PREFACE

Purpose

This manual provides the planning and employment guidance for nuclear weapons in combat operations against targets on or near the earth's surface. It describes operational doctrine for integrating nuclear fire support into the concept of operations, for using target analysis procedures, and for coordinating with sister services and allies.

Scope

This manual is one in a series that covers—

- Operational doctrine for employing nuclear weapons.
- Command responsibilities and staff procedures for employing nuclear weapons.
- Procedures for target analysis.
- The effects produced by nuclear bursts.
- Tabular information concerning target response, troop safety, collateral dam-age, and preclusion of damage.

FM 101-31-1 provides procedural guidance on target planning for nuclear weapons. It contains the doctrine for nuclear weapons employment and the command and staff actions required to carry out the doctrine. FM 101-31-2 (S-RD) provides classified operational characteristics of nuclear weapon delivery systems and nuclear weapons in the US stockpile. It provides the effects data necessary for target analysis and items of information concerning technical procedures not included in FM 101-31-1 because of security classification. A modified version containing information similar in format to that in FM 101-31-2 applies directly to NATO. To provide unclassified training for target analysts, FM 101-31-3 supplies unclassified data for a family of hypothetical nuclear weapons.

The organization of the material in FMs 101-31-2 and 101-31-3 is identical in most cases. FM 101-31-3 is intended only for initial training or when FM 101-31-2 is unavailable. FM 101-31-2 should be used in training to the greatest degree possible so that personnel become familiar with the effects and capabilities of actual nuclear weapons.

Applicability

FM 101-31-1 is based on the principles of war, conditions of modern battle, and operational doctrine as set forth in FM 100-5. It applies to commanders and their staffs at brigade, division, and corps and at Air Force tactical headquarters. FM 101-31-1 applies to the US Army. FMFM 11-4 applies to the Marine Corps; AFP 200-31, Volume I, applies to the US Air Force; NWP 28-0-1 applies to the US Navy. Within this publication, the designation FM 101-31-1 represents all four documents. For guidance on employing nuclear weapons in the air defense role, see FM 44-1A. For employing atomic demolition munitions, see FM 5-106. Pertinent Air Force doctrine is contained in AFM 1-5 (S).

AP-550-1-2-INT provides an alternate means of calculating weapons radii, required yields, and probabilities of damage for both point and area installation targets covered under the vulnerability numbering (VN) systems. The so-called *AP-550 methods* are used for strategic targeting and by Air Force and Navy planners for some types of tactical targeting. Because it is possible to obtain slightly different answers using methods from AP-550-1-2 INT and FM 101-31-2/AFP 200-31, Volume II, planners from all services must use common nuclear targeting methods during joint operations.

The Air Force considers this document as procedural guidance rather than doctrine. Air Force doctrine regarding tactical nuclear operations is contained in AFM 1-5.

The proponent of this publication is HQ TRADOC. Army users submit changes for improving this publication on DA Form 2028 (Recommended Changes to Publications and Blank Forms) and forward it to Commander, US Army Nuclear and Chemical Agency, ATTN: MONA-NU, 7500 Backlick Road, Building 2073, Springfield, VA 22150-3196. Marine Corps users submit comments to Commanding General, Director, Development Center, Marine Corps Development and Education Command, Quantico, Virginia 22134-5080, Air Force subscribers submit recommended changes to Headquarters, AFIS/INT, Boiling AFB, Washington, DC 20332-5000. US Navy users send changes to Chief of Naval Operations (OP-953), Department of the Navy, Washington, DC 20350-1000.

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

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STAFF OFFICERS FIELD MANUAL

NUCLEAR WEAPONS EMPLOYMENT DOCTRINE AND PROCEDURES

CONTENTS

* This manual supersedes FM 101-31-1 and FMFM 11-4, 21 March 1977.

CHAPTER 1

EMPLOYMENT CONSIDERATIONS

In their destructive potential and the forces they release, nuclear weapons are unique. Their use involves international principles, national policies, and military doctrine. Employing nuclear weapons also involves politically significant and sensitive questions, but such questions and subsequent release decisions are beyond the scope of this discussion.

The Law of Armed Conflict

Throughout the history of war, treaties and customs have developed that generally represent the collective views of the belligerents. Their principles protect combatants and noncombatants, safeguard fundamental human rights, and facilitate the restoration of peace by limiting the use of excessive force and the manner in which force is applied. Together, these treaties and customs are known as the law of warfare.

For the Army, applicable laws and customs and their interpretation are contained in FM 27-10. For the Air Force, AFP 110-31 covers the law of armed conflict applicable to air operations. It addresses other matters of relevance to the Air Force, such as obligations toward civilians in occupied areas, air law, and law of the sea. Legal and political matters such as neutrality are examined as they may affect aerial operations.

Neither the law of war nor national policy sanctions devastation as an end in itself. Both recognize the need for a reasonable connection between the destruction of life and property and the defeat of the enemy's forces. The law of warfare permits the use of nuclear weapons; however, because they have such tremendous destructive power, their use must be carefully controlled. Some absolute prohibitions exist, and the US is a party to numerous treaties that regulate the use of nuclear weapons.

Soviet Policy

Soviet military doctrine emphasizes rapid advance by combined arms formations, coupled with nuclear and nonnuclear strikes, to destroy the adversary's ability to defend. The Soviets make little distinction between nuclear and non-nuclear operations. They are better equipped, structured, and trained to conduct NBC warfare than any other armed force.

Soviet military planners recognize how decisive a first, or preemptive, nuclear attack will be. They stress the need for such an attack. Their priority targets for nuclear attacks are—

- Nuclear delivery means.
- Command, control, communications facilities.
- Prepared defensive positions.
- Reserves and troop concentrations.
- Logistics facilities, especially nuclear ammunition storage points.

The Soviets consider defense as a temporary expedient until they can resume the offensive. They will use nuclear weapons to stall an adversary's attacking forces in order to gain the offensive. In the defense, Soviets use nuclear weapons primarily—

- To destroy enemy nuclear delivery means.
- To destroy main attack formations.
- To facilitate counterpreparations.
- To eliminate penetrations.
- To support counterattacks.
- To deny areas to the enemy.

Soviet elements such as operational maneuver groups and special purpose troops will also attack nuclear weapons and their storage sites. For more information on Soviet nuclear warfare doctrine, see the FM 100-2 series.

US Policy

Our national policy on nuclear war is to deter it by means of a strong nuclear warfare capability. This deterrent policy, however, does not preclude the first use of nuclear weapons by US forces. Such use by land, air, and naval forces, when authorized by the president, is closely controlled and likely to be limited in an attempt to reduce the risks of escalation. A nuclear attack should—

- Forcibly change the perceptions of enemy leaders about their ability to win.
- Demonstrate to them that, should the conflict continue or escalate, the certain loss outweighs the potential gain.
- Encourage negotiations.

The principle of retaliatory responses also attempts to control escalation: clearly perceivable limits on retaliatory strikes and the threat of extensive strikes should the enemy choose to escalate. Either way, our primary objective in using nuclear weapons is to end war on terms acceptable to us and our allies at the lowest feasible level of conflict. The Joint Strategic Capabilities Plan (JSCP), Annex C, provides guidelines for strategic and theater nuclear planning.

US Military Doctrine

Nuclear weapons should be integrated with other forms of fire support in a combined arms, joint service approach. Conventional and nuclear weapons must be thoroughly integrated—

- To alter the course of the battle positively and persuasively.
- To preclude the enemy's achieving its objective.
- To ensure the success of the attack by US, NATO, or allied forces.

Echelons above corps allocate nuclear weapons to major maneuver commanders—normally corps commanders—for a specified purpose, period of time, or phase of an operation. Depending on the concept of operations, these commanders may further delegate employment authority to subordinate commanders.

Nuclear weapons are available only in limited quantities and are employed judiciously. Theater employment is directed primarily at producing a political decision; employment at the corps level is explicitly intended to influence an operational decision on the battlefield.

Employment Guidelines

Nuclear fires are not appropriate for all battlefield requirements. Their suitability is based on four considerations.

WEIGHING RELATIVE EFFECTIVENESS

The relative effectiveness of nuclear and nonnuclear weapons must be weighed. When nuclear weapons will produce only a marginal gain in tactical effectiveness over nonnuclear fires, there is no reason to use them. The extent of that marginal advantage varies with the weapon types and yields, the nature and disposition of the targets, the terrain, the weather, and the operational goals. Unless they are integrated into an overall operational concept, which includes all the elements of combat power, they will not produce the desired results.

RECOGNIZING COLLATERAL RISKS

The collateral risks from military operations with nuclear weapons include danger to friendly troops and civilians, obstacles, and enemy responses. The first risk limits the proximity of a nuclear strike to civilians and friendly forces. This limit varies with the protective posture of civilians and friendly units, delivery system accuracy, and weapon yield. The second risk concerns creation of obstacles that inhibit both friendly and enemy movement: trees that are blown down, fires, and rubble in built-up areas. Commanders employing nuclear weapons must consider the likelihood of obstacles restricting friendly mobility. Theater commanders and their staffs must be aware of any theater-level constraints, either political or military, imposed on the battlefield use of nuclear weapons. They must then plan accordingly.

CONSIDERING ENEMY RESPONSES

The third consideration is the enemy's response to our use of nuclear weapons. In developing our plans, commanders and their staffs must consider the Soviet doctrine of preemption and Soviet willingness to use nuclear weapons if required to obtain objectives.

PLANNING EFFECTIVELY

Nuclear fire support must be integrated into all operational planning. Integrated planning addresses the use of nuclear weapons in all phases of air-land battles. Advance planning is absolutely critical to using nuclear weapons successfully. Such planning must be conducted continuously. Aware of what actions are open to the enemy and the vulnerabilities of each, commanders can select the option with the highest payoff. Targeting guidance and plans must be current and consistent with existing or expected release conditions. Planning must also anticipate delays caused by nuclear weapons. Such delays are unpredictable. They may range from several days to only a few hours.

Nuclear Weapons in Tactical Operations

Air-land battles require rapid, decisive offensive action to defeat enemy forces. The authority to employ nuclear weapons increases the flexibility and combat power of commanders. Commanders must use maneuver forces to exploit the advantages gained from nuclear weapons. They should not keep tactical nuclear weapons in reserve to use as a last resort to avoid destruction or defeat. At all echelons, they must take special measures to reduce the vulnerability of friendly forces, installations, and civilians.

Operations in a nuclear environment require flexible planning, organizations, and tactics. Decentralized control will be common. Small-unit leaders will have to operate on their own initiative for extended periods. To facilitate independent operations, combat forces should be task-organized with supporting firepower and logistics. Above company level, units mass only as required for a given mission. Then, they disperse rapidly.

Nuclear weapons employment options are considered in all operational planning. Positive command and control is necessary at all levels of command and within nuclear delivery units. The procedures and resources used for conventional target acquisition, intelligence processing, fire planning, and mission execution apply to nuclear fire support. Intelligence and target planning must continuously support the targeting effort. To be effective, nuclear weapons must be employed in a timely manner; yet, forces in the field are governed by established request and release procedures. To shorten the request-to-release cycle, commanders assist the decision makers considering nuclear release by providing accurate and timely situational information. By comparing developing situations to anticipated enemy courses of action, decision makers can react quickly to requests for release.

TARGET DEFEAT CONSIDERATIONS

In assessing the number of nuclear weapons required to make a positive change in the tactical situation and to defeat a threat, analysts must consider how to defeat the individual targets composing the overall threat. No simple statement of threat and target defeat criteria will pertain in all circumstances.

An enemy force is defeated by nuclear strikes when it can be controlled by available conventional means. Planning must address—

- The number and type of individual targets.
- The vulnerability of those targets.
- The required level of damage for each target to achieve the overall objective.
- The optimum timing.
- The enemy's ability to reconstitute or recuperate.

Planning for a nuclear weapons package (see Glossary) is based on assumptions about the strength and disposition of the enemy forces; the mission of the friendly forces; the number, yields, and types of weapons available; and the status and disposition of friendly forces at the time the package is employed. Among the critical combat units that might be targeted for nuclear strikes are—

- Nuclear delivery units and their associated command and control and logistical elements.
- Regimental and higher echelon command and control elements.
- Tank and motorized rifle units.
- Air defense units.
- Enemy air units and installations.
- Conventional artillery units.

Two basic target categories are area and point. Defeat criteria for area targets are normally expressed as a fractional level, or percentage, of expected or high-assurance coverage. Defeat criteria also specify the level of materiel damage or personnel ineffectiveness. The latter, which is expressed as immediate-permanent (IP) ineffectiveness, immediate-transient (IT) ineffectiveness, or latent lethality (1.1.), depends on the time between the burst and the engagement of the targeted enemy (see pages 84 through 87). Because point targets are single-element materiel targets or occupy a small area in comparison to the damage radius, defeat criteria are expressed only as a specific level of damage and the probability of achieving it.

AREA TARGET DEFEAT CRITERIA	POINT TARGET DEFEAT CRITERIA
● Fractional level or percent of— • Expected coverage. • High-assurance coverage. ● Specified level of damage and personnel ineffectiveness.	● Single element or small target. ● Probability estimates of— • Desired damage. • Ineffectiveness levels.

FRACTIONAL COVERAGE CONSIDERATIONS

Although an area target is struck by a weapon of sufficient yield to meet required coverage and defeat criteria, target degradation occurs beyond the specified radius of damage. The smallest tactical nuclear weapon has potentially lethal effects that cover over one square kilometer. Further, while each degrading effect might not seriously impair soldiers, in combination they can be debilitating. Soldiers suffering with burns from thermal radiation, eardrum damage from overpressure, cuts and broken bones from flying objects, and vomiting from radiation sickness are not likely to be effective in any capacity. Hence, when commanders request that a certain percentage of the target receive a specified degree of damage, they should recognize that much of the remaining portion of the target will also be damaged.

UNIT MISSION AND DISPOSITION. A unit deployed in an assault formation in contact with friendly elements is difficult to target because of its linearity and mobility and because of troop safety constraints. Conversely, a maneuver unit in an assembly area may be ideally configured for nuclear attack.

VULNERABILITY. The most vulnerable aspect of the target's critical elements should be used as a guide in selecting weapons. Crew members in a tank unit, rather than the tanks themselves, may be the appropriate aspect, depending on weapon yield. Radars in an ADA unit and personnel in a CP are other examples. The most vulnerable element of the target, however, is not always the most critical. Additionally, delaying or disrupting large formations may be just as effective in meeting command guidance as destroying a large percent of a combat unit.

UNIT TYPE. Fractional coverage will vary with the type of unit to be attacked. The inherent resiliency of a maneuver unit or the criticality of a nuclear delivery unit may require a larger fractional coverage than less critical units such as a POL or air defense unit. Against units in the defense, an expected coverage of 40 to 60 percent should be used.

UNIT SIZE. For a large unit, such as a battalion with maneuver forces that can be separated and dispersed, two-thirds of its maneuver force elements should be attacked. Doing so ensures that the unit is incapable of performing its mission. Company-size units may be attacked separately; however, a battalion in an assembly area might be a single target. Regiment-size and larger units are normally divided into smaller targets. Follow-on units may be targeted with less stringent defeat criteria. The coverage criterion should consider how both prompt and long-term radiation affect personnel. Thermal radiation, neutron-induced radiation, and electomagnetic pulse (EMP), which delay and disrupt maneuver, should also be considered. The ability of a unit to reconstitute is also a factor in this evaluation.

COLLATERAL DAMAGE CONSTRAINTS

The Army and Marine Corps define collateral damage as undesirable civilian material damage or personnel injuries produced by the effects of friendly nuclear weapons. The Air Force defines it as damage to installations, equipment, and personnel that are not targets in the option being executed or as damage that is not the objective of the DGZ from which the damage is being evaluated.

Collateral damage constraints and military effectiveness must be balanced if operations are to be successful. Therefore, while the overall goal of tactical targeting is to preclude collateral damage to civilian centers, limited damage to populated areas may be unavoidable in some situations.

Determining collateral damage constraints is a command responsibility. If national command or theater authorities do not predetermine constraint levels for collateral damage, a corps or higher commander will normally be responsible for doing so. FM 101-31-2 provides collateral damage avoidance tables for civilians. Specific techniques for reducing collateral damage are—

- Invoking civil defense procedures. Evacuating civilians from the battlefield can greatly reduce civilian casualties. A highly effective measure, it nonetheless requires a significant civil defense effort. If evacuation is infeasible, the friendly populace should be warned to remain in cellars or other shelters during battles near them.
- Reducing yield. Reducing the yield and accepting less coverage can reduce collateral damage. Also, by using less stringent defeat criteria, one can achieve the desired fractional coverage while reducing the yield or number of weapons required. For materiel targets, use moderate damage in lieu of severe damage. For personnel, use IT ineffectiveness in lieu of IP ineffectiveness.
- Using a more accurate delivery system. Accurate delivery systems are less likely to miss the target and cause collateral damage.

- Offsetting the desired ground zero. After determining the areas where damage is not desired, analysts may be able to offset the desired ground zero away from the area where collateral damage would occur and still damage the target enough to defeat it.
- Using multiple weapons. Collateral damage can be reduced by dividing a large target into several small targets and using smaller weapons rather than one large weapon.
- Adjusting the height of burst (HOB). HOB adjustments are a major means of controlling collateral damage and fallout. The HOB has a significant influence on the effect radii.

See Chapter 4 for calculating collateral damage and using the results in target analysis.

COMBINED NUCLEAR AND CHEMICAL CONSIDERATIONS

Any enemy force that might use nuclear weapons to support tactical operations would, if properly equipped, probably use chemical weapons also. It may use chemical weapons to supplement or to enhance nuclear weapons, particularly on area targets such as reserves or support installations. It may use them in lieu of nuclear weapons.

Normally, chemical fires will follow nuclear fires since nuclear effects can reduce the effectiveness of persistent chemical agents. Chemical weapons can be used with conventional weapons when operational or safety constraints restrict the use of nuclear weapons. Chemical weapons can be used efficiently against small critical installations, such as command and control posts, or dispersed nuclear delivery units to produce immediate and/or long-term effects.

Some passive protection measures taken to reduce vulnerability to chemical weapons can also provide protection against nuclear weapons. Covering exposed skin and supplies is an example. Operational planning should always address the possibility that the enemy will use chemical agents. It should also contain guidance on taking defensive measures.

CHAPTER 2

COMMAND RESPONSIBILITIES AND STAFF PROCEDURES

Command actions and staff responsibilities involving the employment of nuclear weapons generally follow established command and staff channels. However, some procedures and techniques are unique. Additional guidance on operations involving nuclear weapons is contained in FM 100-5, FM 100-15, FM 71-100, and LFM 01-1.

Command Guidance

Since nuclear weapons can have a significant influence on ground operations, command guidance to initiate staff planning is vital. In the initial guidance, commanders should provide as much information about employing nuclear weapons as about employing maneuver forces and conventional fires.

Commanders and their staff officers must understand effects, employment procedures, capabilities and limitations of available delivery systems, and combat support requirements for delivery systems. Target analysts provide technical advice and assistance to commanders and staffs.

Command guidance normally consists of the following:

A statement of the desired results such as halting an enemy attack, supporting a counterattack, or rupturing the enemy's defense.

Tactical circumstances or decision points for initiating a release.

The concept for the subsequent use of weapons if the initial effort does not accomplish the desired results.

Defeat criteria for enemy forces or damage objectives for fixed installations.

Delivery systems, weapons, and yields available for planning.

The level of acceptable risk to friendly troops and noncombatants.

Restrictions on fallout from surface or subsurface bursts.

Criteria for avoiding collateral damage.

Criteria for intelligence collection, target priorities, and poststrike analysis.

Target Acquisition

On the conventional battlefield, the primary purpose of intelligence is to provide commanders with sufficient information on enemy locations and probable courses of action so that they can commit combat power at decisive points and critical times. That purpose does not change in a nuclear environment, nor does it change when the combat power may be nuclear.

Target acquisition is an integral part of the intelligence collection process. It involves the timely detection, identification, and location of a target in sufficient detail to use weapons effectively. The intelligence system provides continuous target tracking and development of intelligence for target analysis, target refinement, and weapons employment.

The effectiveness of a nuclear attack is enhanced by the accuracy, completeness, and timeliness of intelligence. Thus, intelligence collection efforts should continuously seek specific information on each target area's—

- Location.
- Size.
- Shape.
- Composition.
- Concentration.
- Vulnerability.
- Recuperability.
- Dwell time or direction and speed of movement.

Without specific target area definition, G2s and target analysts use enemy doctrine and terrain analysis to estimate the size and shape of the target.

The targets identified support the air-land battle. They are not unique nuclear targets; rather, they are targets which will be attacked at the proper time and place by the most appropriate available means. Because each target acquisition technique is limited, intelligence collection must be broadly based, obtaining information from all available sources.

The commanders provide initial planning guidance for developing the information requirements (IRs) and priority intelligence requirements (PIRs) which are the basis for collection management.

The intelligence collection plan should be updated continuously throughout the operation using intelligence preparation of the battlefield (IPB) data and products. The collection plan, coupled with an analysis of the named areas of interest (NAIs) and threat integration, should produce a list of target areas in which the enemy might locate assault elements, reserves, logistics installations, command posts, nuclear delivery units, or other profitable targets. Target areas of interest (TAIs) are nominated from NAIs and confirmed after coordination with the G3 and fire support element (FSE). This target list can be used to determine areas where enemy units could adversely affect the mission or where employment could have a significant effect on enemy capabilities. The areas on this list must be kept to a minimum to avoid over-extending the collection effort.

Planning

Integrated Planning

Planning for nuclear weapons employment is an integrated effort. Target analysts must work closely with intelligence, operations, logistics, and civil-military operations (CMO) officers to ensure that plans for using nuclear weapons are consistent with planning guidance and the overall concept of the operation,

The intelligence officer is the staff subject matter expert on the enemy's doctrine, tactics, and order of battle. He advises the FSE in identifying critical targets. In developing the collection plan, he ensures that intelligence assets are tasked to develop targets and to provide warning of the enemy's use of nuclear weapons.

The operations officer ensures that the nuclear fire plan supports the deep, close-in, and rear battles and that maneuver forces can exploit it fully. In making this assessment, the operations officer must consider the command guidance, the mission, and the recommendations of the fire support coordinator. Since nuclear weapons are employed to obtain an operational objective, the operations officer must determine how to optimize the effect of firepower and maneuver. Depending on the situation, the fire plan may have to be modified to support the maneuver force, or conversely, the scheme of maneuver may have to be modified to optimize the nuclear strike.

The CMO officer develops the population center overlay which the FSE uses in developing the preclusion area overlay. During the battle, he actively tracks civilians, ensuring that fire planners recognize population shifts and meet collateral damage constants.

