lb	Yes (pod)	Yes
A-10	UHF VHF-AM VHF-FM	TACAN INS	30 mm 1,100 rounds	All	16,000 lb	Yes (pod)	No
AH-64	UHF VHF-AM VHF-FM	TACAN ADF Doppler	30 mm 1,200 rounds	70-mm rocket HELLFIRE	3,000 lb	Yes	Yes
F-16[5]	UHF[1] VHF-AM[1] VHF-FM[1]	TACAN ADF INS Radar ILS	20 mm 515 rounds	All	12,000 lb	No	Yes[3]
F-15E[5]	UHF	TACAN ADF INS Radar ILS	20 mm 512 rounds	All	13,220 lb	No	Yes[3]

Notes:		
[1] Can only monitor two frequencies at a time.		
[2] AV-8B "Plus" is equipped with radar but has no laser spot tracker.		
[3] F-16C/D and F-15E can designate if equipped with a LANTIRN pod.		
[4] The AH-1W Night Tactics System aircraft is GPS capable, and its FLIR is grid/range-designation capable.		
[5] Some aircraft are GPS capable.		
Legend:	ADF = automatic direction finder	INS = inertial navigation system
	ILS = instrument landing system	TACAN = tactical air navigation system

Table F-4. Naval Gunfire Weapons Systems.

Weapon	Maximum Range (m) Full Charge	RAP	Maximum Range (m) Reduced Charge	Rate of Fire per Tube (Maximum/ Sustained)	Ammunition	Fuzes
5"/38	15,900	25,265	8,100	20/15	HE, HC, ILLUM, WP, RAP	Quick, MT, CVT, VT
5""/54	23,100	29,181	12,200	20/20	HE, HC, ILLUM, WP, RAP	Quick, MT, CVT, VT, delay

Table F-5. World Artillery, Mortars, and Rocket Launchers.

			Rate of Fire			
Manufacturer/ Weapon	**Basic Range (m)**	**Base Burn/ RAP Range (m)**	**Maximum**	**Sustained**	**Countries/ Organizations Possessing**	**Remarks**
Austria						
GHN-45, 155-mm towed	30,300	39,600	7/min	2/min	Iran, Iraq, Thailand	None
Brazil						
ASTROS II, MRL	—	30,000 60,000	32/min 4/min	Reload Reload	Saudi Arabia, Iran, Qatar	None
China						
WS-1, 320-mm MRL	—	80,000	4/min	Reload	None	None
Type 83, 273-mm MRL	—	40,000	4/min	Reload	None	None
Type 71, 180-mm MRL	—	20,000	10/min	Reload	None	None
WA 021, 155-mm towed	30,000	39,000	5/min	2/min	None	None
Type 83, 152-mm towed	30,400	38,000	4/min	2/min	Iraq	None
Type 82/85, 130-mm MRL	—	15,000	60/5 min	Reload	Thailand	None
Type 59-1, 130-mm towed	27,500	38,000	10/min	10/min	Iran, Iraq, Oman, North Korea, Egypt, Lebanon	None
France						
GCT, 155-mm SP	23,000	29,000	6/min	2/min	Iraq, Kuwait, Saudi Arabia	None
GCT, 155-mm towed	24,000	32,000	3/18 sec	6/min	Cyprus	None
MkF3, 155-mm SP	20,000	25,000	3/min	1/min	Iraq, Kuwait, UAE	None
Germany						
PzH 2000, 155-mm SP	30,000	40,000	3/10 sec	9/min	None	None
Iran						
N10, 450-mm MRL	—	150,000	1/min	2/hr	None	None
Iraq						

