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PREFACE

1. Scope

Joint Pub 3-12.2 provides doctrinal procedures and effects data for the employment of nuclear weapons. It provides guidance to those who plan, coordinate, support, and execute nuclear missions. It covers the classified operational characteristics of nuclear weapons delivery systems and nuclear weapons in the US stockpile: the classified effects data necessary for target analysis: and the tabular information concerning target response, personnel safety, collateral damage, and preclusion of damage. Systems included are: B61 Bomb (Mods 3, 4, 7, and 10), TLAM(N), ALCM, ACM, B83 Bomb (Mods 0 and 1), Minuteman III (MK-12 and MK-12A), Trident I C4, Trident II D5, and Peacekeeper (MK-21).

2. Purpose

This publication has been prepared under the direction of the Chairman of the Joint Chiefs of Staff. It sets forth doctrine and selected joint tactics, techniques, and procedures (JTTP) to govern the joint activities and performance of the Armed Forces of the United States in joint operations as well as the doctrinal basis for US military involvement in multinational and interagency operations. It provides military guidance for the exercise of authority by combatant commanders and other joint force commanders and prescribes doctrine and selected tactics, techniques, and procedures for joint operations and training. It provides military guidance for use by the Armed Forces in preparing their appropriate plans. It is not the intent of this publication to restrict the authority of the joint force commander (JFC) from organizing the force and executing the mission in a manner the JFC deems most appropriate to ensure unity of effort in the accomplishment of the overall mission.

3. Application

a. Doctrine and selected tactics, techniques, and procedures and guidance established in this publication apply to the commanders of combatant commands, subunified commands, joint task forces, and subordinate components of these commands. These principles and guidance also may apply when significant forces of one Service are attached to forces of another Service or when significant forces of one Service support forces of another Service.

b. The guidance in this publication is authoritative: as such, this doctrine (or JTTP) will be followed except when, in the judgment of the commander, exceptional circumstances dictate otherwise. If conflicts arise between the contents of this publication and the contents of Service publications, this publication will take precedence for the activities of joint forces unless the Chairman of the Joint Chiefs of Staff, normally in coordination with the other members of the Joint Chiefs of Staff, has provided more current and specific guidance. Commanders of forces operating as part of a multinational (alliance or coalition) military command should follow multinational doctrine and procedures

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ratified by the United States. For doctrine and procedures not ratified by the United States, commanders should evaluate and follow the multinational command's doctrine and procedures, where applicable.

For the Chairman of the Joint Chiefs of Staff:

WALTER KROSS
Lieutenant General, USAF
Director, Joint Staff

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- **Presents the Methods for Damage and Restriction Calculations**
- **Lists the Necessary Targeting Graphs and Tables**
- **Provides Simplified Reference Targeting Data**
- **Provides Detailed Targeting Data for all US Nuclear Weapons**

General

Joint Pub 3-12.2 provides classified nuclear weapon effects data and related information.

The information provided in Joint Pub 3-12.2 allows for **detailed planning and execution of operational nuclear missions**. Planners should also use it in exercises and training unless in an unsecure environment, in which case they should use the unclassified version, Joint Pub 3-12.3. Either publication is a "stand-alone" document.

Because of the destructive power associated with a single nuclear detonation, **nuclear target analysis and vulnerability assessment require carefully delineated procedures** based on the best effects data available. Joint Pub 3-12.2 provides such procedures.

Terms

Analysts must be familiar with nuclear targeting terms and criteria.

Structural damage categories include light, moderate, and severe. **Materiel damage categories** include moderate (type II) and severe. **Personnel casualty criteria** range from latent ineffectiveness (LI), to immediate transient ineffectiveness (ITI), to immediate permanent ineffectiveness (IPI). Depending on the commander's guidance, analysts might use LI when targeted personnel cannot influence the battle outcome in the next several hours, or ITI or IPI when targeted personnel are an immediate threat. **Ineffective personnel** are those who function at less than 25 percent of their original combat performance capability.

Damage Avoidance

Analysts plan to avoid unwanted injury and damage when selecting the proper nuclear weapon for employment.

Analysts ensure safety of friendly combatants by precluding more than 1 percent LI (negligible risk) or 5 percent LI (emergency risk) to nearby exposed or protected personnel. **Analysts ensure safety of noncombatants** by precluding more than a 5 percent incidence of hospitalizing injuries to nearby personnel or of damage to nearby edges of cities and towns. **Analysts avoid creation of unwanted obstacles** by precluding more than a 10 percent incidence of damage to nearby bridges or of blowdown and fires in nearby forests. Pre-computed safety distances chosen to avoid these unwanted results include buffers accounting for delivery system inaccuracies, thus providing a very high probability (99 percent) of avoidance.

Target Types

There are two types of targets that an analyst must analyze: area and point targets.

Area targets are usually enemy units that contain many elements and occupy some given expanse of terrain. An attack against an area target damages some fraction of the total number of elements in it. Assuming uniform distribution of target elements throughout the target area and normal weapon system delivery errors, averaging predicted results will give the most reasonable outcome. This outcome is termed "expected fractional coverage" and is the standard for expressing damage to area targets.

Point targets essentially consist of a single target element (e.g., a missile launcher or bridge). Area targets that are very small compared to a weapon's area of destruction can also be considered a point target. Here, the probability of damage to the single target element is the standard for expressing target damage. Target analysts select either an "expected" probability of damage (the average or mean) or a "high assurance" probability of damage (occurring at least 90 percent of the time).

Methods of Analysis

There are two methods for performing damage and restriction (avoidance) calculations: target-oriented and preclusion-oriented.

The target-oriented method is used when detailed target information (location, composition, size, movement) is available. The analyst first concerns himself with predicting damage to the selected target for a given nuclear weapon. He then concerns himself with necessary safety distances to avoid unwanted damage or injury, displacing the desired weapon ground zero as necessary to achieve required target damage without exceeding safety constraints.

The analyst has three techniques to predict target damage in the target oriented method: visual,

The **damage prediction technique** of choice depends on target shape, target type (area or point), target category (personnel, materiel, structures), and location of desired ground zero with respect to the target center.

Visual Technique. Analysts may use the visual technique for area targets, and must use this technique for area targets that are not circular in shape or that cannot be easily equated to a circle (long axis is equal to or more than twice the short axis). As the name implies, target coverage is estimated by visually inspecting a weapon damage radius superimposed on the target area and manipulating this damage radius to account for delivery system inaccuracies.

index,

Index Technique. Analysts may use the index technique, the fastest available, for targets that are circular or equatable to a circle, if the target category is tabulated or comparable to one that is, and if the desired ground zero is at or near the target center. For this technique, analysts read expected coverages directly from pre-computed coverage tables.

and numerical.

Numerical Technique. Analysts must use the numerical technique for point targets, and may also use it for circular area targets. For this technique, analysts estimate target damage using graphs and curves.

The preclusion-oriented method is used when detailed target information is not available. This may frequently be the case in a fluid situation. The analyst first concerns himself with necessary safety distances to avoid unwanted damage or injury, since non-target information is often available even when the situation is fluid. **The analyst displays these preclusion areas graphically for each available weapon system,** enabling him to eliminate unsuitable weapon systems where the limiting requirements offer no areas for possible desired ground zero selection. **He then selects likely ground zeros** for suitable weapons to obtain the most complete coverage for the proposed area of employment based on anticipated target categories and command guidance.

Tables

Summary tables containing simplified reference data enable analysts to make quick decisions regarding suitability of particular weapon system/yield combinations.

When performing analysis by either the target-oriented or preclusion-oriented method, using any of the three techniques, **analysts select safety distances, personnel and materiel damage effects radii, and target coverage estimates from tables** grouped first by weapon system and then by weapon yield. Thus, they will find all necessary targeting information for a particular weapon system in a single chapter, and all information for a specific yield of that weapon system in a single portion of that chapter. Included systems are Air Force and Navy aircraft-delivered bombs, cruise missiles, intercontinental ballistic missiles, and submarine launched ballistic missiles.

Additional Information

Employing nuclear weapons requires an understanding of their effects and target responses.

Simplified tables increase ease and speed of use, but are not a substitute for knowledge. Analysts use the appendixes in Joint Pub 3-12.2 to increase and refresh their knowledge of effects and responses, to perform analysis of friendly unit vulnerability, to predict communications blackout effects of nuclear detonations, and to estimate vulnerabilities of electronic equipment to electromagnetic pulse effects.

CONCLUSION

This publication provides doctrinal procedures and effects data for the employment of nuclear weapons. It covers the classified operational characteristics of nuclear weapons delivery systems and nuclear weapons in the US stockpile; the classified effects data necessary for target analysis; and the tabular information concerning target response, personnel safety, collateral damage, and preclusion of damage. Systems included are: B61 Bomb (Mods 3, 4, 7, and 10), Tomahawk land-attack missile(N), air launched cruise missile, ACM, B83 Bomb (Mods 0 and 1), Minuteman III (MK-12 and MK-12A), Trident I C4, Trident II D5, and Peacekeeper (MK-21).

CHAPTER I
CONTENTS, DATA SOURCES, AND APPLICATIONS (U)

1. (U) General. This joint publication provides classified nuclear weapon effects data and related information to allow for detailed planning and execution of nuclear missions. It should be used in all exercises (in lieu of the unclassified version, Joint Pub 3-12.3) so that operational commanders and staffs become familiar with the actual weapons data and procedures. Joint Pub 3-12.2 should also be used as the teaching vehicle to train nuclear weapons employment officers in the various Service schools. Joint Pub 3-12.3 should only be used for training in an unsecure environment, i.e. in support of unclassified correspondence courses.

2. (U) Contents. This chapter describes the various tables and graphs presented in the manual and provides the sources of data used in the calculations. Descriptions of the content, composition, and sources of information are intended to add clarity as well as to provide planning guidance to users of the manual.

a. (U) Units of Measurements. The metric system of measurement is used throughout for distances and dimensions.

b. (~~S-FRD~~) Nuclear Weapon Identification System. [redacted]

c. (~~C-FRD~~) Yields. [redacted]

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[redacted]

d. (U) Air Density. Damage and casualty radii, safety distances, and collateral damage distances were all computed for a standard air density based on a ground height of 310 meters relative to sea level with a moisture content of 0.6 percent by weight for nuclear radiation and computed for 1.0 relative air density for blast effects. Thermal transmissivity was varied (see subparagraph 2f.)

e. (U) Accuracy. The data presented for system accuracy are the best estimates of total system accuracy, not solely individual weapon precision.

f. (U) Thermal Transmissivity. When computing thermal radii for casualties or damage, safety, and collateral damage, a variable thermal transmission factor was used. The 95 percent transmissivity curve was used for safety and collateral damage calculations, and the 50 percent curve was used for casualty and damage computations.

g. (U) Thermal Safety/Casualty Damage Radii. The value of Q, the thermal radiant energy, was obtained from curves in "Personnel Risk and Casualty Criteria (PRCC) for Nuclear Weapons Effects", US Army Nuclear and Chemical Agency, for damage/casualty and for risk.

h. (U) Thermal Partition. Thermal partition is the fraction of total energy which is released as thermal energy. The factor, 0.14, was used for surface bursts, and 0.34 was used for airbursts.

3. (U) Targeting Terms and Criteria

a. (U) Damage Definitions for Structures

(1) (U) Severe Damage. That degree of structural damage that precludes further use of a structure for the purpose for which it is intended without essentially complete reconstruction. Generally, collapse of the structure is implied.

(2) (U) Moderate Damage. That degree of structural damage to principal load-carrying members (trusses, columns, beams and walls) that precludes effective use of a structure for the purpose for which it was intended, until major repairs are made.

(3) (U) Light Damage. That degree of damage that results in broken windows, slight damage to roofing and siding, blowing down of light interior partitions, and slight cracking of curtain walls in buildings. Generally, structures receiving light damage can be used quickly as intended, with only minor repair and removal of debris.

b. (U) Damage Definitions for Materiel

(1) (U) Severe Damage. Major damage that is severe enough to normally cause abandonment or scrapping of the equipment.

(2) (U) Moderate Type II Damage. At least one critical subsystem is nonfunctional and repair requires special tools, specialist skills, or parts not available within the unit owning the damaged equipment.

c. (U) Personnel Casualty Criteria

(1) (U) Combat Ineffective (CI). CI personnel function at less than 25 percent of their pre-exposure performance level.

(2) (U) Performance Degraded (PD). PD personnel, while not CI, function at between 25 and 75 percent of their pre-exposure performance level.

(3) (U) Immediate Permanent Ineffectiveness (IPI). Personnel become CI about 3 minutes after radiation exposure and remain so for any task until death, which usually occurs within 1 day. Injuries that result in CI because of translational effects of blast or because of vehicle or structural damage are tabulated as IPI.

(4) (U) Immediate Transient Ineffectiveness (ITI). Personnel become CI for any task about 3 minutes after exposure to the initial radiation and remain so for approximately 7 minutes. Transient and brief (2-10 hours) recovery to a PD state may occur before

becoming CI until death, which usually occurs in 5 or 6 days. Although defined primarily as a radiation effect, ITI is also computed for overpressure that causes pulmonary injury. In addition, injuries that result in CI because of translational effects of blast or because of vehicle or structural damage are tabulated as ITI.