Contingency Planning

Contingency planning is based on the mission, the enemy, the terrain, the troops available, and time. During the estimate of the situation, the commander develops courses of action, compares and evaluates them against possible enemy responses, and selects the best course of action. To do so, he must identify the contingencies that may require nuclear weapons and the situations where their use would give the commander a significant advantage over the enemy.

Because of the consequences of employing nuclear weapons, these contingencies are operational and involve major changes in the course of the battle. Consequently, planning will limit the number of nuclear weapon packages for a corps and yet allow the commander to deal with the components of each major contingency. In a corps area, analysts estimate the enemy forces which can be employed over any avenue of approach on the terrain. To do so, they identify the enemy force and the level of damage that the mission requires. Then they plan a package against the threat. Proper contingency planning increases the commander's flexibility and facilitates the package approval and release process.

Nuclear contingency plans are normally corps responsibilities, but contingency planning should take place at both corps and divison levels. Corps and division planning staffs must maintain continuous and close liaison to ensure completeness of the plans. The corps integrates division planning into the corps plan and coordinates necessary reviews and updates so that specific orders can be developed rapidly from existing plans as the situation develops. Contingency plans should be provided to the next higher commander to expedite request and release procedures.

Fire Support Coordination

Nuclear weapon packages planned for each contingency will normally specify target areas for engagement by the delivery units expected to be available. They may include division delivery units as well as those from corps or other services, As a contingency plan becomes an order during the actual attack, the appropriate headquarters will designate the units to fire and their firing positions. Planning procedures must be flexible and allow for changes in the situation. The executing commanders ensure that constraints and release guidance are met. The FSE controlling the package must maintain communications with the delivery unit, and a chain of succession for control of nuclear fires must be established to prevent loss of control resulting from the loss of a headquarters.

Operations with combined forces require combined doctrine and procedures for taskings, conflict resolution, target selection, and analysis. The senior US commander in a combined command will provide guidance on the use of nuclear weapons by US forces in such commands. He may also publish directives. Such guidance and directives may modify the doctrine and procedures contained in this manual.

In this circumstance, the commander of the senior Army headquarters must determine that the modifications are within established policy. He also ensures that all Army elements are aware of the modifications and adhere to them.

US Navy or US Air Force delivery systems may support Army operations. Such support should be coordinated. Coordination with the Air Force is made through the Air Force tactical control center by the collocated Army battlefield control element. Coordination with the Navy is made through the air naval gunfire liaison team. When they support Army units, Navy or Air Force commanders may have the final decision concerning yields and delivery methods. However, the weapons must provide the desired degree of damage and meet the constraints of collateral damage imposed by the requesting commander,

Control

Because nuclear weapons are so important tactically, because they have limited availability, and because they are so immensely destructive, their expenditure and resupply must always be tightly controlled. Those nuclear weapons available to the unit should be included in the fire support planning of contingency plans. If additional nuclear weapons are required in the contingency plans, the basic plan should provide for making them available. The commander controls the distribution of nuclear weapons by—

- Determining how many nuclear weapons that organic or attached delivery units will carry as prescribed nuclear loads (PNLs).
- Directing the stockage of nuclear rounds in the nuclear ammunition supply points under his control.
- Arranging for the stockage of any additional nuclear weapons he may require as part of the prescribed nuclear stockage in a nuclear ammunition supply point not under his control.

Distribution

Distributing nuclear weapons is a logistics as well as an operations problem. Distribution is affected by—

- The mission.
- Planned weapon packages for immediate and subsequent requirements.
- Survivability.
- Availability.
- The carrying capacity of the unit.
- Requirements to carry other weapons in the special ammunition load.
- Security.
- The transportation capability of the support unit.

Commanders and staff officers must always know how much support the logistics system can provide. The nuclear weapon logistics system is tailored to operate in various environments. Planning and controlling nuclear weapons support must involve—

- Continuous nuclear logistics support of tactical operations.
- Simplicity and uniformity in procedures.
- Minimum handling of nuclear weapons.
- Security of classified or critical materiel and installations.

Security and operational purposes may cause commanders to have more or fewer weapons on hand than are required when release authority is received. Established procedures must be in place for obtaining additional weapons or having another unit fire them.

Ordnance special ammunition units store and issue Army nuclear weapons to delivery units. See FM 9-6 for details of ordnance ammunition support procedures.

Prescribed nuclear loads and prescribed nuclear stockage are replenished by directed issue. Because nuclear weapons are in limited supply and their locations change to meet the tactical situation, directed replacement is most feasible. See FM 9-84 for details about Army special ammunition logistics support.

Security

Storage sites and convoy operations for nuclear weapons must be secure. Effective security requires early detection, visual or electro-optical assessment, and immediate tactical response. Security equipment must be mutually supportive and overlapping. Security forces must have clearly defined and coordinated authority, jurisdiction, and responsibilities. All elements of the security program must be integrated. Each must complement the others in support of the tactical defense plan.

Nuclear capable units have primary responsibility for their own security. Plans for the security of nuclear weapons during tactical field operations must address the principles of the Personnel Reliability Program, the two-man rule, provisions for custody and accountability, movement in combat, and the field storage of weapons. See FM 100-50 for details about security in tactical field operations.

Warning

Friendly forces require advance warning of nuclear strikes to ensure that they are not exposed to a risk greater than acceptable. Normally, there is no requirement to warn subordinate units when the target analysis indicates that the risk to unwarned, exposed troops will not exceed the negligible levels and insufficient time exists to warn all personnel. In this case, warning is given only to those personnel who, if left unwarned and exposed, might have more than negligible risk. When low-yield weapons are used in dynamic situations, the requirements for positive warning may have to be relaxed.

Warnings of friendly strikes can be time-consuming even when procedures are carefully established. A warning given too early may alert the enemy to the planned strike, decreasing attack effectiveness or possibly triggering a preemptive enemy strike.

Aircraft are particularly vulnerable to weapon effects, even low overpressures. Likewise, dazzle can be a significant hazard to personnel in aircraft. Because aircraft can move rapidly from areas of negligible risk to unacceptable risk, all aircraft in the area of operations should get advance warning during both day and night operations. For strikes on distant enemy targets, advance warning is required only for the aircraft that may be affected.

Air Force, Navy, and Marine Corps aircraft are warned via the air support operations center (ASOC). Warnings should flow both from the fire support element to the collocated ASOC and through the battlefield coordination element (BCE) to the tactical air control center (TACC). Army aircraft are warned through unit command nets or airspace control stations.

Air defense artillery will report the intention to engage hostile aircraft with nuclear weapons via command and control nets to the Army air defense command post (AADCP). The report will state the estimated time, altitude, and world geographic reference of the nuclear burst. The AADCP will transmit a warning message to its associated tactical operations center (TOC) and the sector operations center and/or control and reporting center (SOC/CRC) so that agencies may transmit alerts to their airborne aircraft.

Nuclear strike warning (STRIKWARN) messages are disseminated as rapidly as possible and, insofar as possible, over secure networks. When secure networks are not available, unit communications-electronics operation instructions (CEOI) should contain authentication procedures and encoding instructions for disseminating STRIKWARN messages. Instructions should be easy to use and provide good OPSEC. The STRIKWARNs are broadcast in the clear when insufficient time remains for the enemy to react prior to the strike.

The commander executing the strike issues the initial warning. He ensures that the subordinate headquarters whose units will be affected by the strike are informed. He ensures coordination with adjacent commands and elements of other commands in the vicinity, giving them sufficient time to spread the warning and to take protective measures. When nuclear strikes are cancelled, the commander who issued the initial warning will notify units previously warned as quickly as possible The format for STRIKWARN is shown below.

Not all units should receive the entire STRIKWARN message, only specific instructions about protective measures to take if they are in an area of risk. The message should include—

- A statement that the message is a nuclear warning.
- A brief, prearranged directive concerning the specific protective measures to be taken, including evacuation to an alternate position, if required.

Figure 1. Sample STRIKWARN.

1. Warning Messages. Warning messages will include the following information (See STANAG 2104):

LINE	MEANING
ALFA	Codeword indicating nuclear strike: a. Multiple strike (includes Selective Employment Plan) b. Single—(target number)
DELTA	a. ***Multiple:*** date/time group strike (pulse) will start followed by date/time group strike (pulse) will end (ZULU time). b. ***Single:*** date/time of strike followed by date/time group after which strike will be cancelled (ZULU time).
FOXTROT 1	a. ***Multiple:*** UTM grid co-ordinates of MSD 1 box, six numerical figures each. b. ***Single:*** MSD 1 in hundreds of meters followed by UTM grid co-ordinates of GZ or DGZ (six numerical figures). (If more than one MSD is to be included in STRIKWARN, GZ or DGZ will be included only in first FOXTROT line transmitted.)
FOXTROT 2	a. ***Multiple:*** UTM grid co-ordinates of MSD 2 box, six numerical figures each. b. ***Single:*** MSD 2 in hundreds of meters followed by UTM grid co-ordinates of GZ or DGZ (six numerical figures).
FOXTROT 3	a. ***Multiple:*** UTM grid co-ordinates of MSD 3 box, six numerical figures each. b. ***Single:*** MSD 3 in hundreds of meters (three digits followed by UTM grid co-ordinates of GZ or DGZ (six numerical figures).
HOTEL	If one or more bursts has less than 99% assurance of being an air burst or is a scheduled surface or sub-surface burst, indicate surface, preceded by the total number of surface and/or sub-surface bursts. If only one burst is surface, number need not be sent. If all air bursts, do not transmit.
INDIA	Number of bursts in multiple strike. If single burst, do not transmit.

2. EXAMPLE MESSAGES:

a. Multiple strike: All air bursts. (No burst less than 99% assurance of being an air burst. MSD 3 box only sent.)

ALFA	HOT CANDLE
DELTA	130605 130715
FOXTROT 3	NB590167 NB521723 NB630350 NB600354
INDIA	12

b. Multiple strike: Three surface bursts or three bursts less than 99% assurance of being air burst. (MSD 2 and MSD 3 boxes sent.)

ALFA	LAMP POST
DELTA	162025 162155
FOXTROT 2	PA613423 PA616515 PA655523 PA631450 PA625413
FOXTROT 3	PA602403 PA605536 PA672552 PA642472 PA673442
HOTEL	3 SURFACE
INDIA	22

c. Single air burst. (MSD 2 and MSD 3 transmitted.)

ALFA	AC 016
DELTA	072220 072310
FOXTROT 2	023NB651211
FOXTROT 3	039

d. Single sub-surface burst. (MSD -3 only transmitted)

ALFA	AC 002
DELTA	270915 270930
FOXTROT 3	011PA215154
HOTEL	SURFACE

Units must acknowledge STRIKWARNS. The mean of of acknowledgement should be a unit SOP item. See Figure 2 for protection requirement.

Units outside the affected area are not normally sent a STRIKWARN message. However, effective liaison may require passing strike data to adjacent units as a matter of procedure. Information concerning the strikes may also be of operational concern in updating situation maps and locating obstacles.

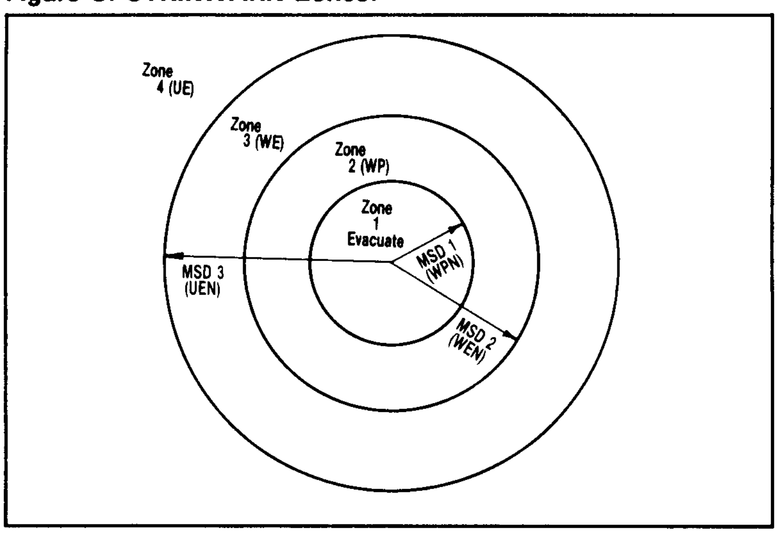
Figure 2. MSD Protective Measures.

Radius	Corresponding to	Zone	Requirements
		1	Evacuation of all personnel (See Note 3)
MSD 1	Limit of Negligible Risk to warned and protected personnel (WPN) (See Note 4)		
		2	Maximum protection (WP) (See Note 5)
MSD 2	Limit of Negligible Risk to warned and exposed personnel (WEN)		
		3	Minimum protection (WE) (See Note 6)
MSD 3	Limit of Negligible Risk to unwarned and exposed personnel (UEN)		
More Than MSD 3			No protective measure except against dazzle and Electromagnetic Pulse (EMP)(UE)

Notes:

1. MSD means Minimum Safe Distance.
2. The MSD is equal to a radius of safety (RS) for the yield, plus a buffer distance (BD) related to the dispersion of the weapon system used. When surface bursts are used, or an intended air burst has less than a 99 per cent assurance of no militarily significant fallout, the fallout hazard will be considered. Details will be transmitted in a subsequent (NBC-3 NUC) report if fallout will be a hazard to friendly units.
3. If a unit commander is unable to evacuate Zone 1, he will immediately require maximum protection and report through his next higher headquarters to the releasing/executing commander.
4. Negligible risk should not normally be exceeded unless significant advantages will be gained. Consider RES, Figure 32.
5. Maximum protection for ground forces denotes that personnel are in closed up tanks or sheltered in foxholes with overhead shielding.
6. Minimum protection for ground forces denotes that personnel are prone on open ground with all skin areas covered and with an overall thermal protection at least equal to that provided by a two-layer uniform.
7. Since the least separation distance (LSD) for light aircraft is exceeded by MSD-3, aircraft remaining beyond MSD-3 will avoid significant degradation of the airframe or pilot performance (except against dazzle) severe enough to prevent mission accomplishment.

Figure 3. STRIKWARN Zones.



Tactical Damage Evaluation

A tactical damage evaluation should be made immediately following a nuclear strike. The intelligence officer must collect data on the enemy to determine if the strike inflicted the desired degree of damage. The reconnaissance after each strike will consider using all available sources of intelligence. It will assess damage to enemy forces, identify targets for restrike, and obtain information on residual radiation, fires, and obstacles. Because of the requirement to exploit the results of the strike immediately, this information must be developed in a timely manner. Remotely piloted vehicles and helicopters can obtain such information immediately.

Residual Radiation Management

Radiation emitted more than 1 minute after a nuclear detonation is called residual radiation. Residual radiation can appear as neutron-induced gamma activity (NIGA) within a relatively small circular pattern around ground zero (GZ) or as fallout in a large, irregular pattern encompassing GZ and extending downwind from the burst point. NIGA within its area is secondary to other effects. See Appendix A for details on residual radiation.

Fallout

Militarily significant amounts of fallout can be precluded by using airbursts. If however, a target must be engaged with a surface burst then a fallout prediction must be performed using the procedures detailed in FM 3-3.

Prediction methods can determine the areas outside of which friendly troops are unlikely to be affected by fallout. But because fallout prediction is so inaccurate, these methods can be used only to identify suspect areas for early monitoring and survey or to plan the movement of units. They are not to be used as a sole basis for executing operational moves. Because atomic demolition munitions are normally detonated at or near the surface, fallout predictions must always be made as early as possible in the planning sequence to determine if collateral damage constraints can be met and to allow the necessary warning message to friendly forces. After the detonation, the fallout prediction should be revised using the actual winds that occurred at the time of detonation as part of the poststrike analysis. From initial planning data through poststrike, each step in refining the fallout prediction analysis permits the tactical commanders to evaluate the impact on current and future plans. See FM 3-3 for preparing detailed and simplified fallout predictions.

Nuclear Fire Planning

Overview

Planning and executing the use of nuclear weapons parallel those actions for conventional fire support. However, a few procedures and techniques are unique, and several considerations become increasingly important. When determining the suitability for use of nuclear weapons, the commander must—

- Consider enemy responses.
- Weigh the relative effectiveness between nuclear and nonnuclear weapons to achieve the desired results on the targets of concern.
- Recognize collateral risks (friendly troops, civilians, and obstacle creation).
- Consider the effect of denial or delay of release.
- Insure the integration of nuclear and nonnuclear fires.

Planning Considerations

Nuclear weapons are available only in limited quantities and must be used judiciously. Theater strategic employment is directed primarily at producing a political decision. Employment at corps level and below is explicitly intended to influence a decision on the battlefield. Tactical commanders and fire support coordinators should plan to employ and integrate nuclear weapons directed for use to achieve the greatest possible tactical advantage. This planning must—

- Be advanced, continuous, and flexible.
- Integrate nuclear weapons and other fire support means with maneuver to exploit the advantage gained from nuclear weapons.
- Insure intelligence collection is planned to determine damage assessment.
- Be coordinated with adjacent units.
- Consider the effects of electromagnetic pulse (EMP).
- Insure an adequate distribution of tactical nuclear weapons and avoid keeping them all in reserve.

Planning Allocation and Coordination

Nuclear weapons must be planned to achieve a specific purpose in the battle plan. To do this, nuclear weapons are allocated (do not confuse this term with authorized for use) to support various tactical contingencies. This allocation process is continuous and occurs both before and after authorization and release.

A tool that enables the commander and his staff to allocate and integrate nuclear weapons into each tactical contingency is the nuclear weapons package. A package is a grouping of nuclear weapons for employment in a specified area during a short time to support a corps tactical mission. A package is characterized and defined by four parameters–

- A specified number of nuclear weapons, listed by yield or by yield and delivery system.
- The purpose for which the package would be employed.
- A time for employment.
- An area of employment.

A package is given a name to identify and refer to a specific set of parameters. That package will then be treated as a single entity for the purpose of request and release.

Corps develops package(s) to meet foreseeable contingencies. The package is then normally sent to higher echelons, adjacent units, and supporting units to facilitate coordination and speed the release process.

Weapons within a package may be allocated to division(s), a separate brigade or an ACR for planning. This allocation is referred to as a subpackage. It is a subelement of a package, and it lies in the sector or zone of a subordinate unit. Subpackages are planned by the subordinate unit and forwarded to corps for approval and inclusion in the corps nuclear package.

A term that is often used interchangeably with nuclear package is nuclear selective employment plan (SEP). However, sometimes it can also have a different meaning in terms of scope. For example, a SEP may cover a large area or contain a large number of weapons in more than one package. EAC would create SEPs consisting of Corps packages.

Phases of Planning

Because of the fleeting nature of the targets usually attacked at corps level and below, most packages/SEPs do not contain fixed target lists.

Like conventional fire support, nuclear fire planning is continuous and dynamic. Nuclear package planning generally follows normal staff planning procedures. Generally, packages are developed through a four-phase refinement process—

- *Peacetime planning* – Preliminary phanning based on the area, type of tactical situation expected, hypothetical threat, known limiting requirements, available resources, and proposed requirements.
- *Transition to war* – Update to packages that may apply to a particular upcoming combat situation. Using updates to limiting requirements, IPB, and the actual threat supplements peacetime planning already accomplished.
- *Battle focus and refinement* – Further development and refinement of the particular packages that specifically apply to the current fluid tactical situation. The situation may also require the development of new packages to meet new contingencies. New and update packages are developed in accordance with issued planning guidance and forwarded to higher headquarters.
- *Approved package refinement* — Refinements made to a package after it has been approved and released but prior to firing. These are made to accommodate changes in the tactical situation. They can be made without further authorization if they remain within the scope of the approved package. The refinement process is the most critical stage, because the fluidity of the tactical situation will most likely require changes during the time it takes to get authorization to fire the package.

Planning Steps

The steps discussed below provide the techniques for nuclear package planning and nuclear target analysis. The assumptions are that no nuclear planning has been done and there are no plans in existence The initial focus is at corps level as directed by the echelon above corps (EAC). The same procedures are used at division and are in fact, an extension of the planning done at corps. It is actually a joint endeavor involving unity of effort and capitalizing on the sharing of information. Subsequently, the focus will shift to division level to discuss wartime planning actions.

Peacetime Planning

Given a contingency plan with an area of operations and a type threat, a large portion of the time-consuming work of nuclear planning and analysis can, and MUST, be completed during peacetime. The objective is to build packages that are flexible enough to apply to a given situation on a fluid battlefield. By using the following steps, the idea is to do as much work as possible ahead of time.

STEP 1. Gather references, and initiate coordination; specifically–

a. Read nuclear references. Locate and read appropriate nuclear references.

b. Read the EAC OPLAN. Extract the corps mission, the assigned area of operations, and Threat information. Make particular note of specific nuclear planning guidance.

c. Input to IPB process. As the FAIO is participating in the G2's IPB process, ensure he is both including the enemy's nuclear posture and identifying lucrative locations and times for friendly nuclear attack for further analysis.

d. Coordinate for obstacle preclusion. Initiate coordination with the nuclear weapons employment officer in the G3 plans section for the identification of critical features, such as a strategic bridge, that under most circumstances, the commander would not want damaged.

e. Coordinate for logistical support. Contact the corps nuclear weapons logistic element (NWLE) officer to determine what weapons may be available and to initiate nuclear weapons logistical support planning.

f. Coordinate for civilian preclusion. Extract population and structure preclusion guidance from the EAC OPLAN, and initiate coordination with the corps G5 to get specific data.

g. Coordinate for delivery system information. Contact the FA assistant operations officer and the ASOC to determine what delivery systems and air-delivered bombs may be available.

STEP 2. Collect and compile planning information specifically—

a. Get the G2's (use FAIO) initial situation template and event template developed during the IPB process. Place this information over the map of your area of operations.

b. Get the obstacle preclusion points from G3 plans, and place this information over this map as well.

c. Get the population and structure preclusion points from the G5, and place this information on the same map.

d. Get information from the FA assistant operations officer and the ASOC about what delivery systems and air-delivered bombs may be available. Identify the weapon yields involved.

e. Produce a preclusion overlay for all weapons and yields ‘available within range.

STEP 3. Identify tentative desired ground zeros (DGZs) for all available weapons that do not violate preclusion constraints on each mobility corridor where critical events and activities are expected to occur and where HVT will appear. Specifically–

a. Start at the forward edge of the corps area of operations and identify the locations where critical events, activities, and HVT are expected to occur on a specific MC.

Notes: The EAC OPLAN may include the results of some nuclear planning that has already been done within the corps area of interest. These should be looked at in more detail.