ARABEL 100, 400-mm MRL	—	100,000	4/min	Reload	None	None
ARABEL 50, 262-mm MRL	—	50,000	12/min	Reload	Former Yugoslavia, Bosnian Serb Army, Croatia	None
Israel						
845, 155-mm towed	24,000	39,000	5/min	2/min	None	None
M71, 155-mm towed	23,500	30,000	5/min	2/min	Singapore, Thailand, South Africa	None
Italy						
Palmaria, 155-mm SP	24,700	30,000	3/20 sec	4/min	Libya, Nigeria	None
North Korea						
M1985, 240-mm MRL	—	43,000	12/min	Reload	Iran	CHEM
M1978, 170-mm SP	40,000	—	INA	INA	Iran, Iraq	None
M46, 130-mm SP	27,500	—	6/min	1.1/min	None	None
BM 11, 122-mm MRL	—	20,500	30/min	Reload	PLO, Syria, Iran, Iraq, Uganda	None
M1981, 122-mm SP	23,900	—	INA	INA	None	None
M1992, 120-mm SP mortar	8,700	—	INA	INA	None	None
Russia/CIS						
FROG-7, MRL	—	70,000	1/min	1/hr	Former Warsaw Pact, Afghanistan, Algeria, Cuba, Egypt, Iraq, North Korea, Libya, Syria, Yemen	NUKE, CHEM
SMERCH, 300-mm MRL	—	70,000	12/min	Reload	Kuwait, UAE	None
2S4, 240-mm SP mortar	9,600	18,000	1/min	40/hr	Iraq, Czech Republic	NUKE, LGM
M240, 240-mm towed mortar	9,700	18,000	1/min	38/hr	IRA, Iraq, North Korea, Egypt, Oman, Lebanon	NUKE, LGM

BM 27, 220-mm MRL	—	35,000	16/min	Reload	Afghanistan, Syria	CHEM, mines
2S7, 203-mm SP	37,500	47,000	2/min	2/min	Czech Republic, Poland, Slovakia	None
2S3, 180-mm towed	30,400	43,800	1/min	1/2 min	India, Iraq, Egypt, Syria	None
2S3, 152-mm SP	20,600	24,000	4/min	1/min	Hungary, Iraq, Libya, Syria	None
2S19, 152-mm SP	24,700	30,000	8/min	8/min	None	LGM
2S5, 152-mm SP	28,400	37,000	5/min	5/min	None	None
2A36, 152-mm towed	28,400	37,000	5/min	1/min	Finland	None
D-20, 152-mm towed	17,230	30,000	5/min	1/min	Algeria, China, Cuba, Egypt, Vietnam, Former Yugoslavia	None
BM 14, 122-mm MRL	—	9,800	16/min	Reload	Algeria, Afghanistan, Cambodia, China, Egypt, Syria, North Korea, Vietnam	CHEM
BM 21, 140-mm MRL	—	20,400	40/min	Reload	China, Egypt, India, Iran, Iraq, North Korea, others	CHEM, mines
2S1, 122-mm SP	15,300	22,000	8/min	1.1/min	None	None
D-30, 122-mm towed	15,300	22,000	8/min	1.1/min	China	None
2S9, 120-mm SP mortar	8,900	13,000	6/min	6/min	Afghanistan	LGM
2S23, 120-mm SP mortar	8,900	12,900	10/min	10/min	None	LGM
2B9, 82-mm SP towed mortar	4,300	—	120/min		Hungary	None
South Africa						
G-6, 155-mm SP	30,800	39,600	3/21 sec	4/min	UAE, Oman	None
G-5, 155-mm towed	30,200	39,000	3/min	3/min	None	None
United Kingdom						

FH 70, 155-mm towed	24,700	31,500	3/13 sec	2/min	Germany, Italy, Japan, Saudi Arabia	None

Former Yugoslavia						
M-77, 128-mm MRL	—-	20,600	32/min	Reload	Bosnia, Bosnian Serb Army, Croatia, Iraq, Serbia, Montenegro	None

Note: A complete listing of all world artillery systems and their characteristics is available in the classified National Government Intelligence Center (NGIC) series *Field Artillery Worldwide*. Reference Defense Science and Technology (DST) 1130S-115-94, *Cannon and Mortars*; DST 1130S-94 Vol. 2, Sup. 1; and NGIC 1143-200D-95, *Multiple Rocket Launcher Systems*.