(5) (U) Latent Ineffectiveness (LI). Personnel will become PD within 3 hours and remain so until death some weeks post-exposure, or become CI at any time within 6 weeks post-exposure. LI can be caused by radiation or blast and is the only casualty criterion also established for thermal radiation. Again, injuries that result in CI because of translational effects of blast or because of vehicle or structural damage are tabulated as LI.

4. (U) Casualty and Damage Assessment. When assessing casualties or damage, the coverage tables consider only blast and nuclear radiation effects (however for LI to personnel either exposed or in open foxholes, thermal radiation is also considered). The combined coverage of the two (or three) effects is listed.

5. (U) Safety Distance Assessment. Blast, thermal radiation, and nuclear radiation are considered for assessing safety distances, and the largest distance is listed. For calculations, friendly personnel are assumed to be in one of two vulnerability categories and exposed to one of two levels of risk.

a. (U) Vulnerability Categories

(1) (U) Unwarned Exposed. Personnel are standing in the open at time of burst but have dropped to a prone position by the time the blast wave arrives. They may have areas of bare skin exposed (up to 12 percent) to direct thermal radiation and may suffer temporary loss of vision. This category also applies to civilian personnel in open areas.

(2) (U) Warned Protected. Personnel have some protection against heat, blast, and radiation. Protected categories include tanks, armored personnel carriers, fighting positions (foxholes), weapons emplacements, and command posts and shelters.

b. (U) Risk Criteria

(1) (U) Negligible Risk. The largest radius corresponding to one percent LI (radiation, thermal, blast).

(2) (U) Emergency Risk. The largest radius corresponding to five percent LI (radiation, thermal, blast).

c. (U) Nuclear Radiation Safety

(1) (U) Negligible Risk. Seventy-five centigray (cGy) for previously unexposed personnel.

(2) (U) Emergency Risk. One hundred twenty-five cGy for previously unexposed personnel.

6. (U) Primary Targets. For personnel primary targets, the combined effects of blast casualties and radiation casualties (plus thermal casualties for personnel in open LI and in foxholes LI) are considered in coverage and effects tables. For materiel primary targets, only blast is considered.

a. (U) Exposed Personnel. Unless otherwise stated, this term refers to personnel in the open, regardless of physical posture or uniform. Radiation casualties are determined based on free-in-air doses sufficient to cause IPI, ITI, or LI as previously identified. Blast casualties are determined from overpressures sufficient to cause severe injury due to lung damage or decelerative tumbling. Thermal radiation burns are computed assuming the personnel are in battle dress uniforms (BDUs) with T-shirt, air space under the garments, and no skin exposed.

b. (U) Personnel in Foxholes. This term refers to individual fighting positions, the data for which are 1.8 m deep open foxholes with a 0.3 m firing step. Blast overpressures of 186 kilopascals cause lung hemorrhage, which is the primary blast injury mechanism for producing casualties to personnel in foxholes. The secondary mechanism is foxhole collapse. Nuclear radiation radii are computed using foxhole protection factors. Thermal radiation burns are computed assuming the personnel are in BDUs with T-shirt, air space under the garments, and no skin exposed, and considering thermal reflectivity of the sides of the foxhole.

c. (U) Personnel in Tanks. Moderate damage to tanks is used to find blast radii for casualties to personnel in tanks. Nuclear radiation radii are computed using protection factors for medium tanks with radiation liners.

d. (U) Moderate Damage to Wheeled Vehicles. The term, wheeled vehicles, refers to a wide variety of trucks, jeeps, and passenger sedans. Data are found in "Defense Nuclear Agency Effects Manual Number 1, Capabilities of Nuclear Weapons" (DNA EM-1).

e. (U) Moderate Damage to Tanks. Radii for moderate damage to tanks are from DNA EM-1. Data apply to light and medium tanks.

f. (U) Moderate Damage to Armored Personnel Carriers (APC)s. Data were obtained from tracked landing vehicles and more modern US and foreign APCs. More detailed information is in Chapter 17 of DNA EM-1.

g. (U) Other Targets. For damage to other equipment and structures found in the effects tables and collateral damage tables, most data are from DNA EM-1.

7. (U) Chapter II - Target Analysis Procedures. This chapter discusses the basic assumptions and target information requirements that a weaponeer needs. It also introduces the target-oriented and preclusion-oriented methods of target analysis.

8. (U) Chapter III - Damage Estimation Concepts. This chapter develops the mathematical requirements for a target analyst and gives some basic target definitions.

9. (U) Chapter IV - Target-Oriented and Preclusion-Oriented Methods for Damage and Restriction Calculations. This chapter presents the three targeting techniques: Visual, Index, and Numerical as well as the target-oriented and preclusion-oriented calculational methods that form the basis of nuclear weaponeering.

10. (U) Chapter V - Graphs and Tables. This chapter includes the graphs for numerical analysis, the comparable target table, the radii of vulnerability table, the protection factors, the induced radiation table, crossing hazard table, and the minimum safe distance (MSD) modification as a function of previous exposure table.

11. (U) Chapter VI - Simplified Reference Data. This chapter gives a quick summary of selected nuclear effects for all weapons included in this manual. This allows the analyst to make rapid comparisons between systems and is helpful in obtaining RDs for the visual analysis technique.

12. (U) Chapters VII through XIX - Weapon Data. These chapters contain the weapon specific information and data. The chapters are organized identically, beginning with weapon system characteristics followed by safety distance tables (personnel safety, preclude, and collateral damaged distances), effects tables (personnel effects and materiel damage effects), and coverage tables.

a. (U) Weapon System Characteristics Section. This section provides general and specific information concerning each weapon and delivery system, to include yields available, fuzing considerations, employment considerations, and reaction times.

b. (U) Safety Distance (with buffer). This section has the tables pertaining to personnel safety, preclusion of damage, preclusion of obstacles, and collateral damage avoidance. Safety yields are used in performing the calculations.

(1) (U) Personnel Safety. Data for personnel safety are the MSD, consisting of radii of safety plus buffer distances for very high assurance (99 percent) of separation. The buffer distances are equal to twice the system circular error probable (CEP). Buffer distances preclude the necessity of applying corrections for personnel disposition. Data tabulated for the warned, protected category are for personnel in open foxholes.

(2) (U) Preclude. Data for preclusion of damage are the least separation distances (LSD), consisting of no greater than a 10 percent incidence of blast or thermal damage added to a buffer distance for very high assurance (99 percent) of separation. Radii for the extreme cases for 10 percent incidence of ignition of forest debris fires were computed and entered in this manual (see Table I-2 for other classes of outdoor tinder materials). For preclusion of damage to naval ships, apply the

column light damage to buildings for yields up to and including 100 kT and the column forest debris fires - deciduous leaves for yields greater than 100 kT.

(3) (U) Collateral Damage Avoidance. This section gives a five percent incidence of the effects shown. Personnel injury normally governs collateral damage constraints. These distances consist of radii of collateral damage plus buffer distances for very high assurance (99 percent) of separation. (Unidirectional buffer distances were used.) The radii for personnel injuries represent a five percent incidence of injuries requiring hospitalization. An injury requiring hospitalization for a civilian is assumed to be the same as an injury rendering a soldier LI. In addition to the five percent incidence of hospitalizing injuries, there will be an unspecified number of lesser injuries, assumed not to require hospitalization. Civilians are assumed to be in one of these environments: Urban, Rural, or In Open. Civilians in the urban environment are assumed to be in the basements of one-story masonry buildings. Injuries to these civilians can either occur because of radiation or blast. The larger of the two distances (blast or radiation) is tabulated. For radiation, a five percent incidence of LI will occur at an absorbed dose of 125 cGy. The radiation protection factors for basements of masonry buildings are 33 neutron protection factor (NPF) and 10 gamma protection factor (GPF). For blast, a five percent occurrence of CI is assumed to occur when five percent of the buildings suffer severe damage. Thermal effects are not considered for personnel injuries inside of buildings. Civilians in the rural environment are assumed to be in one-story wood frame houses without basements. As discussed above, the larger distance associated with 125 cGy incidence for radiation, or five percent severe damage to buildings for blast, constitutes a five percent occurrence of hospitalizing injuries. The radiation protection factors are 1.67 NPF and 1.1 GPF. Thermal effects are not considered for civilians inside buildings. Civilians in the open distances equate to emergency risk to unwarned exposed personnel. Thermal, blast, and radiation effects are all considered, and the largest of the three distances is tabulated. Distances listed for

facilities are five percent incidence of moderate damage. Fixed bridges are defined as single track railroad (RR) truss type bridges (most vulnerable). Railroad equipment is assumed to be full box cars, in a side-on orientation. Moderate damage to one-story masonry buildings is comparable to moderate damage to masonry buildings up to three stories, and petroleum, oil, and lubricants (POL) and water storage tanks. Thermal ignition distances are the distances at which five percent incidence ignition (not necessarily sustained burning) is achieved. A probability of building damage cannot be associated with these thermal radii.

c. (U) Weapons Effects Tables. This section, for each weapon, has a left facing page on personnel effects, and a right facing page on materiel effects. The tables show casualties and damage as a function of preset height of bursts (HOBs). If a weapon system has a contact option or backup fuze, the surface burst radii are also provided.

(1) (U) Personnel Effects. Personnel in vehicles are considered blast casualties when the vehicle receives moderate blast damage. Personnel in structures are considered blast casualties when the structure receives severe blast damage. Radii of other effects are computed, and the combined radius is recorded. Earth shelters refer to any type of structure where personnel are protected by at least one meter of earth and overhead cover. Radii of second degree burns to personnel in BDU and battle dress overgarment (BDO) are computed as a casualty producing effect, and mid-life or design yield is used. It is assumed that personnel are wearing T-shirts and there is an air space under the uniform. Thermal transmissivity is assumed to be 50 percent. The thermal casualty criterion requires that 25 percent of the body receive at least partial thickness burns.

(2) (U) Materiel Damage Effects. Fixed bridges, used for calculating severe damage, are two- and four-lane highway and double track RR girder bridges with spans of 61 m or more. Source is Appendix A, paragraph 11. Fixed bridges, as used here, are relatively hard. Railroad tank and flat cars are assumed to be loaded and randomly oriented. Factories considered are one-story industrial

buildings with steel frames, concrete or brick walls, windows, and with 22,680 to 45,359 kg (25-to 50-ton) capacity interior cranes. For 50 percent incidence of moderate damage to wood frame and brick apartment type buildings and factories, multiply the factors in Table I-3 by the radii of severe damage. The data for the surface-to-air missile (SAM) columns are extracted from OGA-2800-23-92, "Physical Vulnerability Handbook for Nuclear Weapons", Defense Intelligence Agency. Revetted (RVTTD) SAMs are assumed to be in a U-shaped, man-made structure. The SAMs are assumed to be in a horizontal position on their transporters with the top of the revetment extending slightly above the missile. The revetment dissipates some of the dynamic pressure. The missiles and rockets severe damage data assume an intermediate range liquid fuel rocket. In the erect state the missile is fully fueled and ready for launch with damage coming from overturn. In the transporter, erector, launcher state the missile is assumed to be horizontal but not fueled. Damage is also from overturn. For severe damage to supply depots, the depots are assumed to contain POL in 18.5 liter, 208.2 liter (55 gallon) drums; ammunition and rations in standard packages; and other items in small containers. Blast effects only are considered. Ruptured packages serve as evidence of severe damage to supply depots. The exposed (EXPO) and shielded (SHLD) categories for wheeled vehicles and tracked equipment are defined as follows: EXPO equipment is subject to the dynamic pressures from the blast wave without reduction (assumed to be on a flat plane). SHLD equipment is subject to overpressures only (shielding is assumed to reduce dynamic pressures to a nonsignificant level).

(3) (U) <u>Surface Bursts</u>. Most of the weapons have a surface burst option or a contact or backup fuze. The effects tables list the effects for these zero (0) HOB. A fallout prediction MUST be made for surface bursts. In addition, a surface burst will produce a crater, the size of which is dependent upon yield. Crater dimensions for a 1 kT burst on the surface are in Table I-4. Table I-5 contains the scaling factor equations for craters produced by other yields. Craters can be used as obstacles to enemy vehicles and equipment. The effective obstacle diameter can be obtained by multiplying crater radius by 2.3.

d. (U) Coverage Tables. The four tables per weapon present the precomputed effectiveness of the weapons in the form of the expected radius of damage (RD). The system accuracy data, the circular distribution 90 (CD90) or CEP, and the low fallout safe air HOB data are also provided. For personnel, there are three casualty criteria: immediate permanent ineffectiveness, immediate transient ineffectiveness, and latent ineffectiveness. The coverage indices describe the fraction of damage to one significant digit of accurately located (i.e. target location error (TLE) = 0) circular area targets having uniformly distributed elements. This number represents the expected fractional damage. (See Chapter III.) The HOB tabulated in the coverage tables for weapon systems with field selectable HOB are the greater of the fallout safe (99 percent assurance) HOB or the optimum HOB for the effect and target considered. For weapon systems with a single fixed HOB, the preset HOB is used in the calculations. For yields less than 100 kT, the fallout safe HOB is computed as 30 $W^{1/3}$ meters plus 3.5 probable errors in height of burst (PEH), where W is the safety yield in kT. For yields equal to or greater than 100 kT, the fallout safe HOB is computed as 55 $W^{1/3}$ meters plus 3.5 PEH. Accuracy data are provided for use with the visual and numerical target analysis methods and secondary target types.