These may be one point or a cluster of points within an area If they area cluster of points, identify the most probable center or a weighted average center.

b. Select the largest realistic nuclear yield that may fit in the area.

c. Using the planning guidance constraints established by EAC or the G3, extract the preclusion and least separation distances for that yield from FM 101-31-2, and apply the arcs to the preclusion points.

d. Place the weapon aimpoint on or as near as possible to the point or center of points. Ensure that the aimpoint does not fall within any preclusion arcs. If it does, move it slightly off center of the point (within reason).

e. If the aimpoint still lies within a preclusion arc(s), select the next smaller yield weapon and repeat (c) and (d) above.

f. Continue this process down each Mobility Corridor throughout the corps area of interest. The result will be a map overlay identifying the largest yield weapons that could be used to attack HVT in probable critical areas throughout the corps area of interest without violating preclusion constraints.

STEP 4. After receipt of the corps commander's restated mission and initial planning guidance, modify the overlay produced above as necessary.

STEP 5. Develop a selective employment plan; specifically—

a. The G2, G3 and FSCOORD, collectively, use the war-gaming process to develop courses of action. They bring to this analysis the knowledge and results gathered thus far from their own analyses of the corps mission and its essential and implied tasks. During the war-gaming process, the use of nuclear weapons is considered in each instance as are the other means of applying combat power (for example, maneuver, EW, and tac air).

b. The G2 plans officer, G3 nuclear employment officer, and target analyst, as the corps nuclear weapons employment experts, actively participate in this war-gaming process. As situations are identified where the use of nuclear weapons is being considered as an opportunity or a requirement, the G2, G3, and FSCOORD look to this supporting nuclear staff group to provide the expert analysis and technical advice on the use of nuclear weapons.

c. To actively participate in this war-gaming process used in the development of courses of action, this supporting nuclear staff group must develop a methodology for conducting the analysis. A framework for keeping track of the various situations and proposed packages must be developed. One way to do this is as follows:

Split the corps area of operations into sectors. The avenues of approach lines and the time phase lines that run perpendicular to them and the Mobility Corridors that were developed by the G2 can be used. Label each panel and each Mobility Corridor for internal reference using the same labels as the G2.

Then draw a matrix and label each axis accordingly. This will be used to record the objective of use and the number and yield of nuclear weapons to be used in each area Add some additional panels to the matrix to consider multiple Mobility Corridors and/or usage across the entire corps front.

d. As the G2, G3 and FSCOORD identify a situation that may be an opportunity or a requirement for the use of nuclear weapons, the FSCOORD turns to the supporting nuclear staff group for a detailed analysis. Using the updated situation and event templates and a stated objective, they begin to analyze the situation. The G3 plans nuclear employment officer and the target analyst tentatively identify aimpoints that will best counter the Threat actions as depicted on the situation and event templates. The G2 plans officer advises. To do this, two assumptions must be made:

Primary target catgegory -- If attacking a tank division, the defeat criterion Personnel in Tanks/Immediate Transient Ineffectiveness may be chosen if the enemy is capable of closing on the FLOT within 24 hours. Based on this criterion, target coverage is then determined by the corps commander and stated to the staff as a percentage of coverage (e.g., 30 percent).

Conventional damage contribution -- For example, 50% means 50% of the overall required damage will be contributed by conventional weapons and 50% by nuclear weapons.

e. After selecting tentative aimpoints for this one area, the target analyst overlays the preclusion information developed in Step 3 above. If any of the tentative aimpoints selected violate any preclusion constraints, an attempt is made to offset the aimpoints enough to avoid the violation yet achieve desired target coverage.

f. If this does not work, try one of the following procedures:

- Repeat the same steps using smaller yield weapons that could be potentially delivered in this area.
- If the preclusion constraints are self-imposed, modify them.
- Repeat the same steps exchanging nuclear targets for conventional targets or changing the total damage contribution mix.
- If the preclusion constraints are imposed by EAC, make a note that they prevent the optimum execution of a package in this area. This may be addressed to EAC later.

Using the adjusted aimpoints, determine the feasibility of delivering the yields and quantities of weapons within the area. Modify the yields/types/quantities as necessary to arrive at a package that is deliverable.

The following results of evaluating this situation should be recorded on an appropriate area in the matrix:

- Type and strength of forces involved.
- Objective of use.
- Nuclear/conventional damage contribution mix.
- Primary target/category/coverage.
- Number of weapons by type/yield.
- Any unresolved preclusion problems.

This process is used to evaluate the entire corps area of interest. When the G2, G3, and FSCOORD have completed their preliminary analysis of Mobility Corridors, they evaluate the courses of action that involve the use of multiple Mobility Corridors. The use of nuclear weapons in situations involving multiple Mobility Corridors and/or use across the entire corps front should also be evaluated. Include this information in the matrix.

From the situation and event templates and the matrix, identify the key large-scale situations that provide the best opportunity for, and/or that most likely will require the use of, nuclear weapons. Consider the worst-case scenario for the following

- Each main enemy avenue of approach into the corps area of operations.
- Multiple approaches.
- Limited use across the corps front.

From the matrix, extract the weapon packages that apply to the situations identified in (j) above. Compare them with each other, and select the weapon package that is larger in either yield size or quantity of weapons or both.

l. Combine the objectives and damage contribution mixes for as many situations as possible.

m, Coordinate with the NWLE to determine the feasibility of logistically supporting each situation, and modify the situation as necessary.

n. The result of this process is the identification of one nuclear weapons package that is adequate to meet each specific situation yet broad and flexible enough to be employed across the corps front. If two or more of the situation packages or objectives are so drastically different that one package will not suffice, two or more weapon package options may be included within the emerging package.

o. If EAC preclusion constraints in one of the situations identified above would prevent the employment of nuclear weapons, the G2, G3 and FSCOORD must decide if the situation should be reported to the corps commander. If the corps commander agrees and thinks it is necessary, he may elect to identify the situation to the EAC commander and request that the constraint(s) be modified. He should point out the projected detrimental effect on friendly forces if the constraints are not modified.

p. Brief the commander and get his approval.

The G3 with the advice of the G2, and FSCOORD, selects the best course of action. The staff then briefs the commander, reporting the results of their efforts focusing specifically on the selected course of action. In their briefing, the G3 and FSCOORD include the results of the preliminary nuclear analysis that affects the selected course of action.

Subsequently, the supporting nuclear staff group joins the G2, G3 and FSCOORD and briefs the corps commander on the results of the plan development effort. This briefing summarizes the results of the analysis of other courses of action from a nuclear perspective. It includes the nuclear weapon requirements for each course of action throughout the corps area of interest and most importantly, the package(s) that will enable the corps to meet each of these requirements. Also at this time, the nuclear staff group informs the commander of any constraints established at EAC that, if not modified, would prevent the most effective employment of a nuclear weapon(s).

The corps commander tentatively approves the plan and issues his nuclear employment concept to amplify his intent. He explains his decision and states any changes to be made or additional situations to be considered

The supporting nuclear staff group modifies the plan as required on the basis of the corps commander's intent and guidance just received

q. Coordinate with subordinate elements (referred to hereafter as division).

The G3 plans nuclear employment officer, with input from the G2 plans officer and the target analyst, writes the nuclear planning guidance that goes in the nuclear support plan that is part of the corps OPLAN. This nuclear planning guidance should include the following:

- Corps commander's concept for employment of nuclear weapons.
- Nuclear-related planning assumptions.
- Obstacle and civilian population/structure preclusion information.
- Type/yield of weapons potentially available for use.
- Largest yield weapon/preclusion overlay.
- IPB situation and event templates and nuclear sector overlay and nuclear employment matrix (discussed above).

The division staff should follow the procedures listed above in conducting its nuclear analysis; specifically:

- Validate the portion of the corps nuclear analysis that falls within the division area of interest.
- Conduct a detailed nuclear analysis of its division area of operations. This includes developing its own more refined IPB situation and event templates and nuclear employment matrix.
- Compare the results of the analysis with the corps-developed package(s). Recommended changes necessary to meet certain situations or to increase flexibility are noted.
- Brief the division commander on the results of the nuclear analysis, and get his approval.
- Give the results of the nuclear analysis, along with recommended changes, to the corps nuclear support planning staff.

CHAPTER 3

EMPLOYMENT ANALYSIS

Assumptions

Target analysis makes assumptions about certain variables of nuclear weapons employment. The validity of the analysis depends on how closely the actual conditions match the assumed conditions. Although many factors significantly affect target analysis, the methods in this manual give a reasonably good estimate if the assumptions in all five areas are satisfied:

- **weapon reliability**
- **target composition**
- **target locations**
- **atmospheric conditions**
- **terrain.**

These assumptions are defined on page 17.

Information

The available target information will dictate which target analysis method to use. Therefore, target analysts must first identify pertinent information before choosing the suitable method. Such information, particularly detailed target information, is not always immediately available. In such cases, analysts must base estimates on experience and available intelligence.

Command Guidance and Standing Operating Procedures

A division or higher command analyzes the mission and limiting requirements to establish guidance for risks and obstacle preclusion.

Target analysis work sheets aid in organizing and recording target information when estimating damage for a nuclear attack. Figure 4 gives an example of a worksheet. *(Note: the target analysis worksheet at Figure 4 provides more efficient data organization than the superseded version still depicted in later examples and figures. All subsequent references to worksheets should be considered that of Figure 4.)*

Nuclear Weapons Package.

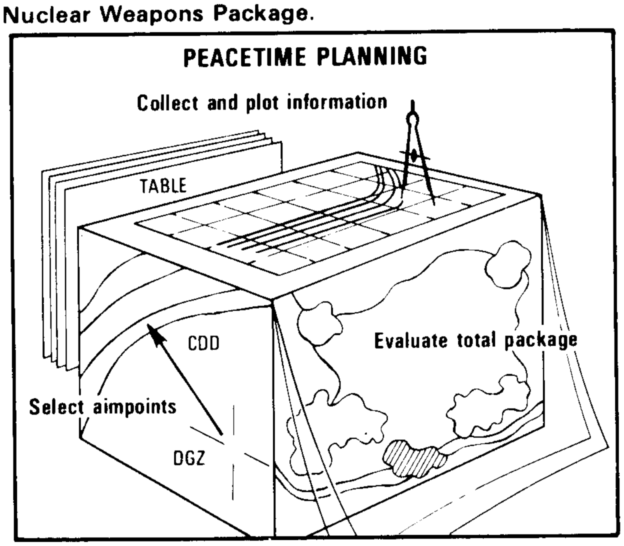


Figure 4. Nuclear Target Analysis Work Sheet.

TARGET INFORMATION			A
1 Tgt No			
2. Description			
3 Dam/Cas Criteria			
4 Loc (Grid Ref)			
5. Size (RT)			
6 TAE Yes/No			
7 Tgt Cat			
8 Dam/Cas Criteria			
9 Desired Cov/P			
10 Tgt Priority			
11 Fallout Yes/No			

WEAPON SYSTEM INFORMATION · INITIAL COVERAGE/PROBABILTY						B
1. Delivery system and yield						
2. Firing Posn (NRA)						
3. Firing Posn (Grid Sq)						
4. Range to Tgt						
5 Initial Cov/P						
6 RD Expt						
7 CEP						
8 TAE Adj $CEP = \sqrt{CEP^2 + TLE^2}$						
9. RD Min						
10. CD 90						
11 TAE Adj CD 90 = 1 83 $\sqrt{CEP^2 + TLE^2}$						
12. HOB. (Option/metres)						
13. PEH						

TROOP SAFETY (MSD)						C
1. Vul/Risk: RES:						
2. Vul/Risk: RES:						
3. MSD 1 (WPN)						
4. MSD 2 (WEN)						
5. MSD 3 (UEN)						

PRECLUSION REQUIREMENTS (LSD)						D
1. Obstacle:						
2. Material:						
3.						

COLLATERAL DAMAGE (CDD)						E
1. Personnel RCD						
2. Material RCD						
3. Assurance % = = CEP(s)						
4. CDD = RCD (Larger) + BD						

NO DISPLACEMENT AREA TGT EXPT COV						F
1. RD Expt/RT						
2. CEP/RT						
3. Cov Predicted ($\bar{f}$)						

D MAX AREA TGT EXPT COV						G
1. CEPA						
2. RD Expt/CEPA						
3. D/CEPA from Graph						
4. or D/RD Expt from Graph						
5. D MAX = Ser 3 x CEPA or Ser 4 x RD Expt						

DISPLACED DGZ AREA TGT EXPT COV DAMAGE OR CAS ESTIMATION						H
1. Final Displacement (D)						
2. CEPA						
3. RD Expt/CEPA						
4. D/CEPA						
5. or D/RD Expt						
6. Final Expt Cov ($\bar{f}$)						

D MAX AREA TGT, HA or PT TGT									J
A	1. RD Min/RT	P	1. RD Min/CEP						
R	2. CD 90/RT	O	2. D/CEP from Graph						
E	3. D/CD 90	I	3. or D/RD Min from Graph						
A	from Graph	N	DMAX = Ser 2 x CEP or						
DMAX Ser 3 x CD 90		T	Ser 3 x RD Min						

DAMAGE OR CAS ESTIMATION AREA TGT HA OR PT TGT									K
1. If NO Displacement Use Serials A4, A5, P4									
2. If Displacement Use Serials A4–6, P4–6									
3. Final Displacement (D)									
A	4. RD/Min RT	P	4. RD Min/CEP						
R	5. CD 90/RT	O	5. D/CEP						
E	6. D/CD 90	I N	6. or D/RD Min						
A	$\bar{f}$ 90	T	P						

RECOMMENDATION/FIRE ORDER			L
1. Unit/Delivery System/C/S			
2. Firing Posn (NRA)			
3. Firing Posn (Grid Sq)			
4. Tgt No			
5. DGZ & Alt			
6. HOB/Option			
7. Back Up Fuze Option			
8. Alt of Burst			
9. Warhead No, KT Yield Designator			
10. TOT/TOD Desired			
11. Cov/P			
12. Latest TOT, TOD			

NOTES
Analysed by:
Signature:
RANK & NAME
Checked by:
Signature
RANK & NAME

Basic Assumption: Target Analysis Procedures.

WEAPON RELIABILITY	The weapon is assumed to be reliable in arriving at the target area at the desired time and within predicted delivery error tolerances and in producing a nuclear detonation of the expected yield.
TARGET COMPOSITION	Actual target elements are assumed to be uniformly distributed in the target area and randomly oriented.
ATMOSPHERIC CONDITIONS	The radii for blast, nuclear, and thermal radiation effects are based on standard atmospheric conditions. Nonstandard atmospheric conditions are not usually considered. Cases where effects may be significantly modified by atmospheric conditions are discussed in Appendix A.
TARGET LOCATION	It is assumed that the exact locations of the targets are known. However, if target location errors (TLEs) exist and they can be characterized by target analysts, then the target-oriented method can accommodate them.
TERRAIN	A flat surface is assumed for all situations considered in this manual. Minor terrain irregularities such as ditches and gullies will not modify nuclear weapon effects, but extreme terrain can. For specific cases, see Appendix A.

NOTE: These assumptions apply to the gray-shaded procedures described in Chapter 4 and Appendix A.

TARGET DEFEAT GUIDELINES. For area targets, the guidelines should specify the level of casualties or damage desired over a specified fraction of the target. Normally, expected coverage (the average expected value) is used for area targets. High-assurance coverage (a 90-percent probability of achieving at least some minimum specified coverage) is an alternative approach. Guidelines should also be used to establish the probability of achieving a specified level of damage to a point target.

DEGREE OF ACCEPTABLE RISK TO FRIENDLY TROOPS. Negligible risk to unwarned, exposed personnel is normally specified. A higher degree of risk may be specified if operationally warranted.

DEGREE OF ACCEPTABLE RISK TO NONCOMBATANTS. Normally a 5-percent incidence of hospitalizing injuries among civilians at the edge of populated areas is an acceptable risk. However, the corps commander or higher authority may specify otherwise. This does not mean that 5 percent casualties would actually be realized. In fact, much less than a l-percent incidence would occur in most cases.

OBSTACLE GUIDANCE. The commander may desire to enhance or minimize obstacles produced by nuclear weapons to fit his overall plan. Appropriate rules of engagement and Chapter 2 of this manual should be reviewed before choosing suitable weapons.

TARGET INFORMATION

Target information includes—

- Location, size, shape, and hardness of the targets to nuclear weapons effects.
- Category of primary target elements and, if applicable, the degree of protection of the target elements against weapons effects.
- Distribution of target elements. This is of particular importance for large targets such as a battalion assembly area. Intelligence concerning the location of subordinate elements or units could result in a more effective attack of the target complex, for example, by using a few small weapons instead of one large weapon.
- Mobility of the target, that is, the expected stay time or rate of movement of a target.

FRIENDLY ELEMENT AND COLLATERAL DAMAGE

Information on friendly elements and collateral damage includes—

- Attack resources, including the weapons available for planning purposes and their locations; and the delivery means available, their response times, and locations.

- Location of friendly troops near the area planned for the burst or bursts, their degree of protection, and their radiation exposure state (RES). See Appendix A.
- Location of areas containing noncombatants and, if obtainable, their degree of protection.
- Location of structures, facilities, or equipment for which damage should not exceed a specified level.
- Response time of delivery units being considered to deliver a weapon.
- General planning guidance for each delivery system. Contained in FM 101-31-2, this planning guidance does not take into account any additional time required to meet release procedure requirements. Whenever possible, actual response times should be obtained from the specific delivery unit.

TERRAIN ANALYSIS

Terrain analysis determines the most likely avenues of approach, possible penetrations. It also determines areas where lucrative nuclear targets might be located or where, based on enemy tactics and doctrine, they may form to support enemy operations.

Target-Oriented Method

The target-oriented method is used to select a weapon based on the characteristics of the acquired target, the desired effects on the target, the delivery errors, and the limiting requirements. The target-oriented method is used for acquired priority targets when the information about the target is sufficient to do an analysis. In general, the weapons that optimize effects while satisfying the limiting requirements will be selected.

DETERMINE SUITABLE WEAPONS

Using the target-oriented method, analysts select a weapon by determining initial coverage or damage probability of those weapons available and by considering the limiting requirements. Then they select the DGZ to meet these limitations and determine the final coverage or damage probabilities for weapons that meet the criteria.

INITIAL COVERAGE AND/OR DAMAGE PROBABILITY. Depending on the characteristics of the target, there are three techniques for estimating damage:

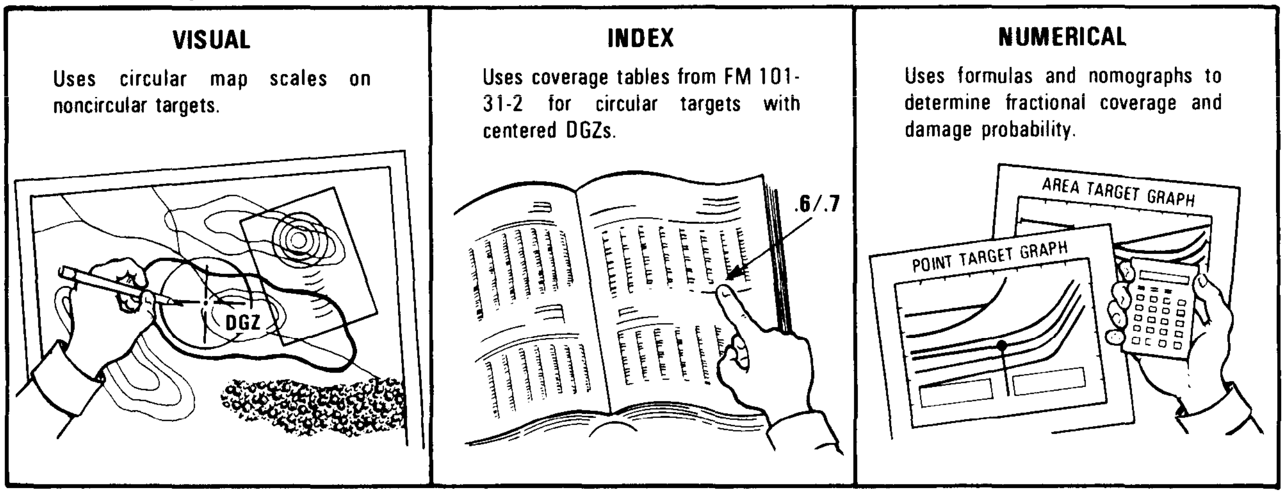
- *Visual technique.* This graphic technique is generally used to estimate coverage of noncircular area targets. Since virtually no tactical or battlefield target is circular, this approach permits a more realistic appraisal of effects against actual targets. Visual analysis can accommodate a displaced aimpoint. It also shows a particular nuclear strike in the context of everything else occurring on the battlefield.
- *Index technique.* This technique, using precomputed coveraged tables, estimates damage against a circular area target when it is in a primary target category and the DGZ is at the target center. Although realistic targets may not meet all the assumptions used in computing the coverage tables, it does provide a means for comparing the capabilities of various nuclear weapons against a particular target.
- *Numerical technique.* This technique estimates fractional coverage of circular (or near circular) area targets or the probability of damage to point targets using area or point target graphs. It is particularly useful for an estimate of damage when the aimpoint is displaced from the target center.

Detailed explanations of the three techniques are contained in Chapter 4.

LIMITING REQUIREMENTS. Restrictions placed on the employment of nuclear weapons are referred to as limiting requirements and are considered in four areas:

- *Troop safety.* Analysts determine if the distance between friendly troops and the DGZ is sufficient to ensure that the troops will not be exposed to a risk exceeding that specified by the commander.
- *Collateral damage.* Analysts determine if the distance between the DGZ and locations containing noncombatants or areas where

Figure 5. Damage Estimation Techniques.



damage preclusion has been directed is sufficient to ensure that the specific preclusion criteria are met.

- *Obstacle preclusion.* Analysts determine if the distance between the DGZ and the point where obstacle preclusion has been directed is sufficient to meet the commander's guidelines.
- *Yield constraints.* Analysts determine if the yield required to accomplish the desired effect is within the yield limitations or restrictions contained in the command guidance.

FINAL DGZ. The target center is initially selected as the DGZ. The final DGZ may be displaced to satisfy limiting requirements and/or to allow for an attack on multiple targets with a single weapon. For selecting a DGZ, see Chapter 4.

FINAL COVERAGE AND/OR PROBABILITY. When a displacement of the tentative DGZ is made, then a revised prediction of casualties or damage using the new DGZ must be made. When the DGZ is not displaced, initial coverage and probability become final.

EVALUATE WEAPON SYSTEMS AND THE TACTICAL SITUATION.