Legend:

CHEM = chemical munitions capable
CIS = Commonwealth of Independent States
INA = information not available
IRA = Irish Republican Army
LGM = laser-guided munitions capable
MRL = multiple rocket launcher
NUKE = nuclear munitions capable
PLO = Palestine Liberation Organization
SP = self- propelled
UAE = United Arab Emirates

Appendix G

Glossary

Section I. Acronyms and Abbreviations

AAA .... antiaircraft artillery
AAV(P) .... assault amphibious vehicle (personnel variant)
ACA .... airspace coordination area
ACE .... aviation combat element
ACIF .... *Artillery Counterfire Information Form*
ADA .... air defense artillery
ADAM .... area denial artillery munitions
ADF .... automatic direction finder
ALP .... Air Liaison Party
AM .... amplitude modulation
AOA .... amphibious objective area
APAM .... antipersonnel/antimaterial
APICM .... antipersonnel ICM
ARBS .... angle rate bombing system
ASAP .... as soon as possible
ASC(A) .... assault support coordinator (airborne)
ATACMS .... Army Tactical Missile System

BBDPICM .... base burn DPICM
BC .... battery commander
BCS .... battery computer system
BDHI .... bearing-distance heading indicator
BLT .... battalion landing team
BMNT .... beginning of morning nautical twilight

BUCS .... backup computer system

CAS .... close air support
CBU .... cluster bomb unit
CEOI .... communications-electronics operating instructions
CG .... guided missile cruiser
CGN .... guided missile cruiser (nuclear)
CHEM .... chemical munitions capable
CIS .... Commonwealth of Independent States
COF .... conduct of fire
CP .... concrete piercing
CVT .... fuze controlled variable time

DA .... Department of the Army
DACT .... data automated communications terminal
DASC .... direct air support center
DD .... destroyer
DDG .... guided missile destroyer
DPICM .... dual-purpose ICM
DST .... Defense Science and Technology

EENT .... end of evening nautical twilight
ET .... electronic time
ETA .... estimated time of arrival

FAC .... forward air controller
FAC(A) .... forward air controller (airborne)
FACP .... forward air control party
FASCAM .... family of scatterable mines
FDC .... fire direction center
FDO .... fire direction officer

FFAR .... folding-fin aircraft rocket
FFCC .... force fires coordination center
FLIR .... forward looking infrared
FM .... frequency modulation
FM .... U.S. Army field manual
FMFM .... Fleet Marine Force manual
FMFRP .... Fleet Marine Force reference publication
FO .... forward observer
FOM .... figure of merit
FPF .... final protective fire
FPL .... final protective line
FSA .... fire support area
FSCC .... fire support coordination center
FSCL .... fire support coordination line
FSS .... fire support station

GCE .... ground combat element
GFCS .... gunfire control system
GPS .... Global Positioning System
GTA .... Graphic Training Aid
GTL .... gun-target line
GURF .... guns up ready to fire

HB .... high burst
HC .... hexachloroethane
HC .... high capacity
HDC .... helicopter direction center
HE .... high explosives
HELLFIRE .... helicopterborne fire and forget missile
HE/Q .... HE/fuze quick
HF .... high frequency

HMMWV .... high mobility multipurpose wheeled vehicle
HOB .... height of burst

IADS .... Integrated Air Defense System
ICM .... improved conventional munitions
IFSAS .... Initial Fire Support Automation System
ILLUM .... illumination
ILS .... instrument landing system
INA .... information not available
INS .... inertial navigation system
IP .... initial point
IRA .... Irish Republican Army

JMEM .... *Joint Munitions Effectiveness Manual*
JTAR .... joint tactical airstrike request