Table I-1. (U) Comprehensive Weapon Systems Identification and Yield Data

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System Warhead-MOD	Yield Designator	Yields in kT Casualty	Safety	$W^{1/3}$ 1/
[redacted]				

Table I-2. (U) Forest Debris Fire Fuels

CLASSES:
- Deciduous Leaves (beech)
- Fine Grass (cheat)
- Coarse Grass (sedge)
- Coniferous - Pine Needles, brown (ponderosa)

Table I-3. (U) Factors to Convert Severe Damage Radii to Moderate Damage Radii

	YIELDS (IN kT)					
	0<0.3	0.3<1	1<3	3<10	10<100	≥100
Wood Frame Building	1.5	1.5	1.4	1.4	1.3	1.3
Brick Apartments	1.3	1.3	1.3	1.3	1.3	1.3
Factories	1.7	1.6	1.6	1.5	1.3	1.3

Table I-4. (U) Crater Size for a 1 kT Surface Burst

SURFACE	RADIUS	DEPTH
Dry Soil or Dry Soft Rock	18.6 m	8.5 m
Wet Soil or Wet Soft Rock	25.0 m	9.4 m
Dry Hard Rock	14.9 m	6.7 m
Wet Hard Rock	17.7 m	8.5 m

CHAPTER II
TARGET ANALYSIS PROCEDURES

1. 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 publication give a reasonably good estimate if the assumptions in the following five areas are satisfied:

a. 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.

b. Target Composition. Actual target elements are assumed to be uniformly distributed in the target area and randomly oriented. Personnel elements are assumed to be performing physically demanding tasks.

c. 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 B.

d. Target Location. It is assumed that the exact locations of the targets are known. However, if TLEs exist and they can be characterized by target analysts, then the target-oriented method can accommodate them.

e. Terrain. A flat surface is assumed for all situations considered in this publication. Minor terrain irregularities such as ditches and gullies will not modify nuclear weapon effects, but extreme terrain can. For a further discussion, see Appendix B.

2. 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.

a. Command Guidance. The joint force commander or designated subordinate analyzes the mission and limiting requirements to establish guidance for risks and obstacle preclusion.

(1) Target Defeat Guidelines. For area targets, the guidelines should specify the level of casualties or damage desired over a specified fraction of the target. Expected coverage (the average expected value) is used for area targets. Guidelines should also be used to establish the probability of achieving a specified level of damage to a point target.

(2) Degree of Acceptable Risk to Friendly Personnel. Negligible risk to unwarned, exposed personnel is normally specified (see Chapter I, paragraph 5). A higher degree of risk may be specified if operationally warranted.

(3) Degree of Acceptable Risk to Noncombatants. A five percent incidence of hospitalizing injuries among civilians at the edge of populated area is an acceptable risk. This does not mean that five percent casualties within the entire area would actually be realized.

(4) Obstacle Guidance. The joint force commander may desire to enhance or minimize obstacles produced by nuclear weapons to fit the overall plan. Appropriate rules of engagement should be reviewed before choosing suitable weapons.

b. Target Information. Target information includes:

(1) Location, size, shape, and hardness of the targets relative to nuclear weapons effects.

(2) Category of primary target elements and, if applicable, the degree of protection of the target elements against weapons effects.

(3) Distribution of target elements. This is of particular importance for a large target 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.

(4) Mobility of the target, that is, the expected stay time or rate of movement of a target.

c. Friendly Element and Collateral Damage. Information on friendly elements and collateral damage includes:

(1) Attack resources, including the weapons available for planning purposes and their location; and the delivery means available, their response times, and locations.

(2) Location of friendly personnel near the area planned for the burst, their degree of protection, and their radiation exposure state. See Appendix B.

(3) Location of areas containing noncombatants and, if obtainable, their degree of protection.

(4) Location of structures, facilities, or equipment for which damage should not exceed a specified level.

(5) Response time of delivery units being considered to deliver a weapon.

(6) General planning guidance for each delivery system. 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.

d. 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.

3. 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.

a. 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 desired ground zero (DGZ) to meet these limitations and determine the final coverage or damage probabilities for weapons that meet the criteria.

(1) Initial Coverage and/or Damage Probability. Depending on the characteristics of the target, there are three techniques for estimating damage:

(a) Visual Technique. This graphic technique is generally used to estimate coverage of noncircular area targets. Since virtually no military 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.

(b) Index Technique. This technique, using precomputed coverage 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.

(c) Numerical Technique. This technique estimates fractional coverage of circular (or near circular) area targets or the probability of damage to point targets using target damage prediction graphs. It is particularly useful for an estimate of damage when the aimpoint is displaced from the target center.

(2) Limiting Requirements. Restrictions placed on the employment of nuclear weapons are referred to as limiting requirements and are considered in four areas:

(a) Personnel Safety. Analysts determine if the distance between friendly personnel and the DGZ is sufficient to ensure personnel are not exposed to a risk exceeding that specified by their commander.

(b) Collateral Damage. Analysts determine if the distance between the DGZ and locations containing noncombatants or areas where damage preclusion has been directed is sufficient to ensure that the specific preclusion criteria are met.

(c) 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.

(d) 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.

(3) 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 IV. 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.

b. Evaluate Weapon Systems and the Military 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:

(1) The highest priority targets should receive first consideration.

(2) Weapons and yields selected must meet any release constraints.

(3) The commander may need to retain certain weapons for follow on use.

(4) The weapon selected normally should give the highest coverage for area targets or the highest probability of defeat of a point target while meeting all personnel safety, collateral damage, and obstacle or damage preclusion criteria. Nevertheless, the minimum yield weapon which gives adequate coverage may be selected. For example, minimum yield weapons may be used to conserve firepower or to reduce both collateral damage and obstacles to follow on military actions to a minimum.

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

(1) Weapon System. The weapon system consists of the recommended delivery system, weapon, and yield.

(2) 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 the system characteristics section of each weapon chapter, Chapters VII through XIX. Most weapon systems have a preset HOB that 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.

(3) DGZ. The point on the surface of the earth at, or vertically below or above, the center of a planned nuclear detonation. It is designated by map or geodetic coordinates.

(4) Time of Detonation. The time of burst is dictated by military considerations such as the general concept of employing an option. The acceptable interval for time of detonation will also be specified because of its impact on personnel warning considerations and because it is an integral part of the employment package concept.

(5) 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.

(6) Limiting Requirements. The personnel safety and collateral damage information will always be presented, graphically if possible.

d. Conduct a Poststrike Analysis. A nuclear strike can be deemed successful if the desired operational results are achieved. However, analysts can estimate the extent to which the nuclear strike was successful or unsuccessful by a poststrike analysis.

4. 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.

a. 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:

(1) 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 intelligence preparation of the battlespace (IPB) process.

(2) Limiting Requirements. Analysts apply personnel safety distances, obstacle preclusion distances, and collateral damage distances to the area of proposed employment.

(3) 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.

b. Evaluate Weapon Systems and the Military 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 military situation.

c. 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.

d. Conduct a Poststrike Analysis. Analysts estimate the strike's degree of success by determining details about the detonation such as yield, HOB, and actual ground zero (GZ).

5. Employment of Several Weapons. The target analyst must consider the survivability of delivery systems if more than one nuclear weapon is to be employed in the same approximate location and at the same approximate time. Consideration of timing, DGZs, and flight paths must be made. In addition, the target analyst should not have a second nuclear warhead within the immediate effects (either by DGZ or flight path) of the detonation of a first warhead to avoid severe stress/deformation or change of flight path. The analyst must give careful consideration to the immediate effects that occur during a nuclear detonation when developing a nuclear strike mission. This is especially critical when employing nuclear weapons via airborne delivery systems. Consulting airborne safe escape parameters may also be necessary to ensure weapon deconfliction.

CHAPTER III
DAMAGE ESTIMATION CONCEPTS

1. Basic Probability. Probability is a mathematical prediction of the relative frequency with which events will occur in repeated trials. Useful in predicting the outcome of an event before it occurs, probability has military applications such as determining the average height of burst error of a specific fuze. This average error may be applied to a future mission with fair reliability. For this approach, the past events from which data are gathered and the future events to which the data will be applied must both belong to the same general class of events.

2. Numerical Interpretation. Analysts can apply probability to practical problems even though they do not understand the mathematical theories completely. They do so by using charts, tables, and nomographs developed specifically to make the process faster and easier. The curves, charts, and tables used in this publication provide the reliable information that would otherwise require pages of calculations.

3. Accuracy of Measurement. Most numbers in the Joint Pub 3-12 series are derived from measurements made with instruments that vary in complexity from simple foot rules to complicated nuclear radiation detectors and counters. Because no measuring device or its users are completely reliable, analysts must give up the concept that the number 4 means exactly four. They must think in terms of what the numbers represent. For instance, in a mathematical example, 20 kilotons could mean 20,000 tons. However, in target analysis, yields are generally considered accurate to plus or minus 10 percent, therefore, 20 kilotons means a yield between 18 and 22 kilotons.

4. Significant Figures. In abstract mathematical work, the number 4 means exactly four, no more and no less. In scientific measurement of the kind used in damage prediction calculations, the number 4 may only approximate four. Likewise, the calculations themselves can distort significant figures. Dividing, multiplying, adding, and subtracting sometimes give answers that indicate more accuracy than the basic data justify. The final result can be no more accurate than the least accurate component. Target analysts should become familiar with the rules concerning significant figures and ensure that any calculations and recommendations reflect these rules.

5. Dispersion. Neither nature nor man can make any two items that will produce exactly the same results; however, two like items will normally produce approximately the same results. Within any group of like items there is a tendency toward an average. This average result is called the mean or standard and the difference between the mean and any single result is called the deviation. The phenomenon of a group of like items tending toward, but having finite deviations from, the mean for the group is called dispersion. Target analysts are concerned with the types of dispersion characterized by a central tendency, which results in a much higher percentage of small deviations than large deviations. The measure of this central tendency is known as the standard deviation or sigma < σ >. For this publication, < σ > has been translated into probable errors to make calculations easier.

6. Distribution Errors. Damage estimation procedures assume that weapons function at their rated yields and within the established accuracies of their delivery systems. To estimate damage, analysts must consider the delivery accuracy of the system. Many weapons released under identical conditions will impact in the vicinity of the aimpoint, forming a dispersion pattern. Assuming the center of impact to be at or near the aimpoint, dispersion is characterized by a higher percentage of small misses or deviations from the aimpoint than large deviations. Assuming the dispersion to be normal (see Figure III-1) and to follow the laws of probability, target analysts can predict average or expected values for target coverage and the probability of not missing by more than a particular distance.

a. Circular Error Probable. By definition, 50 percent of the weapons aimed at a point will land within 1 CEP of it, or conversely, a weapon is expected to hit within 1 CEP of the aimpoint or DGZ 50 percent of the time. Based on horizontal delivery error only, the CEP can be used to predict whether or not a 50 percent probability of obtaining at least a specific amount of fractional coverage is achievable. Knowing the CEP of a delivery system and assuming a distribution pattern (that is, circular-normal distribution), analysts can find the probability of any weapon hitting inside a circle of a specified radius drawn about the aimpoint. For a circular-normal distribution, 93.75 percent of the weapons can be expected to fall within a circle whose radius is 2 CEPs; 99.80 percent of the weapons can be expected to fall within a circle whose radius is 3 CEPs. See Figure III-2.

b. Circular Distribution 90. CD90 is the radius within which 90 percent of the weapons aimed at one point are expected to hit. CD90 is used in the high assurance damage estimation to predict a 90 percent probability of one weapon obtaining at least a specified degree of damage to a point target. If the dispersion pattern for the delivery system is circular-normal, the CD90 can be calculated by multiplying the CEP by 1.83. See Figure III-2.

c. Horizontal Delivery Error. Dispersion patterns will vary among delivery systems but they are assumed to be circular for bombs and cruise missiles. Two terms apply to circular horizontal dispersion patterns: CEP and CD90. CEP and CD90 data have been tabulated for each weapon system. They are in the accuracy data portion of the coverage tables in this publication.

d. Vertical Error. For airburst weapons, the vertical error distribution is expressed in terms of PEH. A distance of 1 PEH from the desired HOB will contain 25 percent of the detonations. A 1 PEH bracket is the vertical distance both above and below the desired HOB within which a single weapon has a 50 percent probability of detonating. The vertical distribution pattern is assumed to be normal about the desired HOB. Figure III-3 shows the relationship between the burst distribution pattern and the PEH. The PEH associated with each weapon system has been tabulated and is included in the accuracy data portion of the coverage tables.

e. Target Location Error

(1) Target analysis normally assumes that there is no TLE. If TLEs associated with target acquisition equipment are known, they may be incorporated into the target analysis. Doing so is particularly important when attacking a point target. TLE can be considered by taking the square root of the sum of the squares of CEP and TLE. TAE = Target Area Error: (SQR(x) means find the square root of x.)

$$TAE = SQR\ (TLE^2 + CEP^2)$$

(2) Use this value in place of CEP for target analysis. For high assurance situations compute TAE90:

$$TAE90 = SQR\ ((1.83TLE)^2 + CD90^2)$$

7. Damage Prediction

a. Components. The critical components of damage prediction are the RD, variability (V), and the degree of damage to materiel and personnel.