For the target-oriented method, the weapons that meet the guidance for each acquired target are identified. When selecting the most suitable weapon for a target, analysts consider that—

- The highest priority targets should receive first consideration.
- Weapons and yields selected must meet any release constraints.
- The commander may need to retain long-range weapons for follow-on use.
- The weapon selected should give the highest coverage for area targets or the highest probability of defeat of a point target while meeting all troop safety, collateral damage, and obstacle or damage preclusion criteria. Nevertheless, the minimum yield weapon which gives adequate coverage may be selected. For example, minimum yeild. weapons may be used to conserve firepower or to reduce both collateral damage and obstacles to a minimum.

MAKE RECOMMENDATIONS

After selecting suitable weapons, analysts present recommendations for defeating the target or group of targets to the commander. When formulating final recommendations, analysts should emphasize the balance between military effectiveness and collateral damage. Each recommendation should include the following six items:

- *Weapon system.* The weapon system consists of the recommended delivery system, weapon, delivery unit, and yield.
- *HOB.* The HOB will be indicated so that the significance of any possible surface contamination can be assessed. For a list of available fuzing options see FM 101-31-2, Chapter 2. Many weapon systems have a preset HOB which cannot be adjusted. In these cases, the exact HOB in meters will be transmitted. When an airburst is the primary fuzing option, analysts recommend whether or not to use a backup impact fuze.
- *DGZ.* The DGZ is that point on the surface above, at, or below which the detonation is desired. It is designated by map coordinates.

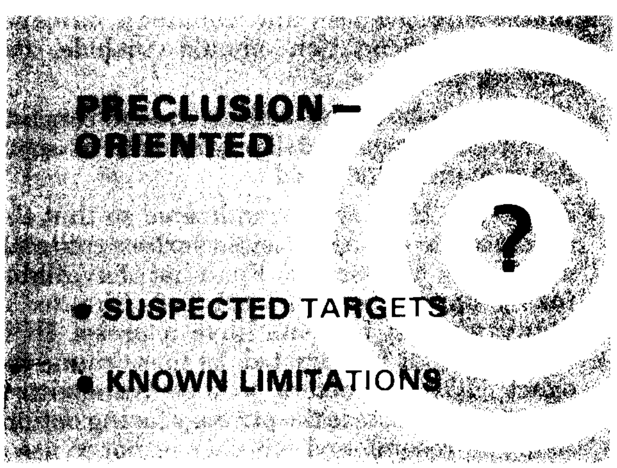
- *Time on target.* The time of burst is dictated by both tactical considerations such as the general concept of employing a package and by technical considerations such as preinitiation. The acceptable interval for time on target will also be specified because of its impact on troop warning considerations and because it is an integral part of the employment package concept.
- *Predicted results.* When the target-oriented method is used, analysts will indicate the fractional coverage of area targets or the probability of achieving a specified degree of damage or casualties on a point target. For visual analyses, the radii of damage can be graphically portrayed on the areas of proposed employment,
- *Limiting requirements.* The troop safety and collateral damage information will always be presented—graphically, if possible.

CONDUCT A POSTSTRIKE ANALYSIS

A nuclear strike can be deemed successful if the desired operational results are achieved, that is, if the enemy attack is halted. However, analysts can estimate the extent to which the nuclear strike was successful or unsuccessful by a poststrike analysis.

Preclusion-Oriented Method

The preclusion-oriented method is appropriate during fire planning when detailed target information is not available. This method is used to select a weapon based on limiting requirements and an analysis of the threat. It is used for suspected targets and for areas that may contain nuclear targets based on the enemy's tactics and doctrine and on the terrain.



DETERMINE SUITABLE WEAPONS

Using the preclusion-oriented approach, analysts select a weapon that meets the limiting requirements in the area of the threat. This method consists of analyzing the terrain and threat, determining the limiting requirements, and eliminating unsuitable weapons:

- *Terrain and threat.* Analysts carefully consider the terrain for likely avenues of approach, probable penetrations, and areas where nuclear targets may be located based on current intelligence and enemy tactics and doctrine. This analysis is normally done as part of the IPB process.
- *Limiting requirements.* Analysts apply troop safety distances, obstacle preclusion distances, and collateral damage distances to the area of proposed employment.
- *Unsuitable weapons.* Weapon yields are eliminated from further consideration when they are greater than command guidance limitations or preclusion guidance eliminates any possible DGZ selection.

EVALUATE WEAPON SYSTEMS AND THE TACTICAL SITUATION

Analysts select weapons and DGZs that will give the most complete coverage of the proposed area of employment consistent with the limiting requirements, available intelligence, and tactical situation.

MAKE RECOMMENDATIONS

Analysts recommend strikes and employments to the commander. Each recommendation should include yield, HOB, DGZ, time on target, predicted results, and limiting requirements.

CONDUCT A POSTSTRIKE ANALYSIS

Analysts estimate the strike's degree of success by determining details about the detonation such as yield, HOB, and GZ.

Summary: Target Analysis Procedures.

INFORMATION	• Command Guidance and standing operating procedures. • Target information. • Friendly elements and collateral damge information. • Terrain analysis in conjunction with the suspected threat.	
	Preclusion-oriented-method	**Target-oriented-method**
SUITABLE WEAPONS	• Terrain and threat analysis • Limiting requirements. • Unsuitable weapons.	• Initial coverage and probability: visual, numerical, or index technique. • Limiting requirements: troop safety, collateral damage, obstacle and damage preclusion, yield constraints, and final DGZ. • Final coverage and/or probability.
WEAPONS AND TACTICAL SITUATION	• Highest priority targets. • Weapon and yield constraints. • Retention of the more effective (flexible) system. • Best coverage.	
RECOMMENDATIONS	• Delivery system, weapon, delivery unit, and yield. • HOB. • DGZ. • Time on target. • Predicted results. • Limiting requirements.	
POSTSTRIKE ANALYSIS	• Achieved results. • Need for strike.	

EMPLOYMENT OF SEVERAL WEAPONS

Consideration of timing, desired ground zeros (DGZ), and flight paths must be taken if more than one nuclear weapon is to be employed in the same approximate location and at the same approximate time. The target analyst should not have a second nuclear warhead within the immediate effects (either by DGZ or trajectory) of the detonation of a first warhead to avoid severe stress/deformation or change of trajectory. If the DGZs are within 2 km, space the rounds at 1 minute intervals. The analyst must give careful consideration to the immediate effects that occur during a nuclear detonation when developing a schedule of fire.

PREINITIATION

Certain weapons may be liable to preinitiation. If a weapon preinitiates, the probable result is a greatly degraded yield. This section provides procedures for reducing the probability of preinitiation while maintaining maximum flexibility for the nuclear weapons employment planner.

DEFINITIONS

PREINITIATION . The premature initiation of the sustained chain reaction of the active material of a nuclear weapon before the desired configuration of the active material has been attained.

SELF PREINITIATION. Preinitiation caused by radiation from nuclear reactions occurring entirely within the warhead's own materials without any stimulation by external radiation. The self preinitiation probability for any weapon is very small (less than 1 percent).

CAUSES OF PREINITIATION

There are six situations where preinitiation is of concern. Each involves the exposure of a preinitiable weapon to nuclear radiation resulting directly from the burst of another nuclear weapon.

Causes of Preinitiation

- **Failure to separate successive nuclear fires (in space and time).**
- **Firing through a nuclear debris cloud.**
- **Induced radioactivity in the soil at the target area.**
- **Fallout at the desired ground zero.**
- **Nuclear burst in the vicinity of a preinitiable weapon firing position.**
- **Fallout at the preinitiable weapon firing position.**

PREINITIATION AVOIDANCE

As the tactical situation permits, the application of the scheduling priorities listed below should be used to reduce the probability of preinitiation. At a minimum compliance with preinitiation prevention rules 1 through 4 will provide a 90 percent pro bability that weapons will achieve at least 90 percent of their yeild.

Preinitiation Avoidance Scheduling Priorties

PRIORITY

I. FIRE THE PREINITIABLE WEAPON FIRST !

II. Fire at the most distant downwind target first.

III. Fire closest most upwind target last.

Figure 2-1 Preinitiation Prevention Rules

RULE 1. ESTABLISH AND OBSERVE STAY-OUT ZONES IN THE TARGET AREA. ***IF*** Weapon A must be fired after another nuclear weapon, ***THEN*** work the following procedures for the DGZ's that may cause preinitiation. *(The effects of both neutron induced gamma activity (NIGA) and masking due to the debris of the first weapon have been considered.)*

Step A. Graphically locate Weapon A's firing position. If the actual firing position is unknown, draw a circle large enough to encompass the vicinity of the expected firing unit location.

Step B. Plot the DGZ's of weapons employed or scheduled for execution prior to Weapon A. Then draw a 1 km radius circle (Zone A), a 2 km radius circle (Zone B), and a 7 km radius circle (Zone C) around each plotted DGZ. For tactical purposes, Zone A is ***NEVER*** engaged with Weapon A.

Step C. ***If*** wind speed (WS) km/hr is known or predictable, ***then*** the radioactive debris cloud drift can be accommodated as follows. *(If wind speed is not known or insignificant use special non-wind procedures Step D below).* Use the following formulas to determine the downwind vectors:

(WS/15) + 2 km = 4 minute downwind vector
(WS/4) + 2 km = 15 minute downwind vector

Draw each vector downwind and parallel to the wind direction from the DGZ and label as shown.

Step D. Draw 3 lines from Weapon A's firing position:

- Line 1 — Tangent to the upwind side of the Zone B circle
- Line 2 — Drawn through the end point of the 4 minute downwind vector
- Line 3 — Drawn through the endpoint of the 15 minute downwind vector

The length of Lines 1 and 3, is the maximum range of the charge *(see Table 2-6)* or the maximum range of the delivery system if the charge is unknown. Line 2 is 2 km less than Line 1. Using Weapon A's firing position for a center point, draw an arc from the Line 1 endpoint to the Line 3 endpoint. Subtract 2 km from the Line 1 endpoint and draw another arc to Line 3. The area within the arcs is Zone D. *(Go to Step E)*

Special non-wind procedure. *If* the wind drift of the debris cloud is not known or insignificant, ***then*** Line 2 is not used and Lines 1 and 3 are drawn tangent to opposite sides of the Zone B circle with a length equal to the maximum range of the charge *(see Table 2-6)* or the maximum range of the delivery system if the charge is unknown. Connect the distant end-points of Line 1 and 3 with an arc. Subtract 2 km from the end-point of Line 1 and draw another arc to Line 3. The area within the arcs is Zone D. *(Go to Step F.)*

Step E. Draw line 4 parallel to the wind direction between lines 1 and 2 tangent to the delivery unit side of Zone B. The area bounded by line 1, line 2, line 4 and the Zone D inner arc is Zone E. If the charge is unknown, then extend line 4 to line 3. The area encompassed by line 1, line 3, line 4 and Zone D is Zone D(+) with a corresponding wait time of 10 minutes.

Step F. Determine ability and time. *(Repeat the above steps for each previous weapon DGZ that is in the vicinity of Weapon A in question.)*

RULE 2. CONSIDER DIRECT RADIATION EFFECTS FROM FRIENDLY OR ENEMY NUCLEAR BURSTS AT WEAPON A'S FIRING POSITION. Determine the yield of the near burst and its distance from the firing point in meters by entering Table 2-4 with the distance and yield and type and extract a firing delay time (in minutes).

RULE 3. ACCOMMODATE FALLOUT FROM PREVIOUS FRIENDLY OR ENEMY NUCLEAR BURSTS AT WEAPON A'S FIRING POSITION. ***IF*** the firing position is receiving radiation fallout at a rate greater than 75 cGy (rad)/hour, ***THEN*** do not fire Weapon A from this position.

RULE 4. CONSIDER FALLOUT FROM OTHER FRIENDLY OR ENEMY NUCLEAR BURSTS AT WEAPON A'S DGZ ***IF*** the radiation rate at Weapon A's DGZ can be determined, and the rate exceeds the levels in Table 2-5, ***THEN*** do not use Weapon A on that DGZ.

Table 2-4. Firing Delay Times for Weapon A Nuclear Bursts in the Vicinity of the Firing Position.

Distance From Detonation (m)	Firing Delay Times (minutes)					
	1 KT Yield		10 KT Yield		100 KT Yield	
	Fission	ER	Fission	ER	Fission	ER
1000	24	30	30	33	N/A	N/A
1500	20	26	26	29	30	33
2000	16	22	22	25	26	30
2500	12	18	18	21	22	26
3000	8	14	14	17	18	22
3500	4	10	10	13	14	18
4000	2	6	6	9	10	10
4500	0	2	2	5	6	6
5000	0	0	1	1	2	1
5500	0	0	0	0	0	0

NOTE: If the yield and/or distance from the burst are unknown or cannot be reasonably estimated, a delay time of 55 minutes from time of burst to firing should be applied.

Table 2-5 Maximum DGZ Radiation Levels.

Time After Burst	Rate
1 Hour	1.0 cGy/hr
5 Hour	6.0 cGy/hr
25 Hour	12.0 cGy/hr

Table 2-6 Maximum Range of Charges in Meters

Charge 1	Charge 2	Charge 3	Charge 4
5,000	10,000	16,000	20,000

ZONE AND WAIT TIME SUMMARY

Zone A		1km—No Fire Area (NFA)
Zone B		2km—1 hour wait
Zone C		7km—2 min wait
Zone D		2km Arc—15 min wait
Zone D(+)		15 min wait
Zone E		4 min wait

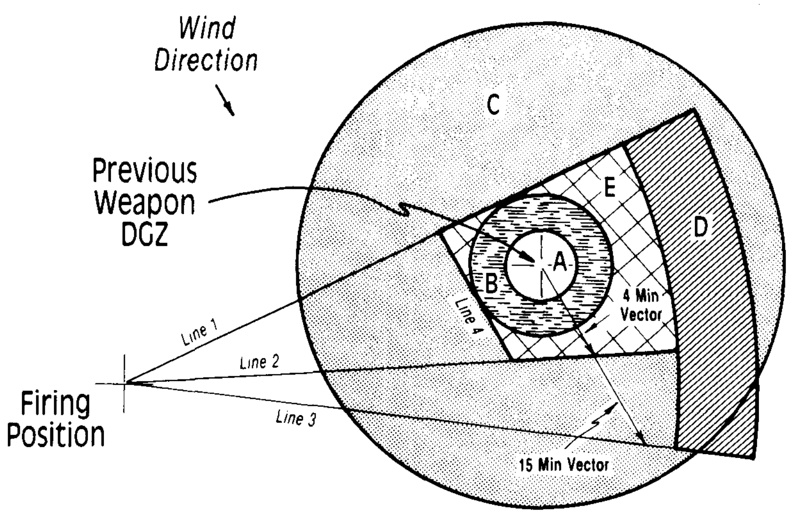
Note: Distance for zones A,B, and C are meseaured from previous weapon DGZ.

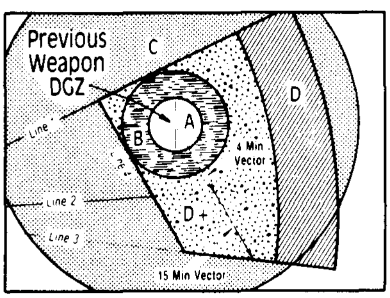
WIND SPEED COMPUTATION

$\frac{WS}{15} + 2km = 4$ minute vector

$\frac{WS}{4} + 2km = 15$ minute vector

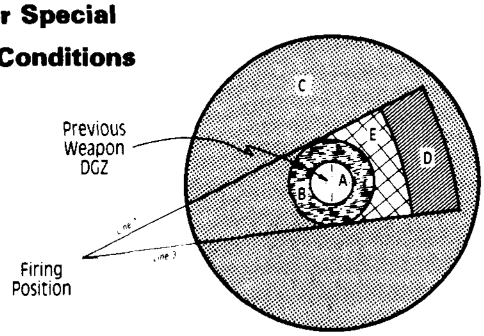
All vectors are drawn downwind





Zone D + **(Unknown Charge)**

Zones for Special Non-Wind Conditions



Determine Ability and Time

1. **IF** the DGZ is not in any zone, **THEN** the DGZ may be scheduled at or after 1 minute of a previous weapon burst.
2. **IF** Weapon A's DGZ falls inside Zone A, **THEN** Weapon A ***may not*** be used.
3. **IF** Weapon A's DGZ falls inside Zone B, **THEN** the DGZ may be scheduled at or after 40 minutes of a previous weapon burst.
4. **IF** Weapon A's DGZ falls inside Zone C but outside other zones, **THEN** the DGZ may be scheduled at or after 3 minutes of a previous weapon burst.
5. **IF** Weapon A's DGZ falls inside Zone D (between the arcs) or Zone D(+), **THEN** the DGZ may be scheduled at or after 10 minutes of a previous weapon burst.
6. **IF** Weapon A's DGZ falls inside Zone E, **THEN** the DGZ may be scheduled at or after 20 minutes of a previous weapon burst.

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APPENDIX A

NUCLEAR WEAPONS: EFFECTS AND RESPONSES

Employing nuclear weapons requires an understanding of their effects and target responses. Those effects of military interest that occur in the first minute are the initial effects. Those that occur after the first minute are residual effects. It may be hours or days before the consequences of some of these effects are known, and they may last for extended periods. See DNA EM-1 and DA Pamphlet 50-3 for more detailed discussions of nuclear weapons effects, including the distances to which various effects extend.

SECTION 1. EFFECTS

Nuclear Energy Partition

The energy released in a nuclear explosion enormously exceeds the energy released in a chemical explosion. This energy, or yield, is measured in thousands or millions of tons of TNT-kilotons or megatons, respectively.

A nuclear weapon detonated at low altitude forms a fireball. Its initial temperature ranges into millions of degrees, and its initial pressure ranges to millions of atmospheres. In the target area, most of the energy from a nuclear weapon detonation appears as three distinct kinds:

- *Blast.* A blast wave with accompanying high velocity winds and drag effects travels outward from the burst faster than the speed of sound.
- *Thermal radiation.* The fireball emits intense thermal radiation at the speed of light, heating and , burning objects in the surrounding area.
- *Nuclear radiation.* Neutron and gamma radiation from the detonation produces casualties and, in many cases, materiel damage as well. Nuclear radiation absorbed in the atmosphere produces ionized regions, which may interfere with the propagation of electromagnetic waves associated with communication systems and radars.

The partition of energy released as blast, thermal radiation, and nuclear radiation depends primarily on whether the weapon uses fission or a combination of fission and fusion.

Fission Weapons

In the detonation of a typical fission weapon, the percentages of total energy appearing as blast, thermal radiation, or nuclear radiation depend on the altitude at which the burst takes place and on the physical design of the weapon. For airbursts near the earth's surface, slightly more than 50 percent of the energy may appear as blast, about 35 percent as thermal energy, and the remaining 15 percent as nuclear radiation.

Fission-Fusion Weapons

For weapons in which fission and fusion are assumed to contribute equally, the energy divides into 30 percent blast, 20 percent thermal radiation, and 50 percent nuclear radiation. With their reduced blast and increased nuclear radiation, these tactical fission-fusion weapons are often called enhanced radiation (ER) warheads. Thus, a 2-kiloton ER weapon will produce the nuclear radiation of a 10-kiloton fission weapon and the blast and thermal radiation of a l-kiloton fission device.

Blast

Air Blast

The blast wave from an airburst causes most of the materiel damage and a considerable number of the casualties. Peak overpressure and dynamic pressure cause the damage.

The magnitude of the air blast depends on the yield of the weapon, height of burst, and the distance from ground zero. For example, a 1-kiloton weapon might produce an overpressure of about 5 PSI at 500 meters from the burst; whereas, a 10-kiloton weapon would produce 5 PSI at approximately 1,100 meters from the burst. The duration of the blast wave's overpressure and dynamic pressure may last from tenths of a second to seconds, depending on the yield and the distance from the burst.

PRESSURES

Except for very high pressures, the positive and negative phases of overpressure are greater in magnitude than those of dynamic pressure. Even though dynamic pressure is not as strong, it causes significant blast wave damage. The positive phases of overpressure and dynamic pressure last about the same length of time. Both overpressure and dynamic pressure vary with time at a fixed distance from the burst (see Figure 41).

OVERPRESSURE. Intensely hot gases at extremely high pressures within the fireball expand to form a blast wave in the air, moving outward at high velocities. The main characteristic of the blast wave is the abrupt rise in pressure above ambient conditions, or overpressure, The peak overpressure occurs at the leading edge, or shock front, of the blast wave. As the blast wave travels in the air away from its source, the peak overpressure steadily decreases. The pressure behind the shock front, which decreases until it is below that of the surrounding atmosphere, forms the negative phase of the blast wave, or underpressure. See Figure 42. Initially, the velocity of the shock front is many times the speed of sound. However, as the front moves outward, it slows down, propagating at the speed of sound and ultimately dissipating.

The characteristics of the blast wave depend primarily on the distance from the burst point and the yield of the weapon. The duration, T, of a blast wave—the time that the blast wave takes to pass a fixed point—increases with distance. See Figure 43. The peak overpressure decreases with distance. As indicated in Figure 44 on page 74, both the duration and peak overpressure increase with yield at a given distance from GZ. The velocity of the shock front decreases with the distance from GZ.

When high overpressure from a blast wave first contacts the side of the object nearest the burst, the far side is still at ambient pressure. This temporary pressure difference about the

Figure 41. Overpressure and Dynamic Pressure.

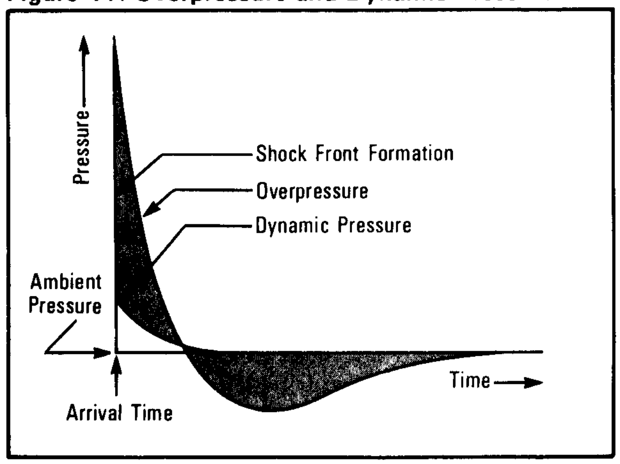


Figure 42. Variation of Overpressure with Distance.

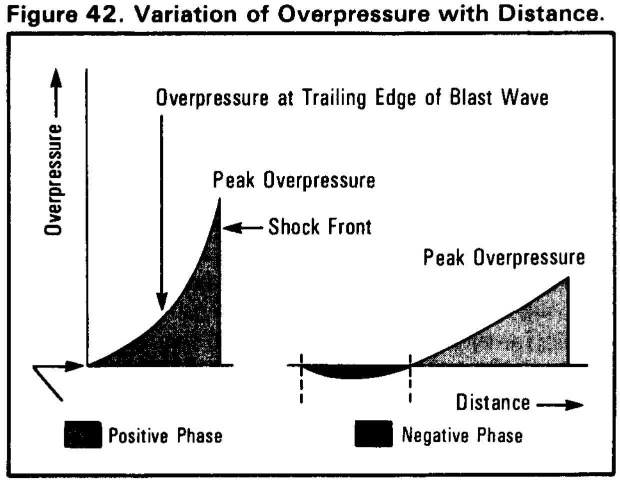


Figure 43.
Increase of Blast-Wave Duration with Distance.