KIA .... killed in action

LANTIRN .... low-altitude navigation and targeting infrared for night
LAR .... light armored reconnaissance
LARS .... left add, right subtract
LGM .... laser-guided munitions capable
LGW .... laser-guided weapon
LNO .... liaison officer
LTD/R .... laser target designator/ranger

MACCS .... Marine air command and control system
MAGTF .... Marine air-ground task force
MBC .... mortar ballistic computer
MCLOS .... manual command to line of sight
MCWP .... Marine Corps warfighting publication

MLRS .... Multiple Launch Rocket System
MO .... multioption fuze, VT, PD, delay
MOS .... military occupational specialty
MPI .... mean point of impact
MRL .... multiple rocket launcher
MT .... mechanical time
MTL .... maneuver-target line
MTO .... message to observer
MTSQ .... mechanical time superquick
MULE .... modular universal laser equipment

NGF .... naval gunfire
NGIC .... National Government Intelligence Center
NGLO .... naval gunfire liaison officer
NLT .... no later than
NSFS .... naval surface fire support
NTS .... Night Targeting System
NUKE .... nuclear munitions capable
NVG .... night vision goggles
OAS .... offensive air support
OB .... operator-burst
OF .... observed fire
OP .... observation post
OPGEN MIKE .... operational message, general (maritime tactical message), amphibious
OPORD .... operation order
OPTASK AMPHIB .... operational tasking (maritime tactical message), amphibious
OT .... observer-target
OTL .... observer-target line

PD . . . . . point detonating
PDF . . . . . principal direction of fire
PE_R . . . . . probable error in range
PGM . . . . . precision-guided munitions
PLGR . . . . . precise lightweight GPS receiver
PLO . . . . . Palestine Liberation Organization
PLRS . . . . . Position Location Reporting System
POL . . . . . petroleum, oils, and lubricants
POSREP . . . . . position report
PPS . . . . . precise positioning system
PRF . . . . . pulse repetition frequency

QE . . . . . quadrant elevation

RAAMS . . . . . remote antiarmor mine system
RALS . . . . . right add, left subtract
RAP . . . . . rocket-assisted projectile
ROE . . . . . rules of engagement
RP . . . . . red phosphorus
RREMS . . . refinement, record as target, end of mission, and surveillance
RTO . . . . . radio/telephone operator

SACC . . . . . supporting arms coordination center
SACLOS . . . . . semiautomatic command to line of sight
SALUTE . . . . . size, activity, location, unit, time, and equipment
SAM . . . . . surface-to-air missile
SEAD . . . . . suppression of enemy air defenses
SFCP . . . . . shore fire control party
SHELREP . . . . . shelling report
SINCGARS . . . . . Single-channel Ground and Airborne Radio System
SITREP . . . . . situation report

SLoCTOP .... security, location, communications, targeting, observation, and position improvement
SOP .... standing operating procedure
SP .... self-propelled

TAC(A) .... tactical air coordinator (airborne)
TACAN .... tactical air navigation system
TACC ....tactical air control center
TACP .... tactical air control party
TAD ....tactical air direction
TADC .... tactical air direction center
TAOC .... tactical air operations center
TAR .... tactical air request
TATC .... tactical air traffic control
TM ....technical manual
TNT ....trinitrotoluene
TOF .... time of flight
TOT .... time on target
TOW .... tube launched, optically tracked, wire command link guided missile
TRAP ....tactical recovery of aircraft and personnel
TRP .... target reference point
TTT .... time to target

UAE ....United Arab Emirates
UAV ....unmanned aerial vehicle
UHF .... ultrahigh frequency
UT1 ....universal time
UTC .... coordinated universal time
UTM .... universal transverse mercator
UTO .... universal time observed

VHF .... very high frequency
VT .... fuze variable time
VT-IR .... variable time-infrared frequency
VT-RF .... variable time-radio frequency