(1) Radius of Damage. The RD is that distance from the burst at which target elements have a 50 percent probability of receiving at least the specified degree of damage or at which half the personnel respond as specified by the casualty criterion (see Figure III-4). Some target elements inside the RD will escape the specified degree of damage while some outside the RD will be damaged, resulting in response variability. Those that do not respond in the desired manner inside the RD are assumed to be approximately balanced by those that do outside the RD. The RD depends on the type of target, the yield of the weapon, the damage or casualty criterion, and the HOB. With the RD specified, one point on a damage distribution curve is established. See Figure III-5 for an RD of 5,000 meters. The variability associated with the target must be specified to complete the curve. Visual target analysis, which places RD circles over targets on maps or charts, cannot assess variability. It uses zero variability.

(2) Variability. V describes the probabilities of damage in terms of distance from the RD. When the V for a given type of target is specified, the damage distribution curve can be completed, and the probability of damage at any distance, or vice versa, can be estimated. V can be expressed as a number, such as 0, .05, or .2, so that a set of curves can be used to approximate more accurately the actual target response. For human beings subjected to a combination of blast, thermal radiation, and nuclear radiation, the Joint Pub 3-12 series uses the V = .2 curve in Figure III-6 (the V number used here is actually a coefficient in an empirical equation that provides an indication of the steepness of the curve's slope).

(3) Degree of Damage. Knowing target type, yield, and HOB, analysts can find the probability of achieving a specific degree of damage as a function of the distance from GZ. The curve of damage versus distance is specified by stating the RD and

variability. Because the Joint Pub 3-12 series standardizes variability, the RD is the only quantity needed to determine the damage versus distance relationship.

b. Assurance

(1) Analysts consider the effect of delivery errors on point target damage probabilities using either expected averages or high assurance estimates. The expected estimate is preferred since it projects what can reasonably be expected given the assumptions and uncertainties associated with such target variables as location, composition, distribution, posture, and response and with such weapon variables as delivery errors, yield, and spectrum output. Using the high assurance estimate, target analysts try to identify a weapon system that will have a 90 percent probability of achieving at least a minimum probability of damage (P) to the point target. All the same simplifying assumptions and uncertainties apply except that the weapon is assumed to detonate no closer than one CD90 horizontally from the point target. This estimate results in a conservative statement of the weapon's capability based on delivery accuracy. Generally used for single critical targets, this estimate usually drives yield requirements above those for expected value calculations or forces the selection of a more accurate delivery system.

(2) For estimating damage to area targets, analysts use only expected averages; they make no high assurance estimates.

8. Patterns of Damage. To understand and predict the results of nuclear weapon effects on a target, analysts should envisage the pattern of damage on the target area and compare the effects of varying yields. Knowledgeable about target response, analysts can predict the amount of damage for a given criterion such as moderate damage to tanks.

a. Given the target elements are evenly distributed, the best results can be achieved against a single target by locating the DGZ at the target center. Doing so centers the RD of the weapon over the target. If weapons under consideration have selectable HOBs, the selected HOB should be as close as possible to the HOB giving the largest RD against the particular target type. Sometimes an HOB higher than optimal must be employed to avoid creating fallout.

b. In general, delivery errors will reduce the damage actually caused to a target. A burst at the outer edge of the horizontal dispersion pattern will offset the center of the weapon effects from the DGZ, resulting in a substantial decrease in the damage to the target. All nuclear weapon delivery systems have associated delivery errors, which analysts must take into account when estimating the fraction of the target covered by the RD. Expected fractional coverage is the sum of the products of all possible fractional coverages with their probability of occurring. This approach results in the best estimate of the effect that the weapon will have on the target.

c. Damage depends on numerous and complex factors. Thus, even if analysts know the exact point of detonation, they cannot be precise about damage to any specific target element. However, damage occurs in a pattern definite enough for constructing curves that plot its probability against the distance from the target to GZ. Damage distribution curves differ according to types of targets and desired damage effects. The six different curves in Figure III-7 should cover most damage distribution cases.

9. Casualties

a. Personnel are vulnerable in varying degrees to three primary effects; blast, thermal radiation, and nuclear radiation. If the probabilities of each effect producing a casualty at various distances from the point of detonation are known, then the overall probability of producing a casualty is given by the formula:

$$PROB = 1 - (Q(B) \times Q(TR) \times Q(INR)).$$

b. The Q's represent the probability of not producing a casualty by blast (B), by thermal radiation (TR), and by initial nuclear radiation (INR). PROB is the probability of producing a casualty by at least one of the three effects. This formula, which assumes that the effects operate independently of one another, produces conservative results. Plotting the overall probabilities of a casualty for various distances results in a curve like that in Figure III-8.

c. The graph in Figure III-8 indicates 50 percent probability of personnel casualties at 2,500 meters. For the given yield, HOB (200 M), target protection category, and desired level of effect, the RD is 2,500 meters. Repeating this calculation for a series of HOBs will produce a set of RDs for one weapon and one situation. Plotting these RDs against the HOBs for which they are computed produces a casualty curve (see Figure III-9). Finally, repeating the process for other yields provides a completed family of curves for the situation.

d. The tabulated data in this publication are derived from a similar approach. Those tables presented for the attack of targets consider casualties and damage caused by blast and nuclear radiation in all cases. Thermal radiation is also included for latent ineffectiveness to personnel exposed or in open foxholes and for personnel safety and collateral damage calculations.

e. The blast damage data used in this publication generally come from DNA publication EM-1. The curves are scaled for yield and the variability of .2 is applied to find the distances beyond the RD to which damage probabilities extend.

f. Nuclear radiation as a function of yield, slant range, and weapons output spectrum was computed using version 6 of the Air Transport of Radiation (ATR) computer program. In predicting damage and casualties for targets or personnel formations, the Joint Pub 3-12 series generally considers only initial radiation effects, not neutron-induced activity or fallout.

g. Analysts may have difficulty estimating the general reliability of the curves generated by the procedure above because blast, nuclear radiation, and thermal radiation vary independently with HOB, yield, weapon design, and situation. However, a variability of .2 does approximate an average of observed phenomena. In general, because the assumptions are conservative, the curves will tend to underestimate casualties and damage.

10. Target Types. There are two types of targets the analyst must analyze: area and point targets.

a. Area Targets. Targeted enemy units usually contain many elements and occupy some given area of terrain. An attack against the area target would damage some fraction of the total number of elements in it. Assuming the target elements are uniformly distributed throughout the target area, normal weapon delivery errors, both horizontal and vertical, and averaging predicted results, the most reasonable outcome is called expected fractional coverage. This is symbolized by $\bar{f}$. For example, asserting that the expected fractional coverage for severe damage to an area target is .6 ($\bar{f}$=.6) means that, on the average, 60 percent of the target will receive at least severe damage and the remaining 40 percent will be damaged less than severely.

b. Point Targets. Point targets essentially consist of a single target element. For example, a missile or a bridge can be considered as a point target. A very small area target (compared to a weapon's radius of damage or delivery error) can also be considered a point target. The prediction now deals with the probability of damaging that one element; either it will receive the required amount of damage or it will not. For example, a building may have a .8 (P = .8) probability of receiving severe damage under certain stipulated conditions. This means that based on previous experience, there is an 80 percent chance of severe damage to the building. But analysts cannot expect with confidence that the experimental probability will be exactly matched on the battlefield. Two techniques are used for estimating the probability of damage to a point target:

(1) Expected Probability of Damage (P). This is the preferred technique because the resulting damage probability estimate represents the mean or expected probability after a large number of trials. The expected probability of damage is determined by weighing each possible probability of damage according to the relative frequency of its occurrence.

(2) High Assurance Probability of Damage (P90). In some cases a point target is of sufficient importance that an average expectation of damage does not suit the needs of the analyst. Given worst case horizontal delivery errors, the high assurance procedure gives the analyst a very conservative prediction of damage. The high assurance probability of damage is determined by assuming the weapon detonates no closer horizontally to the target than one CD90.

11. Limiting Requirements. Nuclear weapons can cause undesirable effects such as: casualties to friendly personnel; collateral damage; fire areas and obstacles to movement; damage to structures, such as bridges, desired for use by friendly personnel; and damage to organic aviation such as helicopters in flight. To avoid or to lessen these undesirable effects, referred to as limiting requirements, restrictions are imposed on the use of nuclear weapons. The limiting requirements, which may be derived from the rules of engagement, may influence the selection of yield, delivery system, DGZ, or time of burst. When the initial solution does not meet limiting requirements, one or more of the following actions must be taken:

a. Move the DGZ so that limiting requirements are met.

b. Use a more accurate delivery means to reduce the required safety or preclusion distances.

c. Use a lower yield weapon to reduce the separation distance requirement.

d. Modify the personnel safety criteria by increasing the protection for friendly personnel, by accepting a higher degree of risk, or by withdrawing personnel to increase the separation distance. These actions can be taken only with the appropriate commander's approval.

e. Use other forms of combat power such as advanced conventional munitions or maneuver elements.

f. Request that the employment guidance and/or constraints be changed; for example, reduce coverage, damage, or preclusion requirements.

12. Personnel Safety. To make personnel safety calculations, analysts determine the MSD. The MSD is the sum of the radius of safety for a specified degree of acceptable risk and vulnerability and a delivery error buffer, the buffer distance (BD).

a. Risk. Nuclear employment analysis recognizes three degrees of risk to friendly personnel: negligible, moderate, and emergency. The tables in this publication include only negligible and emergency risk because the differences between safety radii are usually small. If a moderate risk personnel safety distance is required, use a distance half way between negligible and emergency risks, rounding upward to the next 100 meters.

(1) Negligible. This risk level extends to a 1 percent incidence of LI. Negligible risk should not be exceeded unless a significant military advantage will be gained.

(2) Moderate. This risk level extends to a 2.5 percent incidence of LI. Moderate risk should not be exceeded if personnel are expected to operate at full efficiency after a friendly burst.

(3) Emergency. This risk level extends to a 5 percent incidence of LI. Because of the possible effect on the combat efficiency of a unit, emergency risk should be accepted only when absolutely necessary.

b. Vulnerability. Associated with the degrees of risk is the protection personnel have from weapon effects. To account for the various situations, three vulnerability categories exist: unwarned, exposed; warned, exposed; and warned, protected. The tables in this publication include only the unwarned, exposed and warned, protected categories because the differences between unwarned and warned exposed are small.

(1) Unwarned, Exposed. Personnel in this category are assumed to be standing in the open at the time of the detonation. By the time the blast wave arrives they will have dropped to a prone position but some skin will probably be exposed to direct thermal radiation.

(2) Warned, Exposed. Warned, exposed personnel are assumed to be prone on open ground with their skin covered or protected from thermal effects by at least the equivalent of BDU and T-shirt uniform. Such a condition may exist when a unit is warned of an impending burst but has insufficient time to gain protective shelter such as a personnel carrier or a foxhole.

(3) Warned, Protected. Personnel in this category are assumed to have some protection against blast, thermal radiation, and nuclear radiation. Tanks, APCs, foxholes, weapon emplacements, and shelters can provide such protection.

Thus there are four combinations of risk and vulnerability for which safety distances are given:
unwarned, exposed negligible;
unwarned, exposed emergency;
warned, protected negligible; and
warned, protected emergency.

c. Radius of Safety and Buffer Distance. For each combination of risk and vulnerability, there is a RS. The RS is the distance beyond which weapon effects are considered acceptable. For example, the RS for negligible risk to unwarned, exposed personnel may be 2,000 meters. However, as a result of horizontal dispersion, a weapon might burst closer to friendly personnel than expected. To deal with this possibility, a BD has been added to the RS to provide a very high, or 99 percent, assurance that the stated risk will not be exceeded for friendly personnel in the stated vulnerability condition. When an RS is combined with a BD the result is an MSD.

d. Minimum Safe Distances (MSDs). For weapons described in this publication, the MSDs are precalculated. Personnel who are separated from the DGZ by a distance equal to, or greater than, the MSD that describes their risk and vulnerability are considered safe.