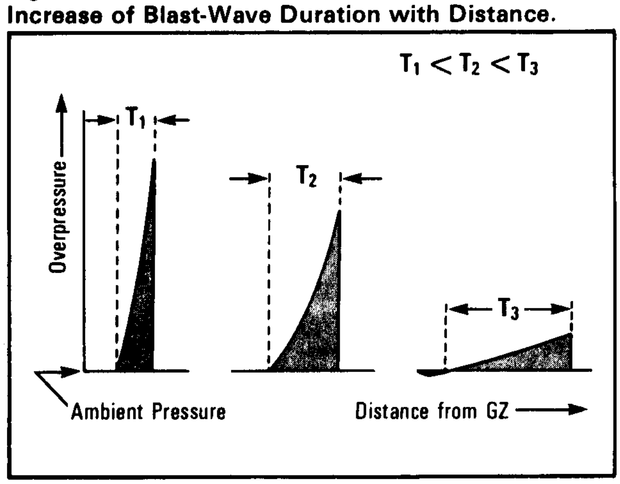
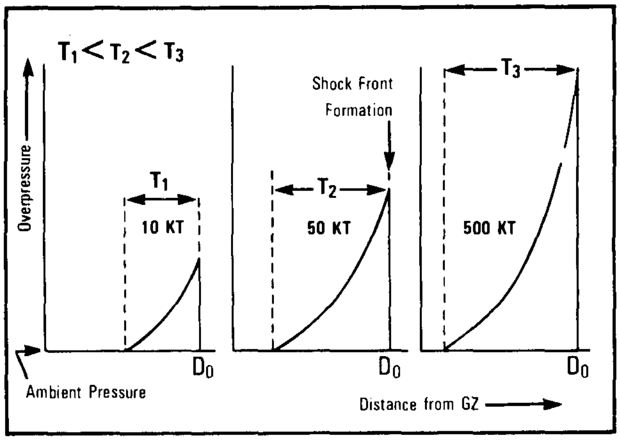


Figure 44.
Increase of Blast-Wave Duration with Yield.



object produces a net force away from the burst. As the blast wave envelops the object, the overpressure exerts a squeezing or crushing force that might result in damage. Buildings with small window areas that are damaged primarily by overpressures are called diffraction targets.

DYNAMIC PRESSURE. The force of the air accompanying the blast wave and the drag forces resulting from the associated winds are referred to as dynamic pressure. Dynamic pressure can cause damage by translating, that is, pushing or tumbling objects along the ground or by tearing targets apart. Targets damaged primarily by dynamic pressure are called drag targets. Most tactical targets of military materiel are drag-sensitive. Personnel can also become casualties when they are translated or hit by flying debris.

Dynamic pressure is proportional to the square of the air velocity directly behind the blast wave and, thus, relates to the winds associated with the blast wave. The dynamic pressure also exhibits a negative phase, but it is small and not militarily significant.

HOB INFLUENCES

AIRBURST. The blast wave from an airburst is reflected by the earth's surface. The reflected wave reinforces the incident (initial) blast wave and increases the overpressure and the dynamic pressure, resulting in greater blast effects over a larger surface area than the reflected or incident wave can cause alone.

The magnitude of this reinforcement depends on the HOB. Since greater blast wave pressures are obtainable at lower altitudes, low airbursts may be employed against blast-resistant materiel targets such as tanks, artillery pieces, and missile launchers. High airbursts reduce the blast pressures but increase the area coverage. Such high bursts are suitable against large area targets such as most buildings and forests.

SURFACE BURST. A surface burst produces less total air blast area coverage to most military targets than an airburst because there is less reinforcement of the blast wave. Moreover, since some of the weapon's energy digs a crater and generates ground shock, the amount of energy in the blast wave is reduced.

SUBSURFACE BURST. Most of the energy from subsurface bursts goes into crater formation and/or ground shock. The actual fraction depends on the yield and depth of burst. Except for very shallow subsurface bursts, the air blast wave produced by buried bursts is weak compared to those from airbursts and surface bursts. As a result, only small amounts of damage can generally be expected from the air blast produced by a subsurface burst.

MODIFYING INFLUENCES

WEATHER. Rain and fog may attenuate the blast wave in the low overpressure region because heating and evaporating the moisture in the atmosphere dissipates energy.

SURFACE CONDITIONS. The reflecting nature of the surface over which a weapon detonates can significantly influence the distance to which blast effects extend. Generally, smooth reflecting surfaces such as thin layers of ice, snow, moist soil, and water are nearly ideal. They reflect most of the blast and thermal energy and, thus, maximize the extent of overpressure. Conversely, surfaces with thick, low, combustible vegetation, dry soils with sparse vegetation, and desert sand are *nonideal.* They absorb some of the thermal and blast overpressure energy. However, a thermal layer often forms, causing a militarily significant increase in dynamic pressure. This precursor phenomenon, when it occurs, provides a bonus damage effect on most tactical targets.

TERRAIN. Most data about blast effects are based on flat or gently rolling terrain. There is no quick and simple method for calculating changes in blast pressures in hilly or mountainous terrain. In general, compared to pressures at the same distance on flat terrain, pressures are greater on the forward slopes of steep hills and lower on reverse slopes. But line-of-sight shielding is not dependable because blast waves bend or diffract around obstacles. In fact, small hills or folds in the ground are considered negligible for target analysis. Hills may decrease dynamic pressure and offer some local protection from flying debris. Forests, in general, do not significantly affect overpressure but do lessen dynamic pressure.

URBAN AREAS. Built-up areas are not expected to have a significant effect on the blast wave. Structures may provide some local shielding from flying debris. They can also increase pressures by channeling the blast wave. However, air blast effects are essentially the same in cities and urban areas as on open terrain.

Ground Shock and Cratering

When a nuclear weapon is detonated beneath, near, or on the surface, a portion of the blast energy compacts and throws a large quantity of earth upward and outward, thereby forming a crater. Thermal radiation, which vaporizes materials, also helps form the crater. This crater may be quite large depending on weapon yield, depth of burst, and soil characteristics. For example, a l-kiloton burst at a depth of 40 meters in wet soil forms a crater about 65 meters in radius and nearly 35 meters deep (see Figure 45). In rocky or cohesive soil, material thrown from the crater ranges from a fraction of a pound to many tons. These ejects pose a hazard to personnel, materiel, and structures. Generally speaking, more than half of the crater ejects is contained in the crater lip, which extends from the rim to about 3 crater radii from GZ. The remaining ejects fall to the ground out to ranges where the overpressure is less than 1 PSI. See Figure 46 for a typical crater.

A portion of the burst energy is transmitted to the surrounding earth as a ground shock wave that travels radially outward through the earth. This ground shock wave attenuates much more rapidly than the air blast wave. Its actual attenuation depends heavily on the geology. As a result, damage radii for ground shock waves are much smaller than those for air blast.

Figure 45. Crater Radius and Depth.

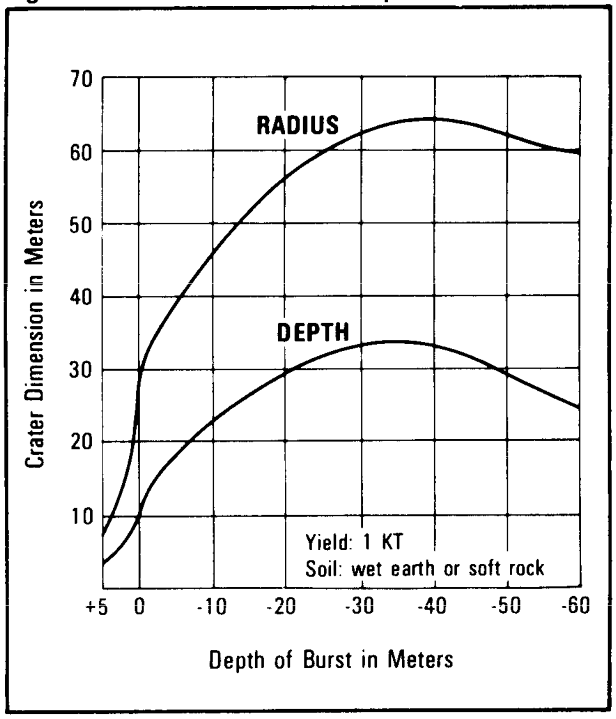
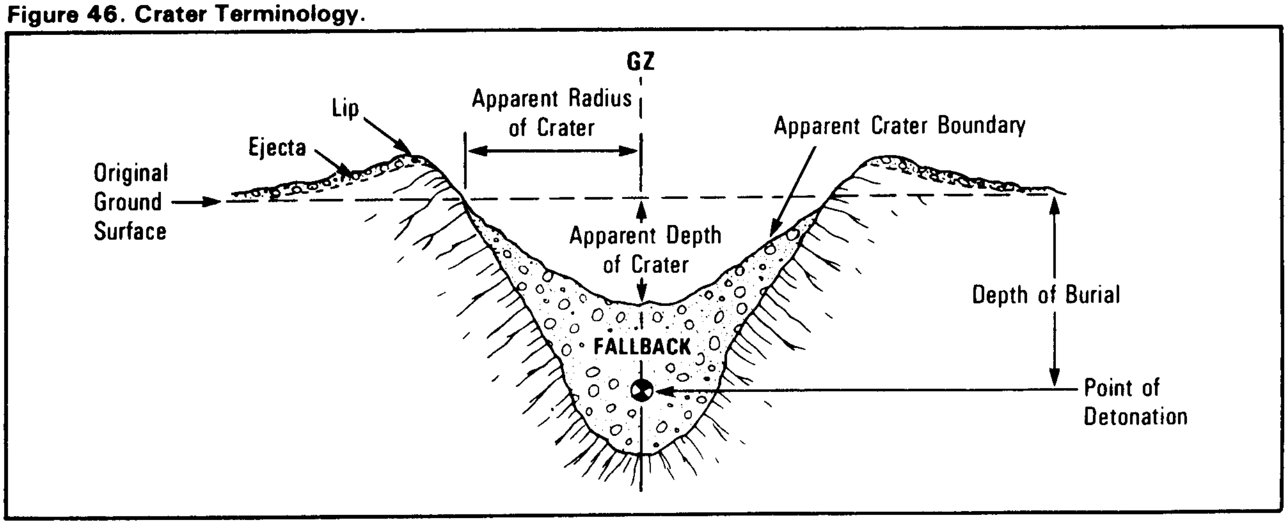


Figure 46. Crater Terminology.



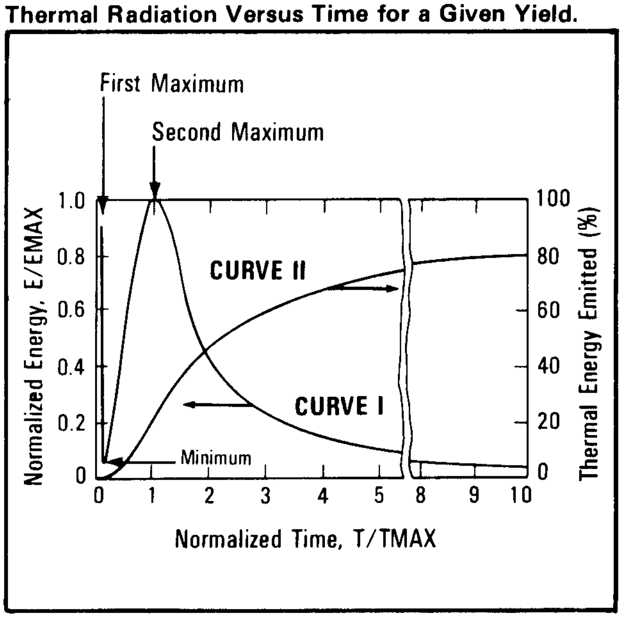
Thermal Radiation

A nuclear explosion releases an enormous quantity of energy in a very small space, creating an initial fireball temperature that ranges into millions of degrees. The temperature drops rapidly as the fireball expands and its energy is transmitted to the surrounding medium. Nuclear weapons detonated in the atmosphere emit thermal energy in two distinct pulses. Curve I of Figure 47 gives the relative intensity of thermal radiation as a function of time. Curve II gives the cumulative percentage of total thermal energy as a function of time.

The first pulse emits X-ray and ultraviolet radiations. They are not militarily significant for low airbursts because they attenuate rapidly in air and do not travel beyond distances where other effects predominate. The second pulse emits mostly visible light and infrared radiation. This energy, which extends to great distances, is responsible for most of the thermal damage of military significance.

For a given type of weapon, the total amount of thermal energy available is directly proportional to the yield. As depicted in Figure 47, approximately 20 percent of the total thermal energy is delivered by the time the second thermal pulse reaches its maximum intensity. The time at which the second maximum occurs for different yields is given in Figure 48. The second pulse lasts nominally ten times as long as it takes to reach its maximum intensity. Figure 48 shows that it would be very difficult to take evasive action to prevent skin burns or flash blindness from bursts of less than a megaton in yield.

Figure 47.
Thermal Radiation Versus Time for a Given Yield.



Characteristics

Within the atmosphere, the principal characteristics of thermal radiation are that it—

- Travels at the speed of light.
- Travels in straight lines.
- Can be scattered, reflected, and easily absorbed (attenuated).

Modifying Influences

WEATHER

Any condition that significantly affects the visibility or the transparency of the air affects the transmission of thermal radiation. Clouds, smoke, fog, snow, ice crystals, and rain absorb and scatter thermal energy. Depending on the concentration, they can attenuate as much as 90 percent of it. On the other hand, clouds above the burst may reflect additional thermal radiation onto the target that would have otherwise dissipated harmlessly.

TERRAIN

Large hills, trees, and any opaque object or material such as camouflage net or tent canvas may provide some line-of-sight protection to a target element. Trucks, buildings, or even another person may protect an individual from thermal radiation. Foxholes provide good protection. However, personnel so protected may still be injured by thermal reflections off buildings or other objects. Surfaces such as water, snow, or smooth sand may reflect heat onto the target and intensify the thermal radiation effect. Even the backs and sides of open foxholes will reflect thermal energy. The amount of reflections varies. For example, foxholes dug in wet black soil reflect 8 percent of the thermal

Figure 48. Time to Second Thermal Maximum as a Function of Weapon Yield.

Yield	Time to Second Maximum
1 KT	.04 second
10 KT	.11 second
50 KT	.23 second
100 KT	.31 second
500 KT	.64 second
1 MT	.87 second
10 MT	2.39 seconds
100 MT	6.58 seconds

radiation; those dug in snow reflect 93 percent. Because of atmospheric scattering and reflections, thermal casualties may be caused at a greater range than casualties from other effects.

HEIGHT OF BURST

The amount of thermal radiation that a surface target receives from a nuclear burst of a given yield will vary with the HOB. The maximum thermal effect at the target will usually be produced by an airburst. A surface burst produces about one-half the amount of the thermal radiation that an airburst produces because of the interaction of the fireball with the surface. No significant thermal radiation is received from a subsurface burst where the fireball is not visible.

Nuclear Radiation

Nuclear radiation is a flow of neutrons, alpha and beta particles, and electromagnetic energy in the form of X rays and gamma rays. The principal types are neutrons and gamma rays. As the neutrons travel through the air, they lose energy in collisions with air molecules. These collisions produce gamma rays called secondary gamma rays. Radioactive fission fragments, called fission products, are also produced in a nuclear explosion. The radioactive decay of these fission products starts immediately after the burst, producing alpha and beta particles, X rays, and more gamma rays.

Nuclear radiations are measured and expressed in a variety of units: the roentgen (R) for exposure, the centigray (cGy) or RAD for absorption, and the roentgen equivalent man (REM) for dose equivalency. For Army operations, the preferred measure of radiation is the cGy. Dosimeters and other radiac meters may be calibrated in roentgens or RADs, but for practical military use they should be read directly in cGy.

Nuclear radiation emitted in the first minute after the burst is initial radiation. The nuclear radiation emitted after is residual radiation.

Initial Radiation

The alpha and beta particles have an extremely limited range in air, have little ability to penetrate the skin, and are of little significance unless they come in direct contact with the skin or are inhaled or ingested. X rays are rapidly attenuated in air, and X-ray effects do not dominate in the lower regions of the atmosphere. On the other hand, neutrons and gamma rays have a long range in air and are highly penetrating. They are the main cause of casualties.

CHARACTERISTICS

The principal characteristics of initial nuclear radiation are that—

- It travels at or about the speed of light.
- A portion is absorbed and/or scattered by the atmosphere through which it passes.
- The atmosphere scatters it enough so that, at ranges of normal interest, some initial nuclear radiation comes from all directions.
- It can penetrate and cause damage to materiel and personnel.

The initial gamma rays received at a target consist primarily of the prompt gamma rays from the burst and the secondary gamma rays from the collisions of neutrons with air molecules. The prompt gamma radiation is received at the target essentially within the first second. Most neutrons from a burst are emitted during the first second, but because their rate of travel is slower and because the atmosphere scatters them, they and the secondary gammas they produce arrive at the target over times longer than a second.

MODIFYING INFLUENCES

For a given HOB, the gamma ray and neutron radiation received by a target at a given range from GZ depends primarily on the yield. In general, the larger the yield of the weapon, the larger the dose of initial radiation received at a given slant range. However, other factors affect these quantities.

AIR DENSITY. The denser air at sea level absorbs and scatters more radiation than does the thinner air at high altitudes. As the HOB or the temperature of the air increases, the air density decreases, and initial nuclear radiation travels farther.

TERRAIN. Terrain features of the target area may significantly influence initial nuclear radiation. Minor irregularities such as ditches, gullies, and small folds in the ground may offer a little protection. Major terrain features between personnel and the burst such as large hills and forests may provide significant protection, depending on the HOB and type of forest.

HEIGHT OF BURST. For surface and subsurface bursts, initial radiation is sharply attenuated by the surrounding ground.

TARGET ELEVATION. A target above the terrain receives more radiation than one on the surface. Personnel in aircraft 100 meters or more above the terrain, for example, may receive much larger doses than they would on the surface at the same distance from the burst.

SHIELDING AND ATTENUATION. One of the factors influencing the amount of radiation received by a target is the shielding that may be provided between the nuclear burst and the target. All material will absorb some nuclear radiation. However, because of the high penetrating power of neutrons and gamma rays, shielding material must be thick to provide significant protection to personnel.

Dense materials such as iron and lead offer excellent protection against gamma rays. Some readily available low-density materials such as water offer the best protection against neutrons. Depending on its moisture content, soil may be a good neutron shield. For example, one meter of soil will attenuate as much as 98 percent of the incident neutron radiation. Sufficient material to protect against gamma rays will also provide some protection against neutrons. As a general guideline, shields of minimum thickness that are intended to absorb both neutrons and gamma rays may be constructed by alternating layers of high- and low-density materials or by homogeneously mixing such materials.

People inside buildings, tanks, or foxholes will receive lower doses than they would in the open at the same distance from GZ. How much less depends on how much radiation is absorbed by the intervening material. The ratio of the dose inside to the dose outside is called the transmission factor.

$$\text{Transmission Factor} = \frac{\text{Dose Inside}}{\text{Dose Outside}}$$

Transmission factor tables in FMs 101-31-2 and 101-31-3 list the transmission factors for neutron, initial gamma ray, and residual radiation for different equipment and protection postures. These transmission factors are used to calculate the dose that may be received through the shielding material.

$$\text{Dose Inside} = \begin{matrix}\text{Transmission}\\ \text{Factor}\end{matrix} \times \text{Dose Outside}$$

The published transmission factors are guides for planning purposes. In actual operations, the transmission factors for residual radiation should be determined from inside and outside dose rates measured in the field.

Residual Radiation

In addition to initial nuclear radiation, a nuclear burst produces residual radiation that may be a lingering and possibly widespread radiation hazard of operational significance. It will be present in and near the radioactive cloud and, depending on weather and the HOB, may be present on the ground.

The hazard in the airspace just outside of the radioactive cloud exists for only a relatively short time, ,and the radiation hazard to aircraft flying within the area is minimal. The hazards on and near the ground are caused by—

- Neutron-induced radiation from radioactive materials produced within a relatively small circular pattern hundreds of meters in radius around GZ.
- Fallout, which is usually found in a large, elongated pattern around and outward from GZ.
- Base surge, which is a low lying, radioactive dust-laden cloud that moves rapidly outward from GZ after the detonation of a surface or shallow subsurface burst. Radioactive dust particles are deposited in a circular pattern about GZ as the base surge cloud stabilizes and settles to the ground.
- Rainout which consists of radioactive debris in the atmosphere brought down by precipitation. Rainout may be more concentrated than fallout, and it may or may not cover GZ.

The extent of the hazards resulting from radioactivity on the ground depends primarily on the HOB. When a nuclear weapon is detonated at a height that precludes damage or casualties to ground targets, such as in an air defense role, neither induced radiation nor fallout of tactical significance occurs. When a nuclear weapon produces damage or casualties on the ground, but the burst is above the minimum fallout-safe height, only neutron-induced radiation occurs. When a surface or near-surface burst is employed, neutron-induced radiation, base surge, and fallout result. The fallout pattern can be expected to overlap and overshadow the entire induced radiation and base surge patterns. Subsurface bursts produce induced radiation, base surge, and fallout in and around the crater. If the proper atmospheric conditions exist, rainout may occur for each of these HOB.

Neutron-induced radiation. fallout. base surge, and rainout have common characteristics. First, the residual radiation persists for relatively long periods. The affected areas are difficult to decontaminate. Second, the extent of the affected area is difficult to predict. Third, the size, shape, and location of contaminated areas depend on wind patterns and speed. The size and intensity of the radiation areas caused by the neutron-induced radiation and base surge depend heavily on soil composition and depth of burst. The size of the rainout area and the intensity of the radiation depend on the relative locations of the precipitation center and the debris cloud. They also depend on the time between the burst and the precipitation.

The most significant residual radiation from these areas is gamma radiation. It presents a serious personnel hazard because of its range and penetrating power, Residual gamma radiation is attenuated or scattered in the same manner as initial gamma radiation.