WP .... white phosphorus

Section II. Definitions

A

add—In artillery and NGF support, a correction used by an observer/spotter to indicate that an increase in range along a spotting line is desired.

adjust fire—An order or request to initiate an adjustment of fire. In artillery, a method of control transmitted in the warning order of the call for fire to indicate that the observer will control the adjustment. In NGF, the spotter uses the term "spotter adjust" as a method of control to indicate his desire to control the adjustment.

adjusting point—The target itself or a point near the center of an area target. Spottings are made *from* this point, and corrections are made *to* this point.

adjustment—A process used in artillery and NGF to obtain deviation (left/right), range (add/drop), and HOB (up/down) corrections when engaging a target by observed fire.

air—In artillery and NGF, a spotting to indicate that a burst or group of bursts occurred above the surface (i.e., in the air).

air burst—An explosion of a projectile above the surface as distinguished from an explosion on contact with the surface or after penetration of the surface.

altitude—The vertical distance of a level, a point or an object considered as a point, measured from mean sea level. (Joint Pub 1-02)

B

battery commander scope—A telescope used by the observer to enable him to remain in defilade while determining directions and vertical angles in the target area.

battle damage assessment—The timely and accurate estimate of damage resulting from the application of military force, either lethal or non-lethal, against a predetermined objective. Battle damage assessment can be applied to the employment of all types of weapon systems (air, ground, naval, and special forces weapon systems) throughout the range of military operations. Battle damage assessment is primarily an intelligence responsibility with required inputs and coordination from the operators. Battle damage assessment is composed of physical damage assessment, functional damage assessment, and target system assessment. (Joint Pub 1-02)

bracketing—A method of adjusting fire in which a bracket is established by obtaining an over and a short along the spotting line, and then successively splitting the bracket in half until a target hit or desired bracket is obtained. (Joint Pub 1-02)

C

close air support—Air action by fixed- and rotary-wing aircraft against hostile targets which are in close proximity to friendly forces and which require detailed integration of each air mission with the fire and movement of those forces. (Joint Pub 1-02)

continuous fire—1. Fire conducted at a normal rate without interruption for application of adjustment corrections or for other causes. 2. In field artillery and naval gunfire support, loading and firing at a specified rate or as rapidly as possible consistent with accuracy within the prescribed rate of fire for the weapon. Firing will continue until terminated by the command end of mission or temporarily suspended by the command cease loading or check firing. (Joint Pub 1-02)

continuous illumination fire—A type of fire in which illuminating projectiles are fired at specified time intervals to provide uninterrupted lighting on the target or specified area. (Joint Pub 1-02)

coordinated illumination fire—A type of fire in which the firing of illuminating and HE projectiles is coordinated to provide illumination of the target and surrounding area only at the time required for spotting and adjusting the HE fire.

correction—Any change in firing data to bring the MPI or burst closer to the target. A communications procedure word to indicate that an error in data has been announced and the corrected data will follow.

D

danger close—Used by an observer/spotter in a call for fire to indicate that friendly forces are within a prescribed distance from a target or impact of rounds.

designate—A command given to lase a target for an LGW.

deviation—1. The distance by which a point of impact or burst misses the target. 2. The angular difference between magnetic and compass headings. (Joint Pub 1-02)

digital communications terminal—A handheld device that enables users to rapidly prepare, transmit, and receive both text and graphical messages (clear and encrypted) over standard military radios or field wire.