13. Collateral Damage. Collateral damage is undesirable civilian personnel injuries or materiel damage produced by the effects of friendly weapons. The collateral damage distance (CDD) is the distance from the DGZ at which there is an acceptable degree of personnel injury, blast damage to facilities, or thermal damage to material. The CDD is the sum of the radius of collateral damage and a BD that provides 99 percent assurance that the acceptable degree of damage will not be exceeded. For weapons described in this publication, the CDDs are precalculated.

a. Personnel Injury. The CDDs listed for personnel injuries represent a 5 percent incidence of injuries requiring hospitalization. In addition to these, an unspecified number of lesser injuries that do not require hospitalization will occur. Noncombatants are assumed to be in one of the following three environments:

(1) In urban areas, noncombatants are assumed to be in the basements of one-story masonry buildings. Either radiation or blast can cause injuries. The larger of the two distances for blast and radiation is tabulated. Thermal effects are not considered for personnel inside buildings.

(2) In rural areas, noncombatants are assumed to be in one-story frame houses without basements. The larger of the two distances for blast and radiation is tabulated. Again, thermal effects are not considered.

(3) In the open, personnel are equated to unwarned, exposed military personnel at emergency risk. Thermal, blast, and radiation effects are all considered, and the largest of the three distances is tabulated.

b. Moderate Damage to Facilities. The CDDs listed are for 5 percent incidence of moderate damage from blast. Five categories of facilities are considered: one-story frame buildings, one-story masonry buildings, light-steel industrial buildings, fixed bridges, and railroad equipment.

c. Thermal Ignition. CDDs listed are the distances at which 5 percent incidence ignition, not necessarily sustained burning, is achieved. A probability of building damage cannot be associated with these distances.

d. Planning and Analysis. To conduct initial planning, analysts can use the simplified reference data provided in Chapter VI. For detailed target analysis, CDDs for each weapon system and yield are contained in the safety distance section for each weapon, Chapters VII to XIX.

14. Damage and Obstacle Avoidance. Analysts must often provide data about precluding undesirable obstacles or damage to structures and forests. Obstacle and damage preclusion is expressed in terms of the LSD, which is the distance from the DGZ for which there is a 99 percent assurance that the probability of incidence of damage or obstacles is no greater than 0.1. The LSD is the sum of the radius of preclusion and BD. For weapons described in this publication, the LSDs are precalculated. Precluding obstacles or damage can influence the selection of yield, delivery system, and DGZ. The DGZ must be separated from

the point where obstacles or damage are to be precluded by a distance equal to, or greater than, the LSD. The procedure for extracting the LSD is the same as for the MSD. If the type of aircraft, tree, or fuel is unknown, analysts use the worst case by extracting the largest LSD for each respective category.

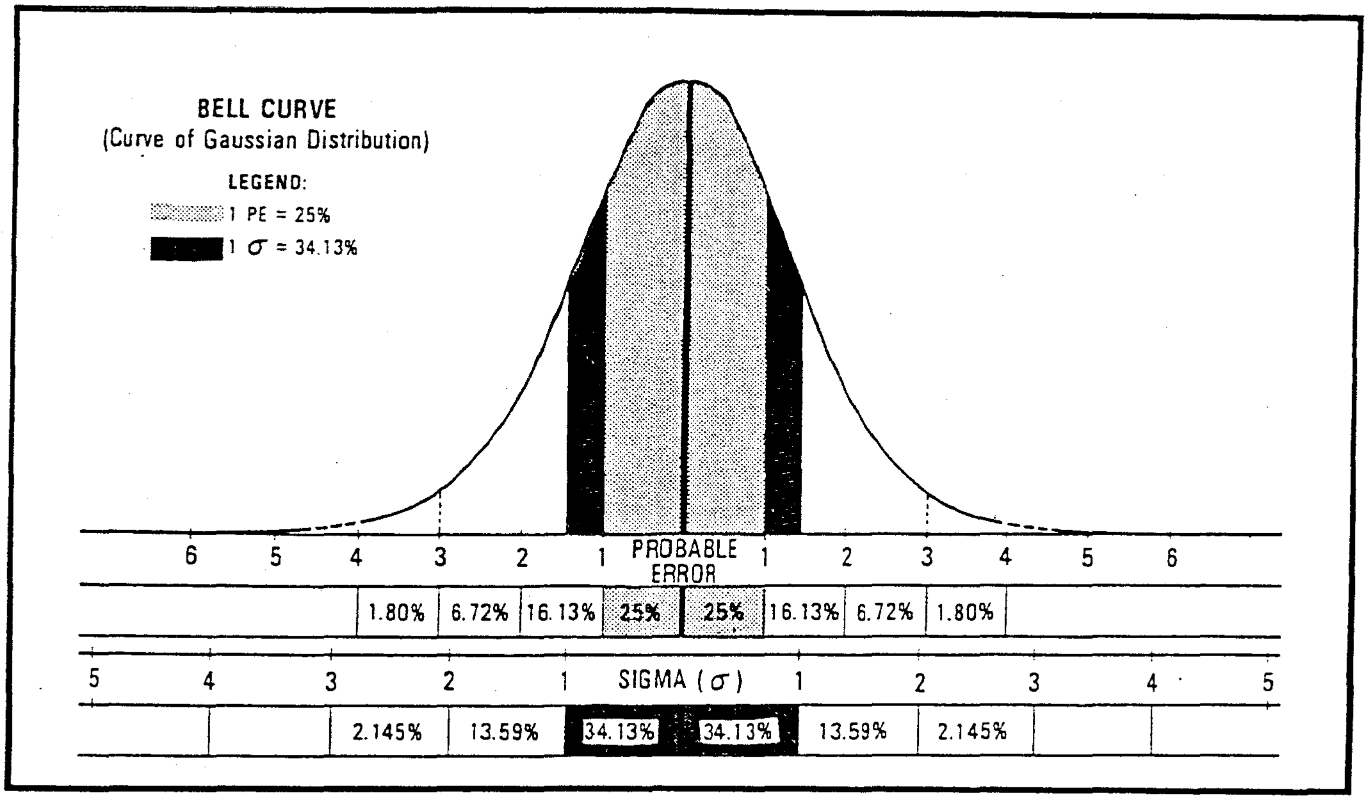


Figure III-1. Curve of Normal Distribution

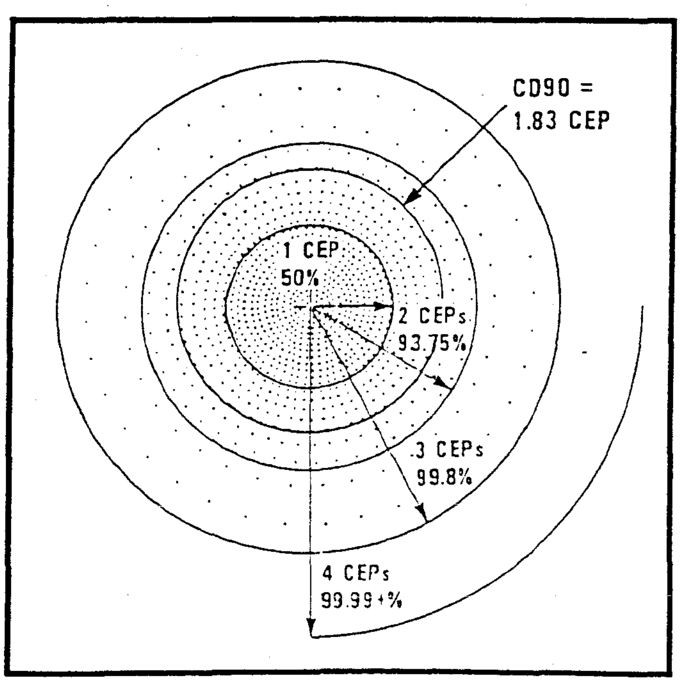


Figure III-2. Circular Pattern, Normal Distribution

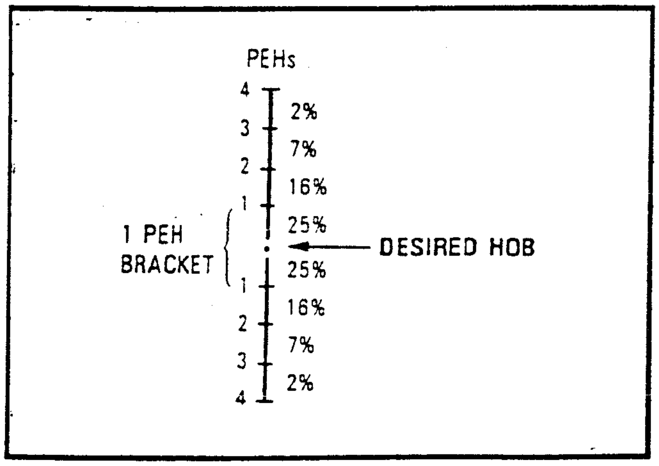


Figure III-3. Vertical Distribution

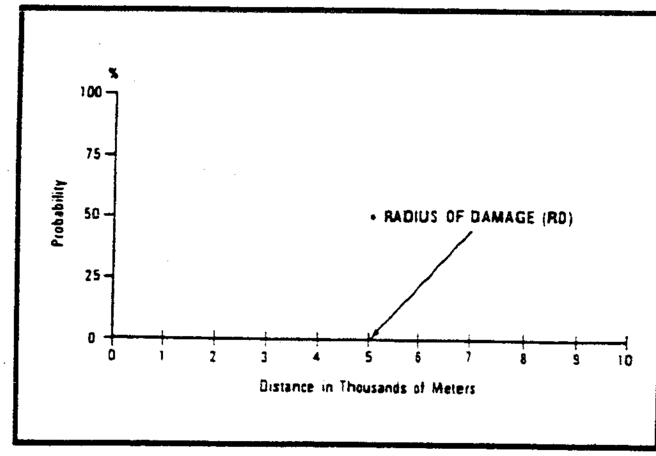
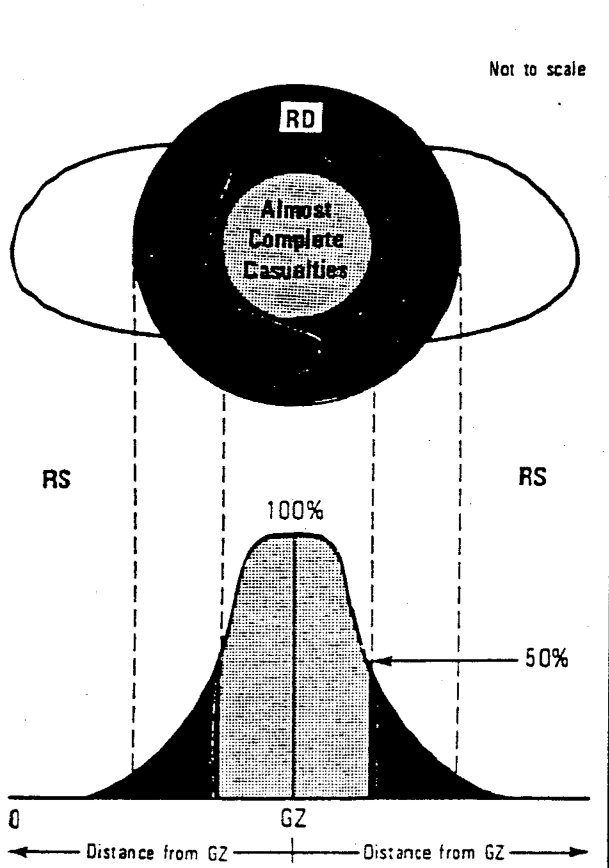


Figure III-5. A Point for a Radius of Damage Curve



The vertical axis shows the probability of an individual becoming a casualty. The probability decreases with distance from the GZ.