NEUTRON-INDUCED RADIATION

The boundary of the significant area of induced activity in the ground is the distance to which a dose rate of 2 cGy/hour extends 1 hour after the burst. For yields of 1 megaton or less, the maximum horizontal radius of this dose rate contour is about 2,000 meters. Usually it is limited to a relatively small area, less than 1 or 2 kilometers around GZ, depending on the yield and HOB. The residual radiation in and around craters created by surface and subsurface bursts can be estimated. Tactical plans can normally be made to ensure that these neutron-induced radiation sources do not disrupt military operations. See FM 3-12 for details about predicting induced soil radiation.

FALLOUT

SOURCES. The weapon debris from a nuclear burst—mainly remnants of fissioned atoms—is highly radioactive. Soil swept into the radioactive debris cloud from a near-surface, surface, or subsurface burst combines with the radioactive debris and creates a radioactive hazard when it falls to the ground.

Fallout will occur whenever the nuclear fireball touches the ground. The heavier fallout particles start reaching the area around GZ shortly after a burst. The lighter particles reach the ground farther downwind at later times. The greatest fallout intensity is usually close to GZ. However, winds, precipitation, or unusual terrain features may create high-intensity hot spots and low-intensity areas. Changes in wind direction can subject some locations to long periods of fallout.

DECAY RATE. The decay rate of radioactive materials from a single weapon can be determined with fair accuracy by using the ABC-M1A1 radiac calculator, which is a component of the M28A1 calculator set or by using newly developed automated aids. To make a quick estimate of fallout decay, analysts decrease the intensity by a factor of ten as the time after the burst increases by multiples of seven. For example, a dose rate of 50 cGy/hour at 1 hour after the burst decays to 5 cGy/hour in 7 hours and to about 0.50 cGy/hour in 49 hours. Boundaries for significant areas of newly deposited fallout are based on dose rates. For short-term (24-hour) occupancy of an area, the dose rate is 20 cGy/hour at 1 hour after the burst. For longer term occupancy, the dose rate is 10 cGy/hour at 1 hour after the burst. FM 3-12 and FM 3-22 contain specific details of fallout prediction, decay, and total dose calculations.

Craters caused by surface and shallow subsurface bursts will be contaminated by neutron-induced radiation and residual radioactive fission products. The activity in and around the crater can be estimated one hour after detonation, and the decay rate established as discussed above.

The large area contaminated by fallout from large surface bursts poses an operational problem of great importance. Fallout may extend to greater distances from GZ than any other nuclear weapon effect. It may influence the battlefield for a considerable time after a detonation.

RAINOUT

The probability of rainout occurring is generally much less than the probability of fallout occurring. However, even though bursts are not expected to produce residual contamination, rainout can contaminate the ground. Radiation levels from rainout may be higher than those from fallout because rainout can deposit more radioactive materials. Thus, rainout may also be militarily significant.

The information for predicting rainout reliably is not available. Such predictions are still too complex and uncertain. Radiological monitoring is the only effective way at present to assess this hazard.

BASE SURGE

When a subsurface burst occurs, a dust and debris cloud called the base surge is formed at the surface of the earth around the debris stem. This debris cloud rolls outward from the column for a period of many seconds. Radioactive dust and soil particles in the base surge cloud settle out and generally produce contamination in a circular pattern around GZ. The extent of contamination depends upon the depth of burst, soil type, and local wind conditions. The information for reliably predicting radiation levels within the base surge cloud does not exist; however, both the radiation and dust within the cloud are hazardous to personnel. Contamination from the base surge is not normally distinguished from main cloud fallout.

EMP, System-Generated EMP (SGEMP), and Transient Radiation Effects (TRE)

EMP, SGEMP, and TRE may damage equipment primarily by affecting electronic and electrical systems. Caused directly or indirectly by nuclear radiation, these effects do not last long; the results can be momentary or permanent.

ELECTROMAGNETIC PULSE

Prompt gamma rays, emitted radially from a weapon burst point, collide with air molecules and knock off (eject) electrons that travel in the same general direction as the gamma rays. This flow of electrons through the air is an electric current that creates intense local electric and magnetic fields. Additionally, this pulse of electric current in the air will radiate an electromagnetic wave as an antenna does. These local and radiated fields are the electromagnetic pulse. Both are extremely intense and last for only a small fraction of a second.

Detonations at HOBs ranging from very shallow subsurface bursts to high airbursts will produce both local and radiated EMP. For low-altitude bursts, significant local EMP fields may extend roughly from the burst point to radiation safety distances for personnel. The radiated fields will extend a few kilometers beyond these radiation safety distances, but the strength of the field will decrease with the distance from the burst.

Weapons that burst at altitudes from 2 to 25 kilometers, such as in an air defense role, will produce a local EMP in the surrounding air but will not radiate significant EMP to the ground. EMP from detonations at extremely high altitudes, tens or hundreds of kilometers, will travel long distances in the rarified atmosphere and will produce electric currents in the upper regions of the atmosphere. These currents create intense radiated fields that may cover areas of hundreds of thousands of square kilometers at the surface of the earth with significant levels of EMP

SYSTEM-GENERATED ELECTROMAGNETIC PULSE

The gamma rays and, in some instances, X rays from a nuclear burst may interact with materials in systems and produce electrons and electrical currents that generate an electromagnetic pulse in the system. For low-altitude bursts, SGEMP occurs in the source region at the same time as EMP. In some instances, intense electric fields may be generated when these electrons are emitted into system enclosures and cavities. This latter phenomenon is a special type of SGEMP—internal electromagnetic pulse (IEMP). Both of these phenomena may pose a significant threat to Army materiel such as missiles and equipment in ground-based communications shelters.

TRANSIENT RADIATION EFFECTS

At distances from a burst where personnel will survive initial radiation effects, neutron and gamma radiation can still damage materiel. The term *transient* indicates that the radiation is a pulse. The effects on material can be either temporary or permanent. Semiconductors and other electronic components are especially sensitive to TRE. When electronic equipment is damaged by a pulse of radiation, this damage is commonly referred to as transient radiation effects on electronics (TREE).

Nuclear Blackout

Radiation from a nuclear burst will produce large disturbances in the atmosphere. For bursts below 25 kilometers, the most disturbed region is the fireball and the surrounding volume. This volume may range in width from less than a kilometer to tens of kilometers. Shallow or very low-altitude bursts may generate large ionized dust clouds in addition to the fireball. When the path of radio transmission is through these burst-affected regions, radio waves may be disrupted or totally blacked out. High frequency (HF) to super high frequency (SHF) tactical radio systems may be affected. Detonations at high altitudes will primarily affect HF skywave and satellite transmissions.

Blackout depends on the HOB, the yield, and the frequency of the radio waves. Radio waves traveling through the nuclear fireball are refracted (bent), partially or totally absorbed, or scattered. Absorption and scattering attenuate the radio waves, thus reducing signal strength at the receiver. Under certain conditions, refraction can cause defocusing of a radio wave beam or even beam splitting. These phenomena also reduce the signal strength, particularly for HF radio using sky wave propagation.

Special Considerations

Extremely Cold Environments

Ice, snow, high winds, and low temperatures can alter nuclear weapon effects. Knowing exactly how is essential in making realistic operational decisions.

BLAST

At temperatures of about - 45°C (-50°F), air blast damage radii for materiel targets such as tanks, artillery, and military vehicles can increase by as much as 20 percent. This increase is partially offset by rough reflecting surfaces such as the thick ice and snow in an Arctic environment, which reduce the dynamic pressures. Extremely cold temperatures below -45°C combined with deep snow and icy surfaces should not increase the radius of expected damage more than 10 percent.

Cratering in ice and frozen soil is similar to cratering in solid rock; however, the crater size would probably be larger than that in rock. Several feet of snow over the soil will reduce crater dimensions.

Blast disturbance of the permafrost may reduce trafficability. Blast may interfere with movement over frozen waterways and, in the spring, cause a spring breakup. Blast may also cause avalanches in mountainous areas.

THERMAL RADIATION

Thermal effects are not normally considered in selecting the main cause of casualties. Yet, in extremely cold environments, a significant adjustment may be required in troop safety distances. For example; when surfaces are covered with snow and ice and atmospheric conditions are clear, the minimum safe distances for unwarned, exposed and warned, exposed personnel must be increased. Add 30 percent to the thermal radius of safety, and then add the weapon system buffer distance. See the troop safety tables in FM 101-31-2. Additional unwarned personnel will suffer flash blindness, particularly at night.

Heavy clothing in extremely cold environments may help protect personnel from thermal effects. In addition, the cold temperatures reduce thermal effects to most materials. Frost covering combustible materials reduces their susceptibility to thermal damage.

Hot Environments

Weapons effects do not vary much in hot and tropical environments as in extremely cold environments. However, personnel in hot environments will be more vulnerable to thermal effects since they will be wearing less clothing and have more skin exposed.

SECTION II. RESPONSES

Response to Blast

Air blast, cratering, and ground shock can damage materiel and injure personnel,

Air Blast

The blast effects from a nuclear weapon are significant damage mechanisms against materiel and personnel. Against some types of military targets, blast may be the only effective damage producer. The specific damage mechanisms and magnitude required for military damage vary, but sufficient experimental data exist for confidently predicting damage to generic classes of military vehicles. Personnel exposed to casualty producing levels of any of the air blast mechanisms become immediate casualties.

MATERIEL DAMAGE

Air blast may damage equipment by diffraction loading and drag loading. Diffraction loading refers to overpressure that crushes or tears off components. Drag loading refers to dynamic pressure that overturns, tumbles, or translates the equipment. Induced shock caused by these phenomena may damage internal components such as radios mounted in combat vehicles. Most military equipment is drag sensitive and, hence, damaged primarily by the dynamic pressures from the passing blast wave. However, sensitive internal equipment such as electronic devices can be damaged. and personnel on or in the equipment can be injured. Parked aircraft, structures, and forests are damaged by a combination of overpressures and dynamic pressures. Aircraft plexiglass windows are particularly vulnerable to overpressure. Pressure sensitive mines may be detonated by overpressures.

PERSONNEL INJURY

Very high overpressures (hundreds of PSI) are required to cause immediate deaths, provided no translational motion occurs. Lower overpressures (tens of PSI) may cause severe internal injuries, especially to lungs and abdominal organs. Eardrum rupture, which is painful but not necessarily disabling, may result from still lower overpressures (less than 10 PSI). Personnel in field fortifications such as shelters and foxholes can become casualties at lower incident overpressures than personnel in the open because the blast pressures can build up from multiple reflections inside such enclosures.

Personnel in the open can be injured by translation, that is, by being picked up and thrown by dynamic pressure. Personnel translated by blast winds may be injured by decelerative tumbling, in which they gradually lose the original momentum, or by impact with solid nonyielding surfaces. There is less certainty of impact with a solid, nonyielding surface. Thus, the decelerative tumbling scheme is used as the basis for developing translational casualty criteria.

Cratering and Ground Shock

Depending on terrain, cratering may be the primary mechanism for producing obstacles to movement. It may also be used to damage structural targets.

Crater ejects fall to earth over a significant area, causing injuries and damaging equipment and structures. For long periods of time after the detonation, residual radiation in and around the crater may be a significant hazard to personnel attempting to breach the obstacle. Ground shock can damage structural targets, but it is a primary damage mechanism only for underground targets.

Cratering and/or ground shock can destroy bridges and underground targets. Since repairing underground structures and utilities is usually difficult, moderate damage should be sufficient to satisfy tactical requirements.

Indirect Effects

The blast wave can turn debris, stones, and sand into missiles. The magnitude of casualties from such missiles is predictable only to low accuracies because the terrain and protection for personnel are so variable. However, to ascertain the possible hazards to friendly troops, analysts use the missiling risk criteria in the troop safety tables in FM 101-31-2. Sand and dust may limit visibility and movement in the target area for an extended period. They may also affect electromagnetic transmissions for a short time after detonation.

Buildings and fortifications that collapse also damage materiel and injure personnel. These casualties can be estimated from the damage done to the structures.

Rubble in built-up areas and trees blown down by air blast often extend far beyond the primary target area. The resulting obstacles with any associated effects such as intense firestorms and residual nuclear radiation may block avenues of approach or hinder the military mission. Cratering can prevent or impede military movements.

Response to Thermal Radiation

Essentially all of the thermal radiation absorbed by a target element is immediately converted to heat. It may cause injury or damage, and it may ignite combustible materials. Since significant amounts of thermal energy may be reflected from a target, the amount absorbed may be only a small fraction of the incident thermal energy.

Personnel

Personnel may be vulnerable to thermal radiation, which causes two general categories of injury: burns and blindness.

BURNS

Thermal burns produced directly by absorbing the thermal energy are flash burns. Those produced indirectly by fires that the thermal energy ignited are flame burns.

Personnel can be burned at great distances from the burst, but predicting enemy casualties from thermal effects is extremely difficult because soldiers can gain protection easily. Given this uncertainty, thermal radiation is not used in predicting casualties to enemy forces. It can be considered a bonus effect, and data have been furnished in the effects tables on radii of thermal effects.

Flash burns occur on bare skin or through clothing. Troop risk criteria developed for thermal radiation exposures are based upon thermal radiation being transmitted through battlefield uniforms in sufficient intensity to cause skin burns.

Flame burns occur from burning clothes or other nearby materials. In an area with numerous flammable objects, flame burns may be the dominant damage mechanism.

BLINDNESS

The flash of light produced by a nuclear explosion may be many times brighter than the sun. The temporary loss of vision from this bright flash is called flash blindness. It may occur even if the fireball is not indirect view. Retinal burns, which are permanent, may occur if sufficient direct thermal radiation is focused by the eye lens onto the retina. Eye damage can be produced farther from the burst than skin burns can be. Sufficient thermal energy arrives so. quickly that reflex actions to protect the eyes, such as blinking, give only limited protection, if any at all.

FLASH BLINDNESS. After viewing a nuclear detonation, an individual will continue to see the afterimage of the fireball. The afterimage will not affect the central vision unless the individual was looking at or near the fireball. The afterimage may last from several seconds to several minutes. Factors which affect how long the afterimage lasts are the amount of light which reaches the eye based on yield, atmospheric transmissivity, observer-detonation distance, pupil dilation, and the optical protection such as tinted visors or sunglasses.

Throughout the rest of the individual's field of vision, a very transient dazzling effect will occur for two or three seconds. It should not interfere significantly with vision.

Because pupils dilate at night, the effect of flash blindness will be prolonged by as much as three times. If the detonation is outside the individual's field of vision, no increase in the severity of flash blindness should occur at night however dark adaptation (night vision) may be lost for as long as 30 minutes. The loss of dark adaptation to pilots would severely impair the conduct of night aviation operations.

RETINAL BURNS. Retinal burns, which are painless, usually occur only if a person is looking in the direction of the fireball. The size of the blind spot produced by a retinal burn depends on several factors such as the distance from the burst and fireball diameter. However, the chance that individual's central field of vision will be affected by retinal burns is small and, therefore, of little military significance.

Environment

FOREST FIRES

Whether thermal radiation will start forest fires depends on fuels, tree canopy, seasonal and recent weather, wind, relative humidity, and topography.

Forest fuels are generally a mixture of dry and green. Dry fuels include surface litter, fallen branches, dead leaves, and dry grass. Green fuels include living branches, green grass, and other living foliage. Thermal radiation normally does not ignite green fuels. However, burning dry fuels can ignite the green fuels,

The tree canopy may smoke and char but ordinarily will not sustain ignition. The tree canopy can protect the dry fuel on the surface.

URBAN FIRES

In cities, direct thermal radiation can ignite such fuels as paper, trash, window curtains, dry grass or leaves, and dry, rotten wood. In addition, the blast wave can start fires by upsetting stoves, causing electrical short circuits, or breaking gas lines.

People trapped in the wreckage of burning buildings will become burn casualties. People in shelters may die of asphyxiation after surviving the other effects.

Response to Nuclear Radiation

All radiation is potentially harmful and should be avoided, if possible. Tactically, however, it may be necessary to accept some radiation exposure. Nevertheless, commanders should appreciate the significance of the exposure and weigh it carefully against any immediate or short-range advantage that may be gained.

Initial nuclear radiation may often affect personnel protected from blast and thermal radiation. The effects from comparatively small doses of nuclear radiation may be delayed, permitting some personnel to remain effective long enough to complete specific tasks. However, the delayed effects may significantly reduce the unit's overall combat effectiveness for a long period of time. Units may have to reorganize or reconstitute to maintain combat effectiveness after subsequent nuclear attacks or radiation exposures.

Troop safety from nuclear radiation is a major consideration. Adequate protective shielding is difficult to acquire. Both friendly personnel and the enemy will probably receive repeated doses of nuclear radiation. The amount and frequency of prior doses and the requirements of the tactical situation will determine the degree to which friendly troops can be exposed during a nuclear attack.

Terminology

The amounts of initial nuclear radiation and residual nuclear radiation received are added together, and the sum is called the total dose. The term *acute dose* describes any *total dose* received in one day. The extent of radiation injury for acute doses is reasonably independent of how the dose has been accumulated. When the period is continuous or when intermittent exposure is longer than one day, the term *chronic* applies.

Radiation sickness is acute when the symptoms occur early and do not last beyond six months; it is chronic when the symptoms persist beyond six months. Acute doses of nuclear radiation, if high enough, produce the response categories shown at right.

Primary Responses

INITIAL DOSE

For yields of about 50 kilotons or less, initial nuclear radiation is the dominant casualty producing effect. Individual response to nuclear radiation depends on several factors, including—

- The composition of nuclear radiation (gamma and neutron) to which an individual is exposed.
- The total dose accumulated, including previous radiation exposures.
- The periods over which the doses are received, that is the radiation dose rate.
- The recuperation time between exposures.
- The individual's physical condition, sex, and age.
- The presence of any additional injuries.

The time it takes for a previously unexposed individual in good health to become sick or die depends primarily on the total dose received, on the length of time over which the total dose was received, and on individual body tolerances. Some individuals are more resistant than others.

Experimental data indicate that the human body has a limited ability to repair radiation injury. However, since the recovery cannot yet be described quantitatively, all exposures are added together, and no allowance is made for recovery.

Figure 32 (page 51) is an aid in computing modified MSDs for personnel with previous radiation exposure. Accumulating data about personnel absorbed doses will be difficult. Previously fielded dosimeters were not capable of accurately measuring the initial radiation dose a soldier may receive. However, the IM-185 tactical dosimeter can measure prompt neutron and gamma exposures. See FM 3-12 for procedures for determining unit radiation doses.

Because individuals have different tolerances to whole body ionizing radiation, it is extremely difficult to predict the effect of a specified dose of radiation on any one individual. However, the average effect on a large group may be predicted with enough accuracy for military purposes. Figure 51, page 87, shows the expected typical responses of groups of individuals to radiation. The data in this table are based on the following assumptions:

- The individuals are healthy, rested, and well-fed.
- They have had no previous exposure.
- They have received uniform whole-body exposures.
- They have received an acute dose.
- They have received no other injuries.
- Equal doses of neutrons and gamma rays produce the same effect.

The predicted response ranges estimate how typical groups of soldiers will respond if exposed to ionizing radiation. The response ranges,

Responses To Acute Doses of Nuclear Radiation.

COMBAT-INEFFECTIVE	Combat-ineffective (CI) personnel function at 25 percent or less of their preirradiation performance level. Combat ineffectiveness is manifested by shock and coma at the high dose levels. At lower dose levels, combat ineffectiveness is manifested by a slowed rate of performance resulting from physical inability and/or mental disorientation.
PERFORMANCE-DEGRADED	Performance-degraded (PD) personnel, while not CI, function at between 25 and 75 percent of their preirradiation performance level. They suffer acute radiation sickness in varying degrees of severity and at different times. Radiation sickness is manifested by various combinations of projectile vomiting, propulsive diarrhea, hypotension, dry heaving, nausea, lethargy, depression, and mental disorientation.
IMMEDIATE-PERMANENT INEFFECTIVENESS	IP ineffectiveness is the physiological response from a dose of 8,000 cGy (RADs). Personnel become ineffective about 3 minutes after exposure and remain ineffective for any task until death, which usually occurs within 1 day.
IMMEDIATE-TRANSIENT INEFFECTIVENESS	IT ineffectiveness is the physiological response from a dose of 3,000 cGy (RADs). Personnel become ineffective for any task about 3 minutes after exposure and remain so for approximately 7 minutes. Personnel recover to greater than 75 percent of their preexposure performance levels after about 10 minutes and remain so for about 30 minutes. Then their performance degrades for around 5 hours for undemanding tasks or 2 hours for demanding tasks, when radiation sickness becomes so severe that they are ineffective. They remain ineffective until death, which usually occurs in 5 to 6 days.
LATENT LETHALITY	LL is the physiological response from a dose of 650 cGy (RADs). For physically undemanding tasks, performance degrades about 3 hours after exposure and remains so for approximately 2 days, when personnel will recover combat effectiveness for 6 days or so. Then they relapse into degraded performance and remain so until 4 weeks after exposure when radiation sickness becomes so severe that they are ineffective. They will remain ineffective until death approximately 6 weeks after exposure. For physically demanding tasks, personnel performance degrades about 2 hours after exposure and remains so for 3 weeks, when radiation sickness becomes severe enough to render the personnel ineffective. They remain ineffective until death approximately 6 weeks after exposure.

however, should not be interpreted as being exact and unchanging. Casualty criteria are ED50s (effective dose 50), the point at which 50 percent of the population will experience the specified effect at the specified time.

Figures 49 and 50 on page 86 show the expected response of personnel for various combinations of dose and time elapsed following exposure. Figure 49 is for physically *demanding* tasks such as loading weapon systems; Figure 50 is for physically *undemanding* tasks such as working in a fire direction center or commanding a vehicle.

To better understand the use of Figures 49 and 50; consider the example of the expected responses of a group of people whose jobs involve physical tasks and who receive 1,500 cGy(RADs) of radiation. The dashed line in

Figure 49 shows that typical group members will be temporarily effective until about 50 minutes after the exposure. This group will become performance-degraded until about 4 hours, after which people in the group will have declined sufficiently to be categorized as CI. The group will remain CI for about 2 days, after which typical group members will recover enough to be placed in the PD category. They will remain PD for approximately 2 days. At approximately 4-5 days after exposure, they will become CI and remain so until they die. Death can be expected about 12 days after exposure for the entire group. Similar information can be derived from Figure 50 for physically undemanding tasks.

Figure 49. Expected Response to Radiation for Physically Demanding Tasks.