direct air support center—The principal air control agency of the U.S. Marine air command and control system responsible for the direction and control of air operations directly supporting the ground combat element. It processes and coordinates requests for immediate air support and coordinates air missions requiring integration with ground forces and other supporting arms. It normally collocates with the senior fire support coordination center within the ground combat element and is subordinate to the tactical air command center. Also called **DASC.** (Joint Pub 1-02)

direct fire—Gunfire delivered on a target, using the target itself as a point of aim for either the gun or the director. (Joint Pub 1-02)

direction—In artillery and naval gunfire support, a term used by a spotter/observer in a call for fire to indicate the bearing of the spotting line. (Joint Pub 1-02)

dispersion pattern—The distribution of a series of rounds fired from one weapon or a group of weapons under conditions as nearly identical as possible the points of bursts or impact being dispersed about a point called the mean point of impact. (Joint Pub 1-02)

doubtful—In artillery and naval gunfire support, a term used by an observer or spotter to indicate that he was unable to determine the difference in range between the target and a round or rounds. (Joint Pub 1-02)

down—In artillery and NGF, a term used in a call for fire to indicate that the target is at a lower altitude than the reference point used in identifying the target. A correction used by the observer/spotter to indicate that a decrease in HOB is desired.

drop—In artillery and naval gunfire support, a correction used by an observer/spotter to indicate that a decrease in range along a spotting line is desired. (Joint Pub 1-02)

F

final protective fire—An immediately available prearranged barrier of fire designed to impede enemy movement across defensive lines or areas. (Joint Pub 1-02)

fire direction center—That element of a command post, consisting of gunnery and communication personnel and equipment, by means of which the commander exercises fire direction and/or fire control. The fire direction center receives target intelligence and requests for fire, and translates them into appropriate fire direction. (Joint Pub 1-02)

fire for effect—The command to fire the ammunition in type and quantity to achieve the amount of casualties desired for the mission.

fire support area—An appropriate maneuver area assigned to fire support ships from which to deliver gunfire support of an amphibious operation. (Joint Pub 1-02)

fire support station—An exact location at sea within a fire support area from which a fire support ship delivers fire. (Joint Pub 1-02)
full charge—The larger of the two propelling charges available for naval guns. (Joint Pub 1-02)

fuze—A device which initiates an explosive train. (Joint Pub 1-02)

fuze (specify)—In artillery and naval gunfire support, a command or request to indicate the type of fuze action desired; i.e., delay, quick, time, proximity. (Joint Pub 1-02)

G

graze—In artillery and naval gunfire support, a spotting, or an observation, by a spotter or an observer to indicate that all bursts occurred on impact. (Joint Pub 1-02)

gun-target line—An imaginary straight line from gun to target. (Joint Pub 1-02)

H

high-angle fire—Fire delivered at angles of elevation greater than the elevation that corresponds to the maximum range of the gun and ammunition concerned; fire, the range of which decreases as the angle of elevation is increased. (Joint Pub 1-02)

I

immediate smoke—A mission fired, normally by a platoon, to immediately screen or obscure the enemy and/or friendly positions or movement.

immediate suppression—A fire-for-effect-type mission, fired normally by battery SOP, in which a platoon fires to force the enemy to take cover.

indirect fire—Fire delivered on a target that is not itself used as a point of aim for the weapons or the director. (Joint Pub 1-02)

L

lateral spread—A technique used to place the mean point of impact of two or more units 100 meters apart on a line perpendicular to the gun-target line. (Joint Pub 1-02)

left—Denotes a shift perpendicular to the OTL.

line—In artillery and naval gunfire support, a spotting, or an observation, used by a spotter or an observer to indicate that a burst(s) occurred on the spotting line. (Joint Pub 1-02)

list of targets—A tabulation of confirmed or suspect targets maintained by any echelon for informational and fire support planning purposes. (Joint Pub 1-02)

low-angle fire—Fire delivered at angles of elevation below the elevation that corresponds to the maximum range of the gun and ammunition concerned. (Joint Pub 1-02)

M

maximum ordinate—The highest point along the trajectory of a projectile. The difference in altitude (vertical interval) between the origin and the summit.

mean point of impact—The point whose coordinates are the arithmetic means of the coordinates of the separate points of impact/burst of a finite number of projectiles fired or released at the same aiming point under a given set of conditions. (Joint Pub 1-02)

O

observation post—A position from which military observations are made, or fire directed and adjusted, and which possesses appropriate communications; may be airborne. (Joint Pub 1-02)

observed fire fan—A device used to refine an observer's estimate of distance in the target area.

observer-target factor—The distance from the observer to the target expressed in thousands to the nearest thousand (for example, the OT factor for 6,300 meters is 6).

observer-target line—An imaginary straight line from the observer/spotter to and through the target.