Figure III-4. Relationship of Percentage of Casualties to DGZ

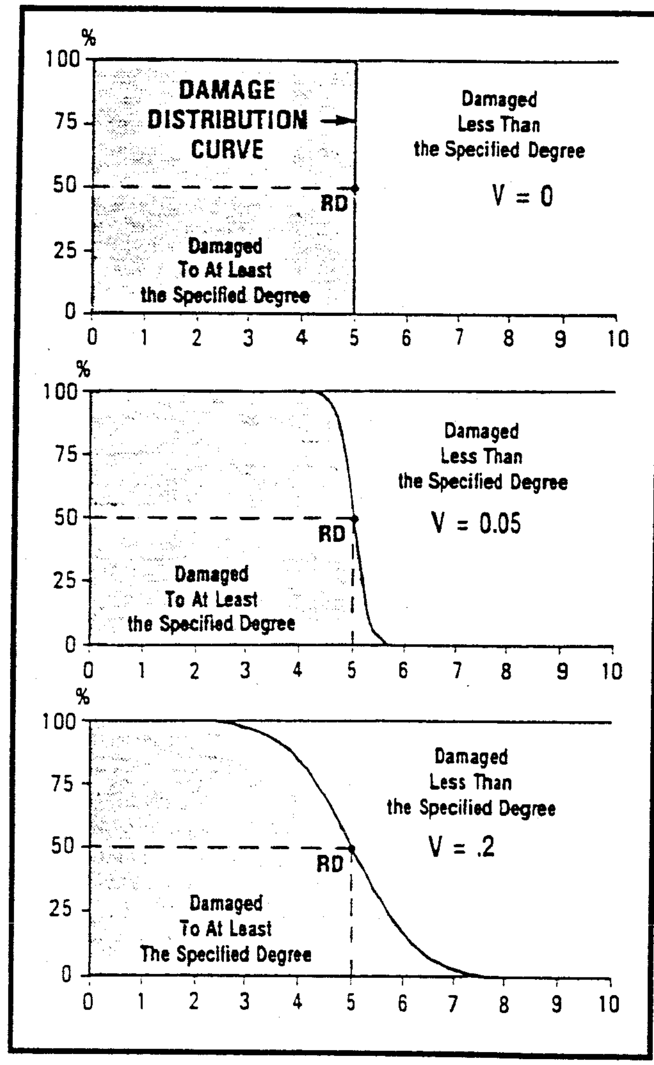


Figure III-6. Effects of Variability on Damage Distribution

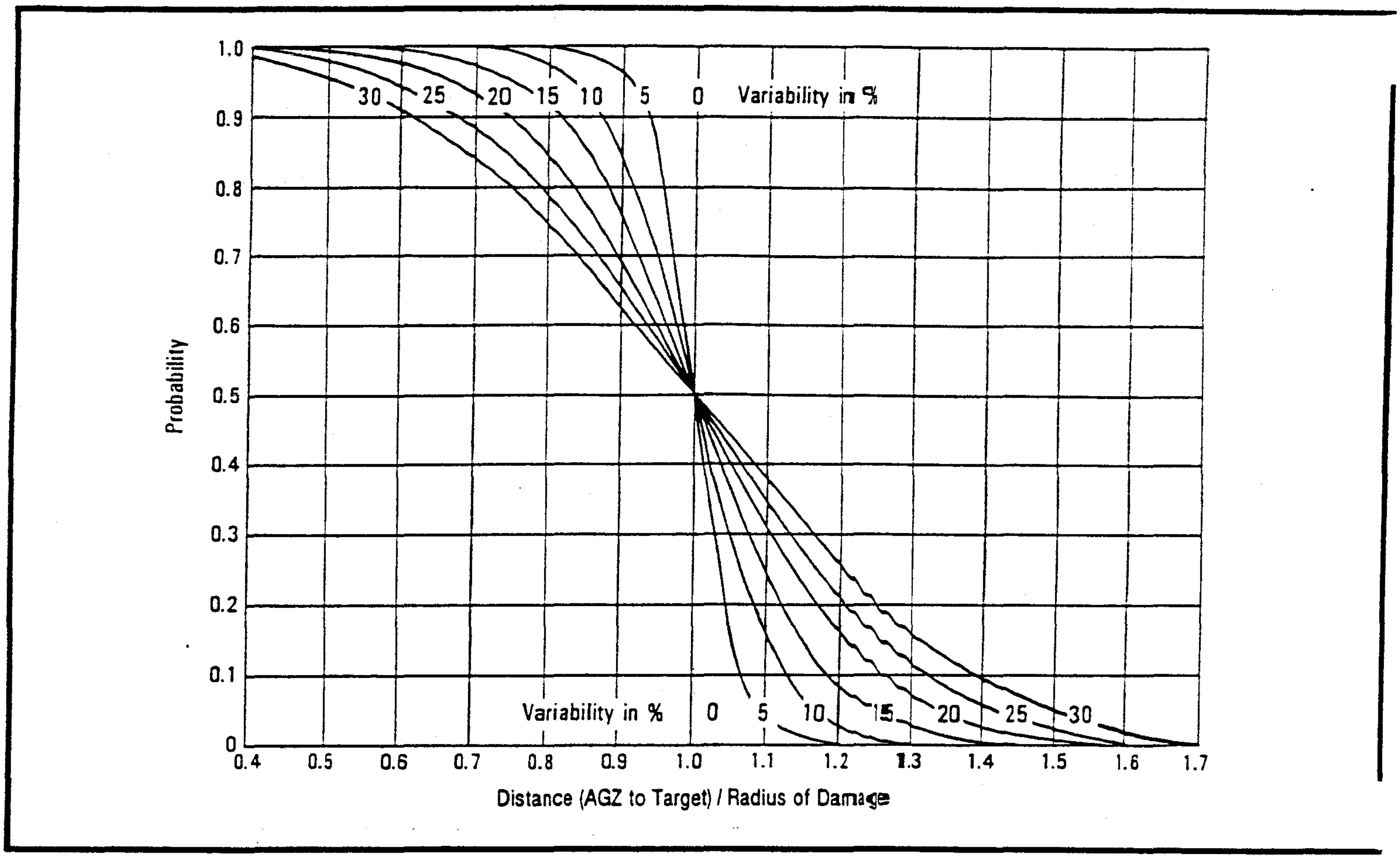


Figure III-7. Damage Distribution Curves

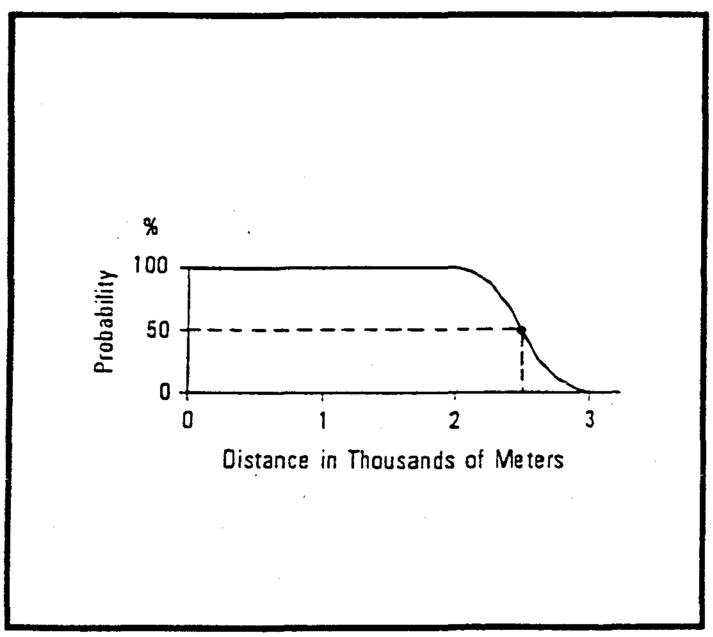


Figure III-8. Probability of Casualty

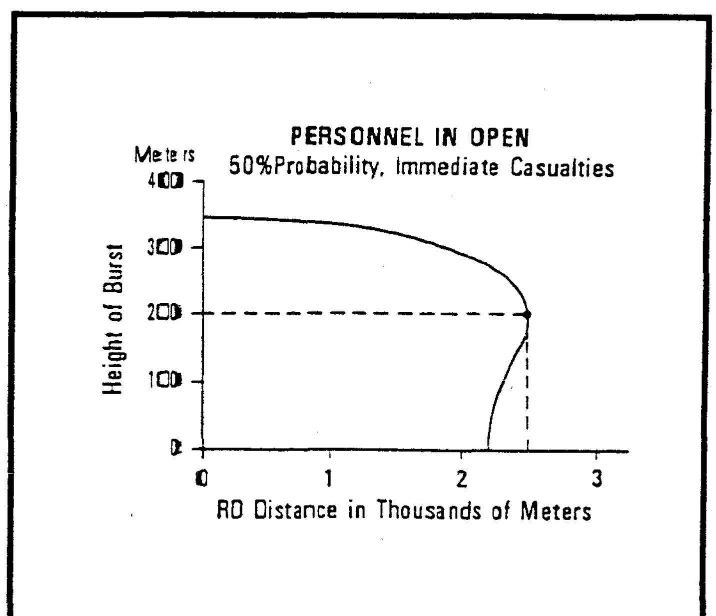


Figure III-9. Curve; RD; Casualties Versus HOB

CHAPTER IV
TARGET-ORIENTED AND PRECLUSION-ORIENTED METHODS FOR DAMAGE AND RESTRICTION CALCULATIONS

1. General

a. Target-Oriented Method. (See Figure IV-1.) This method is used when detailed target information is available. The probability of damage to point targets is determined with either the expected or high assurance technique. Only the expected coverage technique is used for considering the effects of delivery errors on area targets. The expected coverage technique is the sum of the products of all possible fractional coverages with their probability of occurring. It gives the best estimate of the effect that the weapon will probably have on the target. The numerical damage estimation technique is used to determine the probability of damage to point targets. To determine the expected coverage of an area target, target analysts have three damage estimation techniques: visual, index, and numerical. For the visual and the numerical damage estimation techniques, analysts must obtain data for RDs and accuracy from the tables in this publication, Chapters VII to XIX. For the index technique, analysts read the answers directly from the coverage tables. (See Figure IV-2.) Target analysts identify the appropriate coverage table based on the target category, desired target response, delivery system and yield. Analysts enter the table with CEP. For aircraft delivery, CEP is dependent upon the aircraft, delivery technique, weather, and training of the crew among other factors. For cruise missiles, CEP is dependent upon the distance the DGZ is from the last terrain update. Analysts can obtain estimates for the CEP from Joint Pubs or the delivery unit. Analysts round to the nearest CEP in the tables. If the given CEP is precisely between the closest two CEPs in the table, then analysts use the larger CEP. Accuracy data can be found in the system characteristics section of each weapon system chapter, Chapters VII to XIX, and RDs can be found in the effects tables for use in the visual and numerical techniques.

b. Preclusion-Oriented Method. This method is used when detailed target information about size, composition, disposition, location, and movement is not available. This method will permit analysts to select weapons based on personnel safety, obstacle and damage preclusion, and collateral damage constraints, as well as on any other limiting guidance provided by their commander.

2. Visual Technique. The visual technique of damage estimation may be used for area targets. It is the only one for analyzing area targets that cannot be equated to a circle, that is, those whose long axis is equal to or more than twice the short axis. The visual technique consists of estimating the fraction of the target covered by the RD and accounting for the delivery error. To calculate expected coverage (see Figure IV-3):

a. Extract the RD from the coverage tables using the given CEP. Draw concentric circles on a circular map scale with radii equal to the RD and CEP.

b. Select four equally spaced points on the CEP circle and place them on the DGZ. The four cardinal directions can be used.

c. Visually estimate the percent coverage of the target by the RD circle for each point.

d. Compute the average coverage. This is the expected fractional coverage or $\bar{f}$.

3. Index Technique. The index technique for estimating damage is the fastest technique available. It provides an accurate and simple way of predicting fractional coverage. It can be used whenever the following six conditions apply: the target is an area target; the target is circular or equatable to a circle (long axis is less than twice the short axis - see Figure IV-4); the target is, or is comparable to, one of the six primary target categories shown in this publication's coverage tables (see Figure IV-6); the DGZ is located at the target center or close enough so that considering the DGZ to target center offset distance (D) then $D + RD + CEP < RT$; the CEP and PEH are similar to those shown in the coverage tables; any TLE is small compared with RD and/or CEP. To determine the expected coverage (see Figure IV-7):

a. Select the coverage table for the target category, target response desired, delivery system, and yield.

b. Entering with the CEP and radius of target, extract the coverage index at the intersection.

c. The coverage tables can list only a limited number of CEPs and target radii.

d. Analysts enter the coverage table using the nearest listed CEP.

e. The radius of the target may not match any listed radii. If so, analysts interpolate between target radii by using linear interpolation rounded to one significant figure. When the computed coverage is exactly halfway between two numbers, they round down.

4. Numerical Technique. The numerical technique of target-oriented analysis is a powerful tool. It can be used to find fractional coverage of circular (or equatable) area targets and it can be used to determine the probability of destroying point targets. When engaging multiple targets with a single weapon, a numerical analysis can determine the maximum allowable displacement from target centers so that feasible aiming points can be selected that will meet command guidance for target coverage or probability. The analyst uses the graphs in Figures IV-8 and IV-9. On each of the graphs, the analyst calculates various ratios. The point where these ratios intersect on the body of the graph will fall on or near a coverage or probability curve. If the point falls between two curves, choose the closest curve. If the point is exactly halfway between two curves, choose the lower curve. On each graph there is a .95 and a .05 curve. These represent the boundaries outside of which coverage or probability would be expressed as 1.0 or 0.0, respectively. If the point falls on one of these curves, round down to .9 or 0.0, respectively.

a. Area Target, Expected Coverage Procedure with DGZ at Target Center. Using the area target graph (Figure IV-8) for expected coverage (DGZ at Target Center) follow the procedure below:

(1) Using the CEP, determine the RD from the coverage tables, and get the target radius (RT).

(2) Compute the ratios RD/RT and CEP/RT.

(3) Find the points of intersection on the area target graph of RD/RT and CEP/RT. This is the expected fractional coverage, $\overline{f}$.

b. Area Target, Expected Coverage Procedure with Displaced DGZ. To determine fractional coverage with a displaced DGZ, use the following method (see Figure IV-11):

(1) Using the CEP, determine the RD from the coverage tables, and get RT and the distance (D) the DGZ is displaced from the target center.