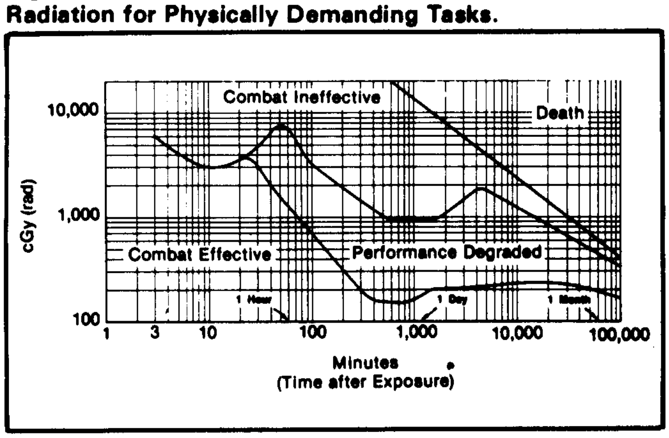
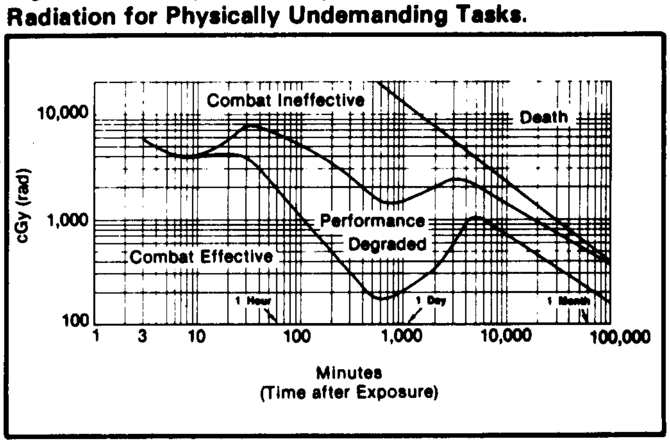


Figure 50. Expected Response to Radiation for Physically Undemanding Tasks.



REPEATED EXPOSURE

On a nuclear battlefield, units may be exposed several times to some levels of radiation from friendly as well as enemy nuclear weapons. In view of these multiple exposures and the slow overall recovery, commanders must consider the consequences of using personnel previously exposed to doses of radiation that may not have caused the symptoms of acute radiation sickness.

To assist commanders, operations officers maintain the radiation status of units assigned. Friendly units are placed in one of four radiation exposure states based on previous exposure history: RES 0 through RES 3.

Categories of Radiation Exposure

RES 0	A unit that has never been exposed to nuclear radiation, a unit which has received no dose.
RES 1	A unit that has received a dose greater than 0 but less than or equal to 70 cGy(RADs).
RES 2	A unit that has received a significant but not dangerous dose of radiation, a dose greater than 70 cGy(RADs) but less than or equal to 150 cGy(RADs). If the situation permits, units in this category should be exposed less frequently and to smaller doses than the units in RES 1 or RES 0 categories.
RES 3	A unit that has already received a dose of radiation greater than 150 cGy(RADs); consequently, further exposure is dangerous. This unit should be exposed only if unavoidable because additional exposure in the immediate future will result in sickness and the probability of some deaths.

Additional information on this subject may be found in FM 3-3.

RECOVERY AND LATE EFFECTS

Persons surviving exposures of 450 cGy(RADs) and below can be expected to regain their combat effectiveness in about 8 weeks after exposure.

Late effects of radiation injury, which can occur many months or years after the exposure, include leukemia, cataracts, and cancer. Late effects can develop in those who have recovered from the initial radiation injuries or even in those who have never been sick, despite repeated exposures.

Figure 51. Biological Effects of Nuclear Radiation. (STANAG 2083 Edition 5).

Dose Range* cGy (RADs)	Initial Symptoms	Performance (Mid-Range Dose)	Medical Care and Disposition
0 to 70	From 6 to 12 hours: none to slight incidence of transient headache and nausea; vomiting in up to 5 percent of personnel in upper part of dose range.	Combat-effective.	No medical care; return to duty.
70 to 150	From 2 to 20 hours: transient mild nausea and vomiting in 5 to 30 percent of personnel.	Combat-effective.	No medical care; return to duty; no deaths anticipated.
150 to 300	From 2 hours to 2 days: transient mild to moderate nausea and vomiting in 20 to 70 percent, mild to moderate fatigability and weakness in 25 to 60 percent of personnel.	DT: PD from 4 hours until recovery. UT: PD from 6 hours to 1 day, and 6 weeks until recovery.	At 3 to 5 weeks: medical care for 10 to 50 percent. At low end of range, less than 5 percent deaths; at high end, death may occur in up to 10 percent; survivors return to duty.
300 to 500	From 2 hours to 3 days: transient moderate nausea and vomiting in from 50 to 90 percent; moderate fatigability in 50 to 90 percent of personnel at high end of range.	DT: PD from 3 hours until death or recovery. UT: PD from 4 hours to 2 days and from 2 weeks until death or recovery.	At 2 to 5 weeks: medical care for 20 to 60 percent. At low end of range less than 10 percent deaths; at high end, death may occur for more than 50 percent; survivors return to duty.
500 to 800	Within 1st hour: moderate to severe nausea, vomiting , fatigability, and weakness in 80 to 100 percent of personnel.	DT: PD from 1 hour to 3 weeks; CI from 3 weeks until death. UT: PD from 2 hours to 2 days and from 7 days to 4 weeks; CI from 4 weeks until death.	At 10 days to 5 weeks: medical care for 50 to 100 percent. At low end of range, death may occur for more than 50 percent at 6 weeks; at high end, death may occur for 90 percent at 3 to 5 weeks.
800 to 3,000	Within the first 3 minutes: severe nausea, vomiting, fatigability, weakness, dizziness and disorientation; moderate to severe fluid imbalance and headache.	DT: PD from 45 minutes to 3 hours; CI from 3 hours until death. UT: PD from 1 to 7 hours; CI from 7 hours to 1 day; PD from 1 to 4 days; CI from 4 days until death.	Medical care from 3 minutes until death. 1000 cGy: 100 percent deaths at 2 to 3 weeks. 3000 cGy: 100 percent deaths at 5 to 10 days.
3,000 to 8,000	Within the first 3 minutes: severe nausea, vomiting, fatigability, weakness, dizziness, disorientation, fluid imbalance, headache and collapse.	DT: CI from 3 to 35 minutes; PD from 35 to 70 minutes; CI from 70 minutes until death. UT: CI from 3 to 20 minutes; PD from 20 to 80 minutes; CI from 80 minutes until death.	Medical care from 3 minutes until death. 4500 cGy: 100 percent deaths at 2 to 3 days.
Greater than 8,000	Within the first 3 minutes: severe and prolonged nausea, vomiting, fatigability, weakness, dizziness, disorientation, fluid imbalance, headache and collapse.	DT and UT: CI from 3 minutes until death.	Medical care needed immediately. 8000 cGy: 100 percent deaths at 1 day.

* Free-in-air

LEGEND:

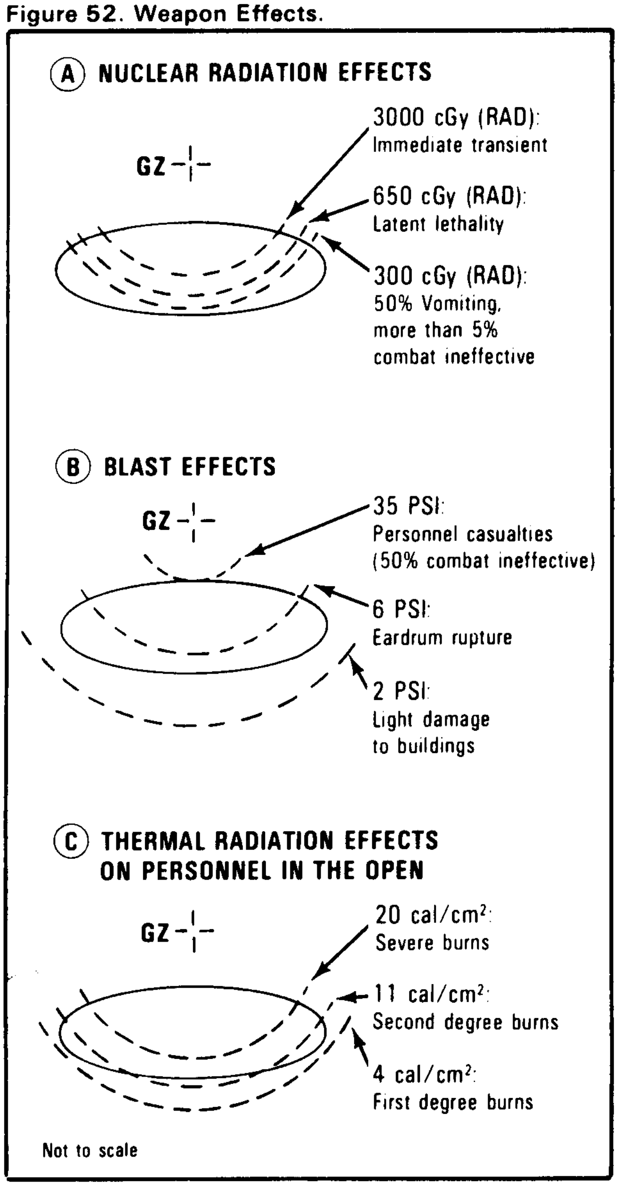
CI — combat-ineffective (less than 25 percent performance)
PD — performance-degraded (25 to 75 percent performance)
DT — demanding task
UT — undemanding task

Additional Responses

AREA TARGET DAMAGE

Understanding weapons effects and target response is necessary in assessing the full impact on the target when a particular fractional coverage is used as the defeat criterion. Weapons affect targets beyond the specified RD. Conversely, severer casualties and damage occur closer to GZ, For example, the stated defeat criterion for an attack on an enemy defensive position with a 750-meter radius may be 30-percent coverage with immediate transient ineffectiveness for personnel in foxholes (3,000 cGy). Figure 52 illustrates the relative distances to which the three basic weapons effects—nuclear radiation, blast, and thermal radiation—produced by a (5-kiloton weapon extend for

Figure 52. Weapon Effects.



Assuming that the criteria are met, Diagram A illustrates that immediate transient casualties from nuclear radiation (a dose of 3,000 cCy) occur over 30 percent of the target. It also shows that the latent lethality criterion (650 cGy) will occur over an additional 20 percent of the target and that soldiers will experience severe vomiting in half of the remaining 50 percent of the target.

The blast level for 50-percent incidence of combat ineffectiveness is not achieved (see Diagram B), However, the overpressure of 6 PSI may cause nonincapacitating blast injuries to personnel over approximately 60 percent of the target area. Light damage to buildings extends far beyond the target limits.

In reasonably clear weather, thermal radiation will cause second and third degree burns to personnel over about 80 percent of the target area and first degree burns over all of the area (see Diagram C). Hence, while a commander specifies that a particular percent of the target receive a certain degree of damage, significant portions of the remainder of the target will receive damaging effects.

EMP, SGEMP, AND TRE

EMP, SGEMP, and TRE may cause permanent damage or temporarily degrade electrical and electronic equipment by burning out or degrading components, introducing undesirable signals, or altering equipment configurations without damaging components. Solid state components and microcircuitry are likely to be more vulnerable to permanent damage than vacuum tubes in older equipment. Lower effect levels may disorder digital circuitry and cause memory loss. Optical and infrared components may also be susceptible to TRE.

The levels of EMP, SGEMP, and TRE which cause equipment damage depend on the type of equipment, its circuitry, its components such as antennas and connecting cables, and the deliberate measures taken to make the equipment more survivable. Damage may occur to some equipment beyond the radii of damage for nuclear radiation effects on personnel and for blast and thermal effects. The radii for specific equipment are unpredictable.

EMP, SGEMP, and TRE do not cause casualties directly. However, they can be significant for friendly unit vulnerability and damage preclusion considerations. Damage to command and control equipment may impair the continued military operations of survivors. See FM 101-31-2, Appendix C, for information pertaining to EMP damage and the established safety radii for some Army systems using electrical components.

BLACKOUT OF TACTICAL COMMUNICATIONS

Radio waves transmitted near or through a region of the atmosphere disturbed b y a nuclear fireball may be disrupted or blacked out totally (see Figure 53). In highly ionized regions caused by low-altitude bursts, blackout interference generally will decrease as frequency increases. Dust-laden clouds caused by near-surface bursts cause blackout effects lasting from a few seconds to several minutes at most and then only when a fireball or dust cloud blocks transmission paths. High-altitude bursts can ionize the atmosphere, causing widespread blackout of HF sky wave and synchronous satellite relay communications lasting from a few minutes to several hours.

The actual blackout interference on the tactical nuclear battlefield will depend on how many nuclear bursts occur in what period of time, at what altitudes, and over what areas. Blackouts from low-altitude bursts will probably not be very significant. Serious blackout problems from high-altitude bursts can be expected for synchronous satellite relays and sky wave propagation.

Blackout may be reduced by using—

- Wire communications systems. However, systems with wires, especially long wires, are more susceptible to EMP.
- Alternate routing through a manual relay or retransmission station to bypass the blackout region.
- An assigned alternate frequency. If it is suspected that interference is being produced by an ionized region, higher frequencies should be tried first. When it appears that dust is the problem, lower frequencies should be tried.

COMBINED NUCLEAR AND CHEMICAL EXPOSURE

Warsaw Pact countries will likely employ chemical weapons simultaneously or sequentially with nuclear weapons to take advantage of whatever operational or physiological interaction might occur. For example, in a chemical environment vomiting induced by ionized radiation will very probably force wearers to remove protective masks, thereby increasing vulnerability to chemicals. Further, damage to either the chemical protective overgarment or to skin by nuclear weapons effects will provide entries for chemical warfare agents to get at sensitive tissues.

Physiological synergism is not as easily defined but certainly exists. For instance, certain chemicals can influence the human body's response to ionizing radiation exposure, perhaps providing significant protection in some cases. No definitive studies have been done on how combined exposures might produce human responses different from those caused by separate exposures.

Figure 53. Blackout of Radio Communications.

BURST REGION	MODE OF PROPAGATION	FREQUENCY BANDS	BLACKOUT SOURCE	ESTIMATED DURATION OF BLACKOUT
Near-surface	Line of sight	VHF, UHF, SHF	Dust, fireball	Few seconds to few minutes
Near-surface	Satellite relay	UHF, SHF	Dust, fireball	Few seconds to tens of seconds
Low-altitude	Troposcatter	UHF, SHF	Dust, fireball	Few seconds to tens of seconds
Low-altitude	HF groundwave, skywave	HF, VHF	Fireball	Negligible to few seconds
Low-altitude	Satellite relay	UHF, SHF	Dust, fireball	Few seconds to tens of seconds
High-altitude	Troposcatter	UHF	Ionized region	Few seconds to minutes
High-altitude	HF skywave	HF	Ionized region	Minutes to many hours
High-altitude	Satellite relay	UHF, SHF	Ionized region	Few minutes to hours

APPENDIX B

ANALYSIS OF FRIENDLY VULNERABILITY

Large units, which might be targeted for multiple strikes, could suffer unacceptable casualties from even a single nuclear weapon. Units that are stationary for relatively long periods of time and rear-area units are especially vulnerable. All such units must take measures to reduce their vulnerability.

Passive Protection

Analyses of present and planned friendly dispositions must be continuous. Passive measures to reduce the effectiveness of enemy targeting include dispersing units, using individual protective measures, and avoiding visual and electromagnetic detection. However, these measures are not without penalties. For example, while dispersion can decrease the risk of destruction from nuclear attack, it can also complicate the control of units and reduce the efficiency of the support system. Frequently the requirements of the mission conflict with the need to disperse troop concentrations that are profitable targets. Commanders must resolve these conflicts by making a risk-benefit analysis for each specific situation.

Vulnerability Analysis

The primary tool for analyzing friendly dispositions is the radius of vulnerability (RV). RV is the radius of the circle within which friendly troops will be exposed to a risk equal to, or greater than, the emergency risk criterion (5-percent combat ineffectiveness) and/or within which materiel will be subjected to a 5-percent probability of the specified degree of damage. See Figure 54 for a hypothetical unclassified

Figure 54. Radii of Vulnerability.

CATEGORY	PERSONNEL (LL) IN— (Based on Governing Effect)					MODERATE DAMAGE TO—				SEVERE DAMAGE TO—		
						Wheeled Vehicles					Randomly Parked Helicopters	
Yield (KT)	Open	Open Foxholes	APCs	Tanks	Earth Shelter	Exp	Shld	Tanks	Towed Arty	Supply Depot	Cargo Trans	Light Obsn
0.1	700	600	600	500	300	200	150	100	100	100	400	500
0.5	900	800	800	700	450	300	250	200	200	200	500	800
1	1200	900	900	800	500	400	350	300	250	250	700	1100
2	1700	1000	1100	900	600	500	450	400	300	300	850	1300
3	2000	1100	1200	1000	700	600	500	500	400	450	1000	1600
5	2500	1200	1250	1100	800	700	600	600	500	500	1200	1900
10	3200	1300	1300	1250	900	800	700	700	600	600	1500	2500
15	3700	1400	1400	1300	950	900	800	800	700	700	1800	2800
20	4000	1500	1450	1400	1000	1000	900	900	800	800	1900	3400
30	5000	1600	1500	1500	1100	1200	1100	1000	900	950	2200	3700
40	5500	1700	1600	1600	1200	1400	1250	1100	1000	1200	2500	4100
50	6000	1800	1700	1700	1300	1700	1500	1200	1200	1400	2700	4500
100	8000	1900	1800	1800	1400	2200	1900	1300	1300	1700	3200	5700
200	12000	2000	1900	1900	1500	2500	2000	1500	1500	1900	3700	6200
300	14000	2100	1950	1950	1600	3000	2100	1600	1600	2000	3800	7100

NOTES:

1. Radii listed are distances at which a 5 percent incidence of effect occurs.
2. HOB used is $60W^{1/3}$ meters.
3. To obtain a radius of vulnerability, enter the YIELD column at the nearest listed yield.

(Distances are in meters)

version of the RV table in FM 101-31-2, Chapter 15. The GZ for the RV is always assumed to be the point where detonation will do the greatest damage to the friendly unit or installation. Delivery errors are not considered.

Analyzing the vulnerability of friendly dispositions and installations consists of—

- Determining the appropriate threat yields based on current intelligence.
- Determining the disposition of personnel in friendly units.
- Obtaining the appropriate vulnerability radii from the RV table.
- Estimating the fractional coverage of the unit using the visual techniques discussed in Chapter 4. Analysts select the GZ that results in the highest fractional coverage of the target. Then they determine if casualties or materiel damage is greater or less than an acceptable level.
- Recommending ways to decrease vulnerability or increase protection if the estimated damage exceeds the acceptable loss criteria established by the commander.

Poststrike Hasty Estimation

Analysts may also use these RV tables to make a quick assessment of the damage from an enemy strike before communications are reestablished or a reconnaissance can be conducted. By using actual GZ, estimated yield, and known troop locations, analysts determine the RV. Units outside the RV may be assumed combat effective; those inside the RV must be individually evaluated for combat effectiveness.

APPENDIX C

COVERAGE CALCULATIONS

Conventional fires cover targets with many rounds, the inherent dispersion of which distributes the effects over the target area. Nuclear fires generally use only a single weapon on a target, requiring analysts to estimate coverage to make the best use of the nuclear weapons available. Given the inherent dispersion of any delivery system and the variability of target response to nuclear weapon effects, estimation methods must be based on probabilities. Because calculating such coverage data is too time-consuming and complicated for target analysts to do in the field, it appears in the precomputed coverage tables in FM 101-31-2. The information below shows how the coverage tables are derived.

Radii of Damage

The coverage tables provide two damage radii: the expected and the probable minimum. They are based on variations caused by vertical dispersion of the delivery system. For exposed personnel, the nuclear effects criteria were translational motion to prone personnel and the radiation appropriate to the table (IP, IT, LL). For protected personnel, overpressure and radiation, as modified by transmission factors, were used. For material targets such as tanks and towed artillery, moderate damage was used.

Depending on the target category and vertical dispersion of the delivery system, the RD may vary over wide limits. Target analysts in the field cannot consider these variations in the RD. For most cases, target analysts should use the expected RD; for more exacting requirements, they can use the probable minimum RD. The probable minimum RDs in the tables should generally be met or exceeded by 90 percent of all successful rounds.

See Example 27 for calculating a probable minimum RD. There is a 90-percent assurance (50 percent above and 40 percent below) that a successful round will give at least this RD. Other probable minimum radii are determined in a similar fashion, depending upon the exact shape of the damage curve within the vertical dispersion pattern for the HOB of interest. Expected radii of damage are calculated using HOB versus RD curves except that the products of RDs times their probability of occurring are summed over the HOB continuum to obtain the expected values. See Figure 56 for a representation of RDs and their probability of occurring. The expected RD and probable minimum RD form the basis of the coverage indexes.

Assured Coverage

The refined method of addressing both vertical and horizontal dispersion is presented, not for field use, but to improve understanding of how vertical dispersion affects target coverage.

The curve in Figure 56 shows the relationship between the damage radius and HOB for moderate damage to wheeled military vehicles by a 20-kiloton weapon. A vertical dispersion

Example 27.

Problem

Find the probable minimum RD

Given

Delivery system: free-flight rocket

Yield: 20 kt

Range: 10,000 meters

Target: exposed personnel IP

HOB: low air

PEH: 50 meters

Solution

The optimum HOB for blast is $53(20)^{1/3} = 143$ meters; the F-SHOB is $30(22) + 3.5(50) = 259$ meters. Use the F-SHOB of 259 meters.

Figure 55 shows the relationship between the damage radius and HOB for IP casualties exposed to a 20-kiloton weapon. The vertical dispersion pattern, superimposed on this curve, shows the desired HOB. Fifty percent of all rounds burst high. They give an RD of about 1,150 meters. Vertical dispersion on the high side need not be considered in this case. An additional 40 percent of all rounds burst within 1.9 PEH below the DHOB, giving a probable minimum RD of 1,125 meters.

Figure 55. Vertical Dispersion Pattern.