P

point target—A target of such small dimension that it requires the accurate placement of ordnance in order to neutralize or destroy it. (Joint Pub 1-02) It is generally a target that is less than 200 meters in length and width.

probable error—The measurement of the impact distribution in the dispersion pattern around the MPI.

projectile—An object projected by an applied exterior force and continuing in motion by virtue of its own inertia, as a bullet, shell, or grenade. Also applied to rockets and to guided missiles. (Joint Pub 1-02)

R

range spread—The technique used to place the mean point of impact of two or more units 100 meters apart on the gun-target line. (Joint Pub 1-02)

reduced charge—1. The smaller of the two propelling charges available for naval guns. 2. Charge employing a reduced amount of propellant to fire a gun at short ranges as compared to a normal charge. (Joint Pub 1-02)

reference line—A convenient and readily identifiable line used by the observer or spotter as the line to which spots will be related.

reference point—A prominent, easily located point in the terrain. (Joint Pub 1-02)

refinement—A final correction sent to the FDC to move the center of impact to the adjusted point. Refinement is always given for any mission.

registration—The adjustment of fire to determine firing data corrections. (Joint Pub 1-02)

right—Denotes a shift perpendicular to the OTL.

round—One shot fired by a weapon.

rounds complete—In artillery and naval gunfire support, the term used to report that the number of rounds specified in fire for effect have been fired. (Joint Pub 1-02)

S

salvo—1. In naval gunfire support, a method of fire in which a number of weapons are fired at the same target simultaneously. 2. In close air support/air interdiction operations, a method of delivery in which the release mechanisms are operated to release or fire all ordnance of a specific type simultaneously. (Joint Pub 1-02)

sheaf—In artillery and naval gunfire support, planned planes (lines) of fire that produce a desired pattern of bursts with rounds fired by two or more weapons. (Joint Pub 1-02)

shell (specify)—A command or request indicating the type of projectile to be used.

shelling report—Any report of enemy shelling containing information on caliber, direction, time, density and area shelled. (Joint Pub 1-02)

ship adjust—In NGF, a method of control in which the ship can see the target and adjust the fire.

shot—A report that indicates that a gun or guns have been fired.

splash—In artillery and naval gunfire support, word transmitted to an observer or spotter five seconds before the estimated time of the impact of a salvo or round. (Joint Pub 1-02)

spotting—A process of determining by visual or electronic observation, deviations of artillery or naval gunfire from the target in relation to a spotting line for the purpose of supplying necessary information for the adjustment or analysis of fire. (Joint Pub 1-02)

spotting line—Any straight line to which the fall of shot of projectiles is related or fire is adjusted by an observer or a spotter. (Joint Pub 1-02)

spreading fire—A notification by the spotter or the naval gunfire ship, depending on who is controlling the fire, to indicate that fire is about to be distributed over an area. (Joint Pub 1-02)

summit—The highest altitude above mean sea level that a projectile reaches in its flight from the gun to the target; the algebraic sum of the maximum ordinate and the altitude of the gun. (Joint Pub 1-02)

supporting arms—Air, sea, and land weapons of all types employed to support ground units. (Joint Pub 1-02)

suppression of enemy air defenses—That activity which neutralizes, destroys, or temporarily degrades surface-based enemy air defenses by destructive and/or disruptive means. Also called **SEAD.** (Joint Pub 1-02)

sustained rate of fire—Actual rate of fire that a weapon can continue to deliver for an indefinite length of time without seriously overheating. (Joint Pub 1-02)

T

target number—The reference number given to a target.

time of flight—In artillery and naval gunfire support, the time in seconds from the instant a weapon is fired, launched, or released from the delivery vehicle or weapons system to the instant it strikes or detonates. (Joint Pub 1-02)

time on target—1. Time at which aircraft are scheduled to attack/photograph the target. 2. The actual time at which aircraft attack/photograph the target. (Joint Pub 1-02)

trajectory—The path of a projectile, missile, or bomb in flight.