(2) If $(D + RD + CEP) \leq RT$, use the area target graph for expected coverage (Figure IV-8), and solve the coverage problem as if DGZ were at the target center $(D = 0)$. This approximation assumes that fractional coverage will be about the same for all cases in which the RD circle lies entirely within the target.

(3) If $(D + RD + CEP) > RT$, use the Area Target Graph -(Expected Coverage) Displaced DGZ (Figure IV-9) to compute an adjusted CEP (CEPA) as follows: (SQT(x) means the square root of x.)

$$CEPA = SQT(CEP^2 + .4\ (RT^2))$$

or

$$CEPA = SQT(CEP^2(1 + .4\ (RT/CEP)^2))$$

Or use the graphic aid found at the lower right corner of the Area Target Graph - (Expected Coverage) Displaced DGZ. Calculate the ratio RT/CEP. Enter the graph with that ratio and intersect vertically with the curve. At the point of intersection, read the multiplier factor (k) off the right vertical axis. CEPA = k x CEP.

(4) Determine the ratios RD/CEPA and D/CEPA.

(5) Enter the Area Target Graph - (Expected Coverage) Displaced DGZ with RD/CEPA on the vertical axis and D/CEPA on the horizontal axis. The point where the two entry values intersect is the expected fractional coverage, $\bar{f}$.

c. Area Target, Expected Coverage Procedure to Determine Maximum DGZ Offset Distance (DMAX). Use the Area Target Graph - (Expected Coverage) Displaced DGZ (Figure IV-9) and follow the procedure below (see Figure IV-12):

(1) Using the CEP, determine the RD from the coverage tables and get RT and $\bar{f}$.

(2) Compute the CEPA with the value for k taken from the lower right portion of the graph (Figure IV-9):

$$CEPA = k \times CEP$$

or use the formula:

$$CEPA = SQT(CEP^2 + .4\ (RT^2))$$

(3) Determine the ratio RD/CEPA.

(4) Enter the Area Target Graph - (Expected Coverage) Displaced DGZ with the ratio RD/CEPA. Extend to the right and intersect the desired coverage curve.

(5) From the intersection in step 4 above, drop vertically to the D/CEPA axis, and read the D/CEPA value.

(6) Solve for DMAX by multiplying the D/CEPA value by the CEPA. The product is DMAX.

d. Point Target, Expected Probability of Damage Procedure. Single element targets such as bridges or missile launchers are point targets. Additionally, area targets are considered point targets when the RD is large compared to the RT (RD/RT > 10) or when the horizontal delivery error, CEP, is large compared to the RT (CEP/RT > 10). Probability of damage is the major concern in engaging point targets. The expression P = .8 means that there are 80 out of 100 chances that the target will receive at least the specified damage. The curves on the point target graph in Figure IV-9 indicate the probability of achieving the specified degree of damage for particular ratios. For point targets, three variables influence the probability of damage: RD, CEP, and D. The vertical axis represents RD/CEP; the horizontal axis represents D/CEP. For any given RD, CEP, and D, analysts can calculate the probability of achieving the desired degree of damage to a point target. In the upper left portion of the graph is the extension for use when RD/CEP and/or D/CEP is greater than 10. When the values of the ratios on the point target graph exceed the maximum value, the RD or the D is so large with respect to the CEP that the horizontal delivery error will be insignificant. The point target graph extension shows the probability of achieving the desired degree of damage to a point target when the horizontal dispersion is zero. This scale uses the ratio D/RD for the entry value. To calculate probability of damage (see Figure IV-13):

(1) Enter the appropriate coverage table with the CEP (or effects table for most point targets) and extract the RD.

(2) Compute the ratio RD/CEP and, if a displacement exists, D/CEP.

(3) If there is no DGZ displacement, read P directly from the vertical axis (RD/CEP) of the graph. If the DGZ is displaced from the target, read P at the intersection of the RD/CEP ratio and the D/CEP ratio. If the point of intersection falls between curves, interpolate between the curves. If RD/CEP and/or D/CEP is greater than 10, calculate D/RD, enter the point target graph extension with that value, and read the corresponding probability.

e. <u>Point Target Procedures to Determine DMAX When RD/CEP < 10</u>. To calculate DMAX when the RD/CEP ratio is less than 10, use the following procedure (see Figure IV-14):

(1) Enter the appropriate coverage table with the CEP and extract the RD.

(2) Compute the RD/CEP ratio and get the desired probability of damage.

(3) Enter the graph with the RD/CEP ratio and move horizontally across the graph to the right until that entry intersects the minimum acceptable probability curve.

(4) Determine the D/CEP value for the point of intersection found in sub-paragraph 4e(3). Solve for DMAX by multiplying the CEP by the D/CEP value at the point of intersection of the RD/CEP ratio and the probability curve.

f. <u>Point Target Procedure to Determine DMAX When RD/CEP > 10</u>. To calculate DMAX when the RD/CEP ratio is greater than 10, use the following procedure (see Figure IV-14):

(1) Enter the appropriate coverage table with the CEP and extract the RD.

(2) Compute the RD/CEP ratio. If this ratio is greater than 10, use the point target graph extension.

(3) Using the extension, determine a D/RD value corresponding to the required probability.

(4) Multiply the D/RD value by the RD to obtain the DMAX. If P = .9, DMAX = .73 x RD.

g. Point Target, High Assurance Probability of Damage Procedure. The P90 to a point target is calculated using the point target graph extension in Figure IV-9 and the parameters RD, CD90, and D. This method is used for critical targets when the analysts need a conservative estimate of the probability of damage. To calculate P90 (see Figure IV-15):

(1) Enter the appropriate coverage tables with the CEP and extract RD and CD90.

(2) Determine the DGZ to target offset distance, D.

(3) If D = 0, enter the point target graph extension with the ratio CD90/RD (instead of D/RD) and read the corresponding P90.

(4) If D > 0, the analyst must determine a CD90 multiplication factor (MF) from the graph in Figure IV-10. Enter the graph with the ratio D/CD90 and read MF from the vertical axis. Go to the point target graph extension with the ratio MF x CD90/RD (instead of D/RD) and read the corresponding P90.

h. Point Target Procedures to Determine DMAX for High Assurance. To calculate DMAX for a specified P90 (see Figure IV-16):

(1) Enter the appropriate coverage table with the CEP and extract RD and CD90.

(2) Enter the point target graph extension in Figure IV-16 with P90 and read the corresponding D/RD ratio.

(3) Multiply the ratio from (2) above by RD to obtain the impact distance from the target that the weapon is assumed to have in order to achieve P90.

(4) Divide the product from (3) above by CD90 to obtain the MF.

(5) If MF from (4) above is less than or equal to one, there can be no DGZ to target offset distance (DMAX = 0) and still achieve P90.

(6) If MF is greater than one, enter the vertical MF axis of the graph in Figure IV-10 with MF and read the corresponding D/CD90 ratio from the horizontal axis. The product of this ratio and CD90 is DMAX.

5. Restriction Calculations. In addition to predicting the damage to enemy targets, the analyst must consider the possibility of undesired damage or injury because of the effects of friendly nuclear weapons. To preclude these undesirable effects, also known as limiting requirements, analysts use the three distance concepts defined in Chapter III: MSD, CDD, and LSD.

a. MSD Procedure. To calculate the MSD for personnel safety, follow the procedure below:

(1) The safety distance table is entered with the nearest listed CEP. If the actual CEP is halfway between two listed CEPs, the larger of the two MSDs is used (see Figure IV-17).

(2) On a nuclear battlefield, units may be repeatedly exposed to radiation from friendly as well as enemy nuclear weapons. Analysts must consider the consequences of further exposure for personnel who have already been exposed. Friendly units are placed in one of four radiation exposure states, RES 0 through RES 3, based on previous exposure. For additional information, see Appendix B and FM 3-3-1. The MSDs listed in the safety distance tables are based on no previous RES 0. Using the appropriate safety distance table, analysts determine whether prior radiation must be considered in safety calculations as shown by an (*). An asterisk (*) above a particular safety and risk category in the MSD table denotes that radiation is the dominant effect for personnel

safety considerations. If so, they must also use Figure IV-18 to modify the appropriate MSD. For example, when the delivery weapon has a CEP of 150 meters and the personnel risk and vulnerability condition is negligible risk to exposed personnel and they are in RES 2, the MSD would have to be modified: MSD = 1500 + 200 = 1700.

b. CDD Procedure. To calculate the CDD, use the following procedure:

(1) The collateral damage distance table is entered with the nearest listed CEP. If the actual CEP is halfway between two listed CEPs, the larger of the two CDDs is used (see Figure IV-19).

(2) Select the CDD for each appropriate collateral category. If the personnel posture or building type is unknown, select the largest CDD for each appropriate category.

c. LSD Procedure. To calculate the LSD for damage and obstacle avoidance, use the following procedure:

(1) Enter the LSD portion of the safety distance table (see Figure IV-20).

(2) Select the LSD for each appropriate material category. If the building damage level, type of aircraft (or more than one is present), or tree or fuel is unknown, select the largest LSD for each appropriate category.

6. DGZ Calculations. Once the available weapons, target type, and limiting requirements have been determined, the analyst should select the optimum location for the DGZ. Initially, the DGZ should be at the target center. However, at times it will become necessary to displace the DGZ primarily to meet limiting requirements, cover multiple targets, or fulfill both reasons above. Analysts determine the appropriate limiting requirements, MSD, CDD, and LSD, for each available delivery system and yield. The DGZ must be located at a distance equal to, or greater than, the LSD, CDD, and MSD. The DGZ is located as close as possible to the target center while still satisfying the limiting requirements. For multiple targets, analysts determine the DMAX for the appropriate targets. The DGZ must be located at a distance equal to, or less than, the DMAX from the respective targets. An area of overlap is an area for the

DGZ that gives additional coverage or probability above the minimum required. This additional coverage is normally divided among the area targets. If all targets are point targets, the additional probability is divided among them. One target may be specified to receive all the additional coverage. In this case, the DMAX is not computed for that target. The DGZ is located as close as possible to the target center while still providing the minimum acceptable coverage or probability to the other targets. The analysts then select the weapon that results in the largest fractional coverage or probability of damage. See Figures IV-21 through IV-24 for sample DGZ calculations.

7. <u>Preclusion Method</u>. With this method, analysts first determine the appropriate MSD, LSD, and CDDs for the available weapon systems and yields. These are determined by entering the appropriate tables with the nearest listed CEP. If the actual CEP is halfway between two listed CEPs, the larger of the two distances is used. Then the analyst displays them graphically. Draw the appropriate values to scale on a map overlay. The CDDs are scribed to scale around the appropriate preclusion area. The LSDs are drawn to scale around the area to provide preclusion. The MSDs are drawn to scale from the forward line of own troops and lateral tactical boundaries to ensure personnel safety. Analysts next eliminate unsuitable weapons where the limiting requirements offer no areas for possible DGZ selection. For the remaining weapon systems, analysts select DGZs so that the RDs will give the most complete coverage for the proposed area of employment based on target categories and command guidance for defeating these targets. These DGZs must be consistent with limiting requirements, weapon systems and yields available, the threat, and the military situation.

8. <u>Poststrike Analysis</u>. When nuclear weapons are used to attack targets, poststrike surveillance ascertains the degree of success. Before this surveillance can be completed, target analysts refine damage predictions using the following information: actual location of GZ, estimation of the yield, and actual HOB. Army FM 3-3-1 provides information concerning nuclear burst surveillance, data collection, and reporting techniques. The two techniques used to estimate damage are the visual and the numerical. Each technique requires knowledge of the actual location of the GZ, the realized yield, and the actual HOB. Yield and HOB are used only to establish whether the weapon detonated normally. Yield is considered normal if it is within 10 percent of the designed yield, while the HOB is

considered normal if the detonation occurred within 2.5 PEH of the aimpoint. In instances where the actual GZ and HOB are not known, poststrike damage estimations must rely on intelligence reports or actual observation of the target area.

a. Visual Technique. The visual technique of poststrike damage estimation is used to refine damage predicted against irregularly shaped targets. To use this method, analysts plot the actual GZ in relation to the target. Once that is done, they extract the RD from the effects table based on the nearest HOB, or use expected RD based on target category, type of burst, yield, and CEP. Using this RD on the appropriate circular map scale, analysts place the center of the map scale over GZ and visually estimate the fractional coverage (see Figure IV-25).

b. Numerical Technique. The numerical technique of poststrike damage estimation is used for circular area and point targets.

(1) Area Targets. When this technique is used on circular area targets, analysts must know the actual GZ in relation to the target center, the RT, and the expected RD. Using the numerical technique, analysts enter the Area Target Graph - Poststrike Analysis (Figure IV-26) with the ratios RD/RT and D/RT. At the intersection of the two ratios, analysts read the fractional coverage (see Figure IV-27).