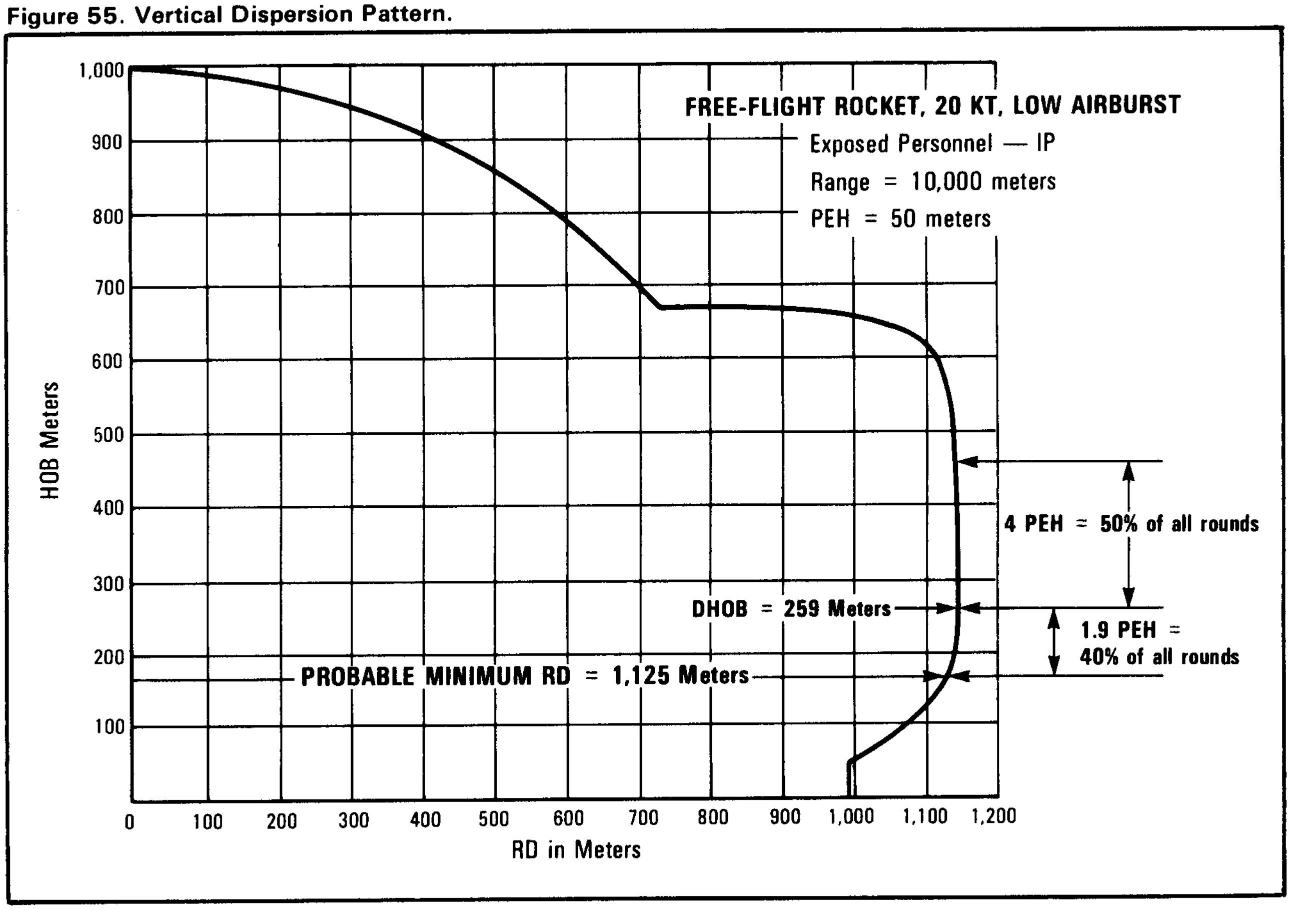
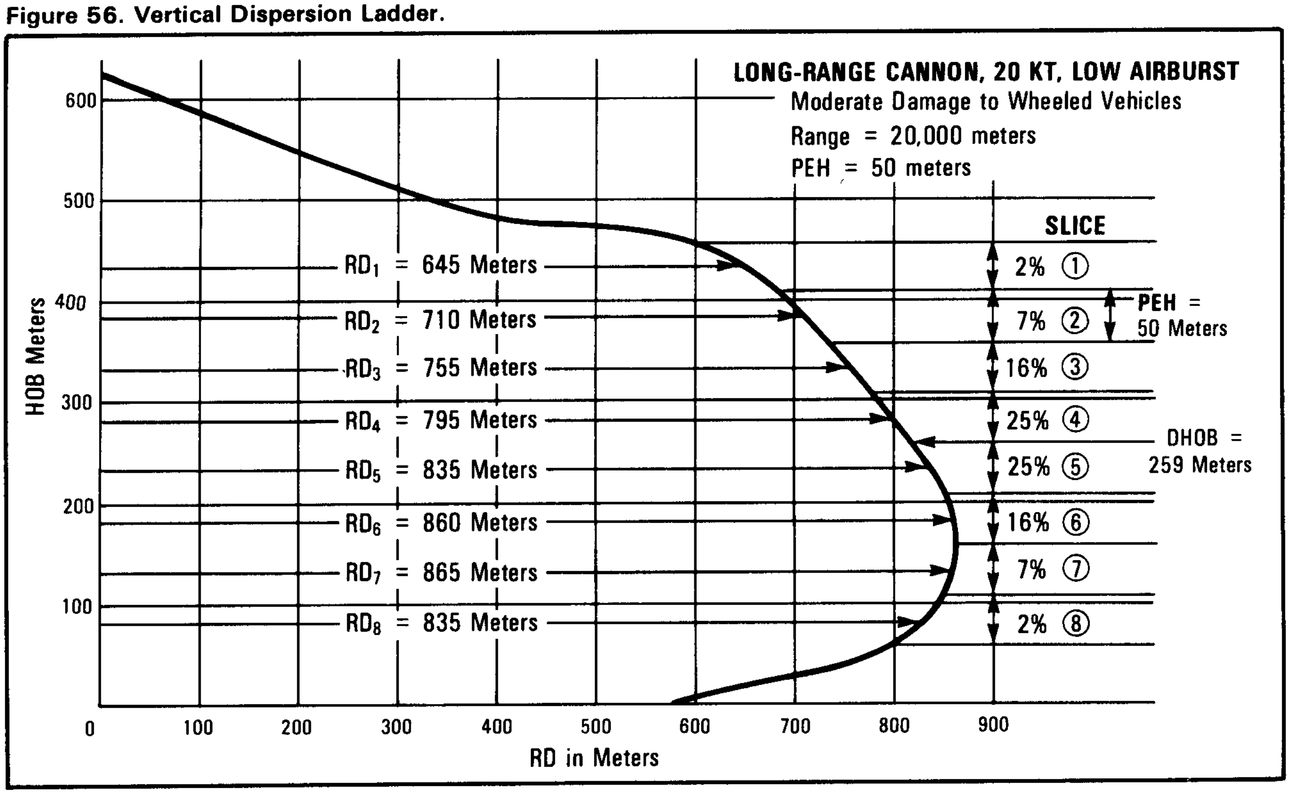


Figure 56. Vertical Dispersion Ladder.



ladder for the weapon system, superimposed on the curve, shows the desired HOB of 259 meters. The dispersion ladder divides the possible HOB zone into eight slices and gives the probability of burst for each. The slices are numbered from 1 to 8 for convenient reference. An average RD at the midpoint of each slice is estimated. The RD appears along with the probability that a burst will occur within the vertical zone of the slice. Smaller slices would provide greater precision.

If the vertical error of the delivery system causes the burst to occur within the sixth slice, the weapon will have an average RD of 860 meters against this type target. With this RD, a CEP of 138, and a target radius of 1,000 meters, the probability of at least 50-percent target coverage P(50) can be found by using a complex mathematical process (computer program). This process numerically integrates damage probability over the target area based on the definition of an RD and its variability (20 percent), and delivery system inaccuracies (CEP, CD90).

The program which uses normalized/dimensionless parameters, has led to the data graphically presented on the area target nomographs (see pages 69 through 70). In this case, P(50) = .99+.

In this target analysis, horizontal and vertical errors can be assumed to be independent. Thus, one can be held fixed while the effect of the other is considered. If a burst occurs in the sixth slice, there is a 99-percent probability that it will give a coverage of at least 50 percent. This probability considers only the variations from horizontal error since the vertical error has been limited to a certain zone. Vertical error probabilities, P, are calculated. Figure 57 indicates a 16-percent probability that the burst will be in the sixth slice regardless of horizontal error.

The product of these two probabilities considers both horizontal and vertical errors. This product is the contribution of bursts within the sixth slice to the total probability of desired coverage. The contribution of each slice to the total probability is found in the same way, and the results are added to find the answer to the problem. The computations are summarized in Figure 57.

There is a 90-percent probability of achieving at least a 50-percent fractional coverage. Actually, more damage to the target may occur, but there is little likelihood of getting much less than 50 percent. This method of computation can provide the probability for any selected coverage. The solution will be the probability of achieving at least the selected coverage.

Figure 57. Total Probability Data.

Slice	RD	RD/RT	CEP/RT	P(50)	P	P(50) × P
1	645	.645	.138	.0	.02	.0
2	710	.710	.138	.0	.07	.0
3	755	.755	.138	.94	.16	.15
4	795	.795	.138	.99+	.25	.25
5	835	.835	.138	.99+	.25	.25
6	860	.860	.138	.99+	.16	.16
7	865	.865	.138	.99+	.07	.07
8	835	.835	.138	.99+	.02	.02

Total = Σ P × P(50) = .90 = .90(50)

Computing the fractional coverage associated with a 90-percent probability is less direct. For example, assume that the solution to the previous example had been P(f) = 80(50). This value fixes one point on the P(f) curve. Another could be found by solving for P(40). For this problem, assume that P(40) = 95(40). Then 90(f) lies between these two points and is approximately .044. Because of the numerous simplifying assumptions required to permit this calculation, an accuracy to one significant figure is sufficient in determining target coverage. Thus, 90(f) = .4 is the correct answer. The answer is no better than the least accurate information which led to its determination.

The examples discussed here use eight horizontal slices to illustrate the procedures for computing the probable minimum target coverage. To increase the accuracy of the computations for the indexes, 20 slices are used.

Expected Coverage

The expected coverage is that which one could expect from many weapons firing under the same conditions. It is obtained by weighing each possible result according to the relative frequency (probability) of its occurrence.

Calculating the average coverage is like computing the probable minimum coverage. In the previous example, no rounds fired under these conditions will give higher than .86

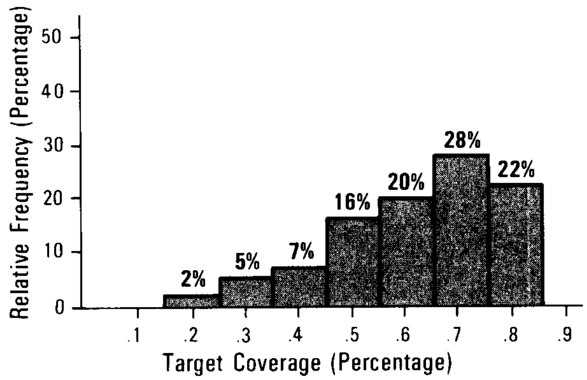
coverage of the target; however, 22 percent will give higher than .75 coverage. Thus, 22 percent will give between .75 and 0.86 target coverage. In the same way, 50 percent will give better than .65 coverage. Therefore, 28 percent will give between .65 and .75 coverage: 50% - 22% = 28%.

These relative frequencies plotted against the corresponding target coverages appear in Figure 58. The average coverage is the sum of the products of each possible coverage times the probability of its occurrence. In this case, all coverages within a frequency block in Figure 58 are assumed to be concentrated at the midpoint of the block.

Thus, to one significant figure, f = .6. This is the average coverage corresponding to the RD, RT, and CEP used. Vertical dispersion is not considered in this example. Including the effect of vertical dispersion would require a similar set of computations for each of several HOB slices. They would use the RD corresponding to each HOB slice to obtain the coverage for that slice. The coverage for each slice is then multiplied by the probability of the burst occuring in that slice, and these products are added together. The total sum is the coverage for a particular target size, CEP, and HOB.

Figures 57 and 58 give an indication of the possible variations of target coverage caused by delivery errors. Preparing such a figure is too time-consuming in the field. As an indication of the effectiveness, the expected coverages have been precomputed and listed in the coverage index tables.

Figure 58. Weighted Coverage.



WEIGHTED AVERAGE

.2 × 2/100	= .004
.3 × 5/100	= .015
.4 × 7/100	= .028
.5 × 16/100	= .080
.6 × 20/200	= .120
.7 × 28/100	= .196
.8 × 22/100	= .176
Total	= .619

The coverage indexes are two-part numbers, one-part if assured and expected are equal. These numbers predict the fractions of damage to accurately located circular area targets having uniformly distributed elements with random orientation when the aimpoint, or DGZ, is the target center. The first decimal gives the minimum fraction of damage that will occur for high-assurance coverage. The second decimal gives the expected fractional damage. If the values are the same when rounded to one decimal, then only one number is printed.

Some of the data tabulated in FM 101-31-2 or presented here are to the nearest meter. Analysts should not attach a false sense of exactness to these numbers, either as to their reliability or to the need for precise calculation. In many of the field calculations performed with these data, analysts may round off the final result to the nearest 10 to 50 meters with little or no operational impact.

GLOSSARY

Acronyms and Abbreviations

AADCP	Army air defense command post
acft	aircraft
ADA	air defense artillery
ADM	atomic demolition munitions
ADML	atomic demolition munitions location
AFB	Air Force base
AFM	Air Force manual
AFP	Air Force publication
ALO	Air Force liaison officer
alt	alternate
APC	armored personnel carrier
apt	apartment
ASI	additional skill identifier
aslt	assault
ASOC	air support operations center
ATR 4	Air Transport of Radiation Version 4
auth	authenticate
B	blast
BCE	battlefield coordination element
BD	buffer distance
bldg	building
(C)	confidential
C	Celsius
cal	calorie
CD90	circular distribution 90
CDD	collateral damage distance
CEOI	communications-electronics operation instructions
CEP	circular error probable
CEPA	adjusted CEP
cgo	cargo
cGy	centigray (SI unit for RAD)
CI	combat-ineffective
cm	centimeter
CMO	civil-military operation
con	control
conif	coniferous
coord	coordinates
cov	coverage
CP	command post
CRC	control and reporting center
D	displacement
DA	Department of the Army
D(AGZ)	distance to actual ground zero
dam	damage
decid	deciduous
del	delivery
DGZ	desired ground zero
DHOB	desired height of burst
DMAX	maximum displacement
DNA	Defense Nuclear Agency
DT	demanding task
ED50	effective dose 50
EM	effects manual
emer	emergency
EMP	electromagnetic pulse
equip	equipment
ER	enhanced radiation
exp	exposed

expt	expected
f	expected fractional coverage
f̄	average expected fractional coverage
f90	high assurance fractional coverage
F	Fahrenheit
FEBA	forward edge of the battle area
FFR	free flight rocket
fltg	floating
FM	field manual
FMFM	fleet marine force manual
FSE	fire support element
F-SHOB	fallout-safe HOB
G2	intelligence officer
G3	operations officer
G5	civil affairs officer
GEP	group employment plan
GM	guided missile
GZ	ground zero
H	vertical distance
hel	helicopter
HF	high frequency
HOB	height of burst
IEMP	internal EMP
indust	industrial
IP	immediate-permanent
IPB	intelligence preparation of the battlefield
IR	information requirement
IT	immediate-transient
JCSP	Joint Strategic Capabilities Plan
k	multiplication factor
kPa	kiloPascal
kt	kiloton
LA	low airburst
LFM	landing force manual
LL	latent lethality
loco	locomotive
LSD	least separation distance
lt	light
m	meter
min	minimum
mod	moderate
MOPP	mission-oriented protection posture
MOS	military occupational specialty
MPF	multiplying factor
MRC	medium-range cannon
MSD	minimum safe distance
mt	megaton
NAI	named area of interest
NATO	North Atlantic Treaty Organization
NBC	nuclear, biological, chemical
neg	negligible
NIGA	neutron-induced gamma activity
no	number
NR	nuclear radiation
NWP	naval warfare publication
obsn	observation
OPTHOB	optimum HOB
OPSEC	operations security

P	probability
PD	performance-degraded
PE	probable error
PED	probable error in deflection
PEH	probable error in height of burst
PER	probable error in range
PI	performance-ineffective
PIR	priority intelligence requirement
PNL	prescribed nuclear load
POL	petroleum, oils, and lubricants
PRCC	personnel risk and casualty criteria
prob	probability
PSI	pounds per square inch
Q	probability of not producing a casualty
R	roentgen
RAD	radiation absorbed dose
RADCAS	radiation casualty
RCD	radius of collateral damage
RD	radius of damage
REM	roentgen equivalent man
rqd	required
RES	radiation exposure state
RS	radius of safety
RT	radius of target
rvttd	revetted
(S)	secret
SGEMP	system-generated EMP
SHF	super high frequency
shld	shielded
SOC	sector operations center
SP	self-propelled
(S-RD)	secret--restricted data
STRIKWARN	nuclear strike warning
sys	system
T	duration
TACC	tactical air control center
TAI	target area of interest
TD	table of distribution
tgt	target
TLE	target location error
TNT	trinitrotoluene (dynamite)
TOC	tactical operations center
TOE	table of organization and equipment
TR	thermal radiation
trans	transportation
tvlg	traveling
TRE	transient radiation effects
TREE	TRE on electronics
(U)	unclassified
US	United States
UT	undemanding task
util	utility
UWE	unwarned, exposed
v	variability
ve h	vehicle
VN	vulnerability numbering
VA	Virginia
w	yield
WE	warned, exposed
whd	warhead
WP	warned, protected

Definitions

alpha particle — a particle emitted from the nuclei of some radioactive elements; a helium nucleus with an atomic weight of four and an electric charge of plus two.

beta particle — a particle ejected spontaneously from a nucleus of either naturally or artificial y radioactive elements; an electron with an atomic weight of 1/1,840 and an electric charge of negative one.

circular distribution 90 (CD90) — the radius of a circle around the mean point of impact within which a single round has a 90-percent probability of impacting or within which 90 percent of the rounds fired will impact.

circular error probable (CEP) — an indicator of the delivery accuracy of a weapon system, used as a factor in determining probable damage to a target. It is the radius of a circle within which half of a missile's projectiles are expected to fall.

collateral damage — for the Army and Marine Corps, undesirable civilian personnel injuries or materiel damage produced by the effects of friendly nuclear weapons; for the Air Force, damage to installations that are not targets in the option being executed or damage that is not the objective of the DGZ from which the damage is being evaluated.

collateral damage distance (CDD) — the minimum distance in meters that a DGZ must be separated from civilian personnel and materiel to ensure with a stated degree of assurance that a specific incidence of injuries or property damage will not be exceeded.

desired ground zero (DGZ) — the point on the surface of the earth at, or vertically below or above, the center of a planned nuclear detonation.

flash blindness (dazzle) – temporary impairment of vision resulting from an intense flash of light. It includes loss of night adaptation and dazzle, and it may be associated with retinal burns.

gamma rays — high energy electromagnetic radiation emitted from atomic nuclei during a nuclear reaction. Gamma rays and very high energy X rays differ only in origin. X rays do not originate from atomic nuclei but are produced in other ways.

governing effect — the nuclear effect which extends the farthest from GZ.

gray — for any ionizing radiation imparted to any matter, a measure equal to the radiation that deposits 1 joule per kilogram: 1 gray equals 100 RADs, 1 cGy (centigray) equals 1 RAD.

height of burst (HOB) — the vertical distance from the earth's surface or target to the point of burst.

high airburst — an HOB used in special cases for maximum blast coverage to soft targets such as light frame buildings and exposed personnel and for reducing the intensity of induced radiation in the vicinity of GZ. However, a high airburst also reduces the effective RD to most tactical land warfare target elements and thus receives little attention in this series of manuals.

impact (contact surface) burst — a burst used to cause blast, ground shock, and cratering. It may be used against hard underground targets located relatively near the surface. Fallout is produced.

induced radiation — radiation produced as a result of exposure to radioactive materials, particularly the capture of neutrons.

initial nuclear radiation — all the radiation that occurs within the first minute after a nuclear detonation.

least separation distance (LSD) – the minimum distance in meters that a DGZ must be separated from an object to preclude damage or preclude obstacles with 90-percent assurance.

low airburst — an HOB option providing the most effective coverage for ground targets of materiel or personnel while still giving a very high assurance (99 percent or more) of precluding militarily significant fallout. The low-air HOBs tabulated in FM 101-31-2 are the larger of possibilities 1 and 3 or 2 and 3 below, depending on whether the target is blast or radiation sensitive and whether the governing effect is blast or radiation.

1. For blast effects the optimum is $53\,W^{1/3}$ meters, where W = yield in kilotons.
2. For radiation effects the optimum HOB is extracted from curves, based on weapon design, that plot HOB against radius of effects.
3. The HOB that has a 99-percent assurance of not producing fallout (HOB99) depends on yield. When $W \leq 100$ kilotons, HOB99 = $30(W)^{1/3}$ + 3.5 PEH meters. When W is >100 kilotons, HOB99 = $55(W)^{1/3}$ + 3.5 PEH meters.

minimum safe distance (MSD) — the sum of the RS and BD.

mission-oriented protection posture (MOPP) – a flexible system of chemical protection for operations in a toxic chemical environment. This posture requires personnel to wear individual protective clothing and equipment consistent with the chemical threat, the work rate imposed by their mission, the temperature, and the humidity without unacceptably degrading their efficiency from the effects of heat stress, psychological stress, and other factors affecting the senses,

near-surface burst — a burst occurring in the atmosphere but low enough so that the fireball contacts the surface. It will cause fallout.

nuclear weapons package — a discrete grouping of nuclear weapons by specific yields planned for employment in a specified area during a short time period.

preinitiation — the initiation of the fission chain reaction in the active material of nuclear weapon at any time earlier than that at which either the designed or the maximum compression or degree of assembly is attained.

prescribed nuclear load (PNL) — a specified quantity of nuclear weapons to be carried by a delivery unit. The establishment and replenishment of this load after each expenditure is a command decision and is dependent upon the tactical situation, the nuclear logistic situation, and the capability of the unit to transport and utilize the load. It may vary from day to day and among similar delivery units.

probable error in height (PEH) bracket — the distance above and below the desired HOB within which there is a 50-percent probability that a weapon will detonate.

radius of damage (RD) — the distance from ground zero at which there is a 50-percent probability of achieving the desired damage.

residual radiation — nuclear radiation caused by fallout, radioactive material dispersed artificially, or irradiation that results from a nuclear explosion and persists longer than 1 minute after burst.

subsurface burst — a burst generally used to damage underground targets and structures and to make craters as barriers and obstacles. Shallow subsurface bursts may produce a significant amount of fallout.

target analyst — the nuclear and chemical target analyst qualified for duty in a unit with a TOE/TD position requiring knowledge of the techniques and procedures for nuclear and chemical target analysis. On completion of required training, the analyst is awarded an ASI of 5H added to the current MOS. See AR 611-101 for initial and refresher requirements.

variability (V) — the manner in which the probability of damage to a specific target decreases with the distance from GZ; or, in damage assessment, a mathematical factor introduced to average the effects of orientation, minor shielding, and uncertainty of target response to the effects considered.

Symbols

σ standard deviation

Σ summation

REFERENCES

These references are sources of additional information.
They are not required in order to understand this publication.

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FM 3-4. NBC Protection.

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FM 9-84. Nuclear Special Ammunition Direct and General Support. Unit Operations.

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