U

Universal time—A measure of time that conforms, within a close approximation, to the mean diurnal rotation of the Earth and serves as the basis of civil timekeeping. Universal Time (UT1) is determined from observations of the stars, radio sources, and also from ranging observations of the Moon and artificial Earth satellites. The scale determined directly from such observations is designated Universal Time Observed (UTO); it is slightly dependent on the place of observation. When UTO is corrected for the shift in longitude of the observing station caused by polar motion, the time scale UT1 is obtained. When an accuracy better than one second is not required, Universal Time can be used to mean Coordinated Universal Time (UTC). Also called **ZULU time.** (Joint Pub 1-02)

up—A term transmitted in a call for fire to indicate that the target is higher in altitude than the point that has been used as a reference point for the target location. A correction used by an observer or a spotter to indicate that an increase in HOB is desired.

Section III. Air-Brevity Codes

Code	Definition
Abort	Directive to cease action/attack/event/mission.
Angels	Height of friendly aircraft in thousands of feet.
Bent	System indicated is inoperative.
Bingo	Fuel state needed for recovery.
Cleared hot	Ordnance release is authorized.
Continue	Continue present maneuver; does not imply clearance to engage or expend ordnance.
Cyclops	Any UAV.
Dash (#)	Aircraft position within a flight. Use if specific call sign is unknown.
Laser on	Directive to start laser designation.
No joy	Aircrew does not have visual contact with target.
Offset (direction)	Informative call indicating maneuver in a specified direction with reference to the target.
Pushing	Departing designated point.
Rope	Illumination of an aircraft with an infrared pointer.
Shift	Directive to shift laser illumination.
Smoke	Smoke marker used to mark a position.
Snake	Directive to oscillate an infrared pointer about a target.
Sparkle	Target marking by infrared pointer.
Stop	Stop infrared illumination of a target.
Talley	Sighting of a target.
Terminate	Stop laser illumination of a target.

Winchester No ordnance remaining.

(reverse blank)

Appendix H

Notes

1. Allan R. Millett, *Semper Fidelis: The History of the United States Marine Corps* (New York: Macmillan Publishing Company, 1980), p. 133.

2. This was due to logistical problems (the Marines had three-inch guns whose caliber was not in use in France) and the decision by Gen Pershing that there was no need for a Marine division in the American Expeditionary Force. Millet, pp. 295 - 296. David N. Buckner, *A Brief History of the 10th Marines* (Washington D.C.: History and Museums Division, Headquarters, U.S. Marine Corps, 1981), pp. 18 - 20.

3. Peter B. Mersky, *U.S. Marine Corps Aviation: 1912 to the Present* (Baltimore, MD: Nautical & Aviation Publishing Co. of America, 1987), p. 11. On October 14, 1918, Marines of Squadron 9, 1st Marine Aviation Force, flew a mission against the German-held railyards in Belgium. The flight of five DH-4 and three DH-9A bombers conducted the first mission to be flown by Marines on their own in World War I.

4. Richard P. Hallion, *Strike from the Sky: The History of Battlefield Air Attack 1911-1945* (Washington: Smithsonian Institution Press, 1989), p. 74.

5. Fleet Marine Force Reference Publication (FMFRP

) 12-15, *Small Wars Manual* (April 1987), p. 9-1. FMFRP 12-15 is a reprint of the 1940 edition of the *Small Wars Manual*.

6. Millett, p. 407.

7. Ibid., p. 409.