(2) Point Targets. The numerical technique of poststrike damage estimation is used for point targets. Because no delivery error is associated with the prediction, analysts enter the point target graph extension with the proper ratio value for D/RD, and read the probability of the target being destroyed (see Figure IV-28).

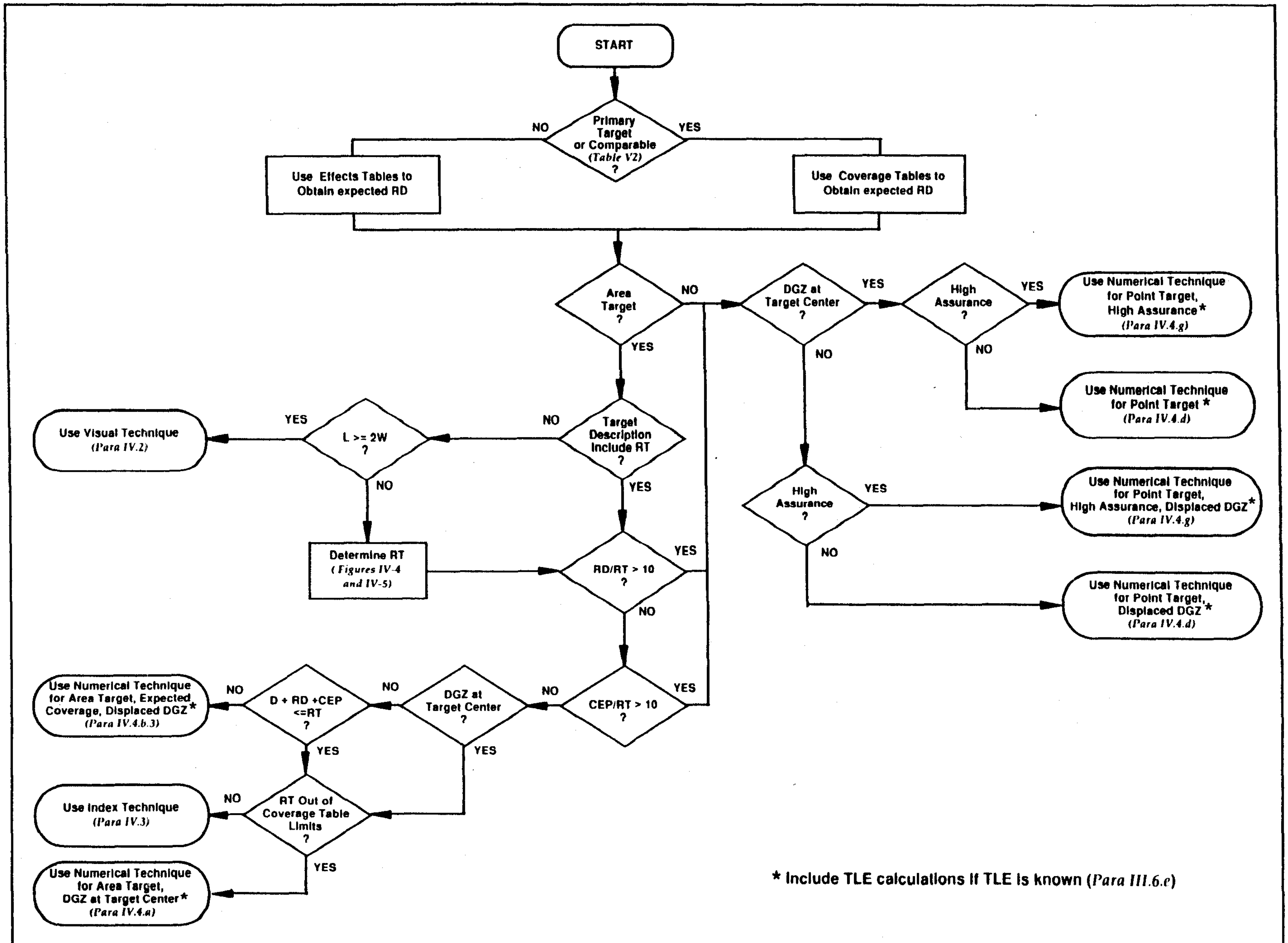


Figure IV-1. Procedures for Selecting Damage Estimate Technique

BIG BOMB
10 KT - Y2

TARGET COVERAGE

EXPOSED PERSONNEL

ENTER BY CEP

IMMEDIATE PERMANENT - AIRBURST

COVERAGE RADIUS OF TARGET (IN METERS)								ACCURACY DATA (IN METERS)				
400	600	800	1100	1250	1450	1900	2500	RD	CD90	CEP	HOB	PEH
1.0	.9	.8	.6	.4	.3	.2	.1	806	273	150	200	8
.9	.8	.7	.5	.4	.3	.2	.1	806	547	300	200	8
.8	.7	.6	.5	.4	.3	.2	.1	806	820	450	200	8
.6	.6	.5	.4	.4	.3	.2	.1	806	1094	600	200	8

IMMEDIATE TRANSIENT - AIRBURST

COVERAGE RADIUS OF TARGET (IN METERS)								ACCURACY DATA (IN METERS)				
600	800	1100	1450	1600	1750	2500	3000	RD	CD90	CEP	HOB	PEH
1.0	.9	.7	.5	.4	.3	.2	.1	953	273	150	200	8
.9	.8	.7	.5	.4	.3	.2	.1	953	547	300	200	8
.8	.7	.6	.4	.4	.3	.2	.1	953	820	450	200	8
.7	.6	.5	.4	.3	.3	.2	.1	953	1094	600	200	8

LATENT INEFFECTIVENESS - AIRBURST

COVERAGE RADIUS OF TARGET (IN METERS)								ACCURACY DATA (IN METERS)				
950	1300	1500	1750	2000	2500	3200	4000	RD	CD90	CEP	HOB	PEH
1.0	.9	.8	.6	.5	.3	.2	.1	1344	273	150	200	8
.9	.8	.7	.6	.5	.3	.2	.1	1344	547	300	200	8
.9	.8	.7	.6	.5	.3	.2	.1	1344	820	450	200	8
.8	.7	.6	.5	.4	.3	.2	.1	1344	1094	600	200	8

Figure IV-2. Typical Coverage Table

Problem

Find the expected fractional coverage ($\bar{f}$)

Given

Target shape: irregular (see (A) below)

CEP: 540 meters

RD: 881 meters

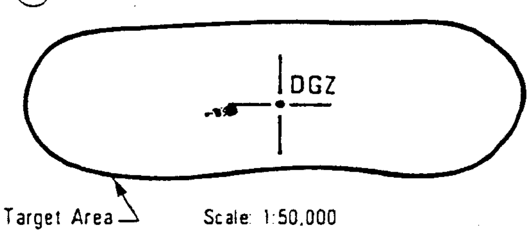
Solution

1. Draw the CEP and expected RD on the circular map scale. See (B) at right.
2. Place the map scale over the target area so that the CEP circle touches the DGZ in any one of the four cardinal directions. In Diagram (C) the template is oriented east of the DGZ. Any set of four points spaced 90 degrees apart could be used.
3. Estimate to the nearest tenth the fraction of the target area covered by the RD circle. This is $\bar{f}$. For Diagram (C), $\bar{f}$ = .4.
4. Repeat the estimate for the other three directions. Diagram (D) shows the template oriented north of the DGZ, where $\bar{f}$ = .3.
5. Average the four coverages. This is the expected fractional coverage.

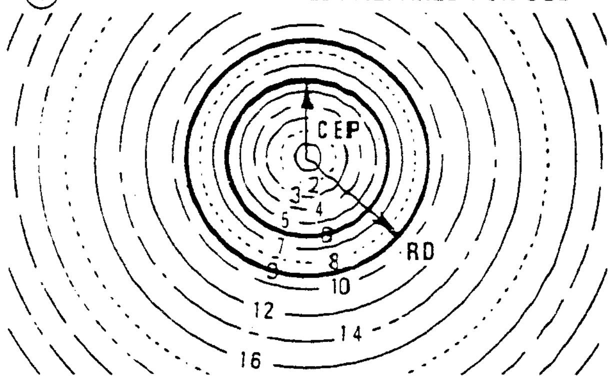
Direction	Coverage
East	.4
North	.3
West	.5
South	.3

$\bar{f} = (.5 + .3 + .4 + .3)/4 = 1.5/4 = .375 \cong .4$

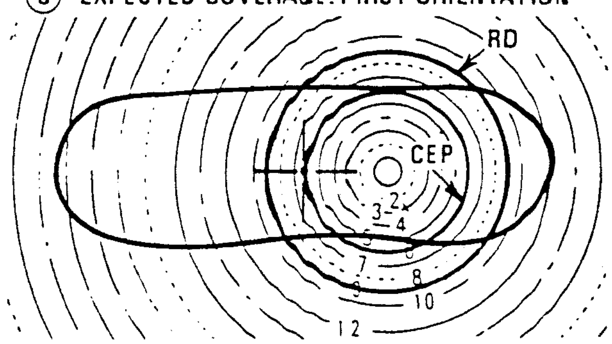
(A) IRREGULAR TARGET



(B) CIRCULAR MAP SCALE PREPARED FOR USE



(C) EXPECTED COVERAGE: FIRST ORIENTATION



(D) EXPECTED COVERAGE: SECOND ORIENTATION

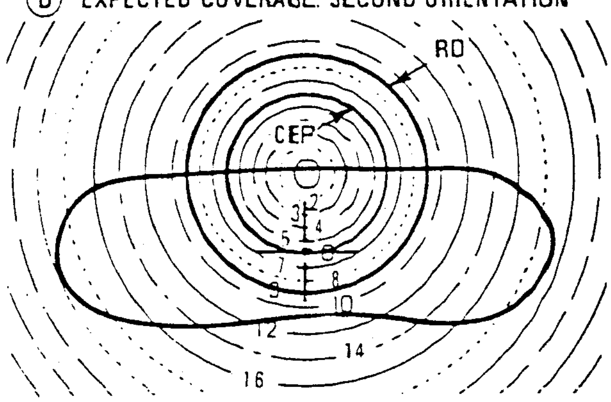


Figure IV-3. Example of Expected Fractional Coverage (Visual)

If the target is circular or nearly so, RT is the radius of the target circle. If the area target length is less than twice the width, then equate to a circle by the following procedure. This procedure permits the target analyst to convert almost any geometric shape into a usable target radius. Analysts can establish the target radius by drawing a circle around the outside of the target area and another circle on the inside of the target area, touching as many sides as possible, then add the radius of the inside circle (Ri) to the radius of the outside circle (Ro) and divide the total by two to determine the equivalent target radius RT (see Figure IV-5). They may also use the nomographs to convert to circles of equivalent area (see Figure IV-5). When the length is at least twice the width, then the target cannot reasonably be equated to a circle, and the visual method must be used.

$$RT = \frac{Ri + Ro}{2}$$

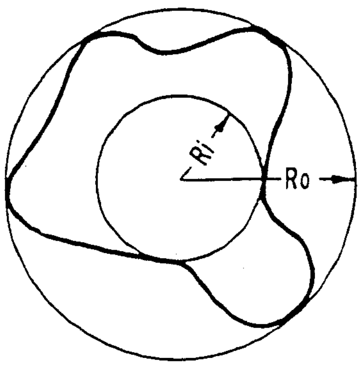
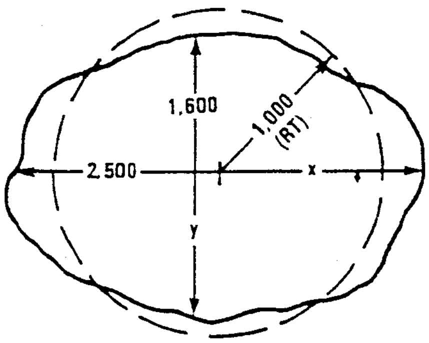


Figure IV-4. Example of Equivalent Target Radius

ELLIPTICAL TARGET



Use the nomograph to determine the target radius (RT) of a circle equivalent in area to an ellipse with a longer axis x and a shorter axis y. Use it only when x ÷ y is less than 2.

Example:

Problem

Find the RT for a circle of equivalent area.

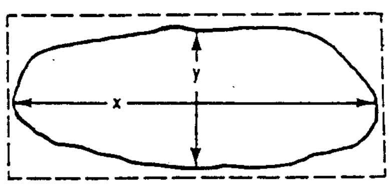
Given

Rectangular or elliptical target with x = 2,500 meters and y = 1,600 meters.

Solution

1. The conversion nomogram is used because x ÷ y is less than 2.
2. Placing a straightedge to intersect 2,500 on the x scale and 1,600 on the y scale, determine the point of intersection with the RT scale.
3. At the intersection with the RT scale, read RT = 1,000 meters.

RECTANGULAR TARGET



For a rectangle with longer axis x and shorter axis y (x ÷ y is less than 2), determine the equivalent RT by following steps 1-3 above and then multiply number read from graph by **1.1284** to obtain RT.

(For example, with dimensions above RT for rectangle would be 1128 meters)

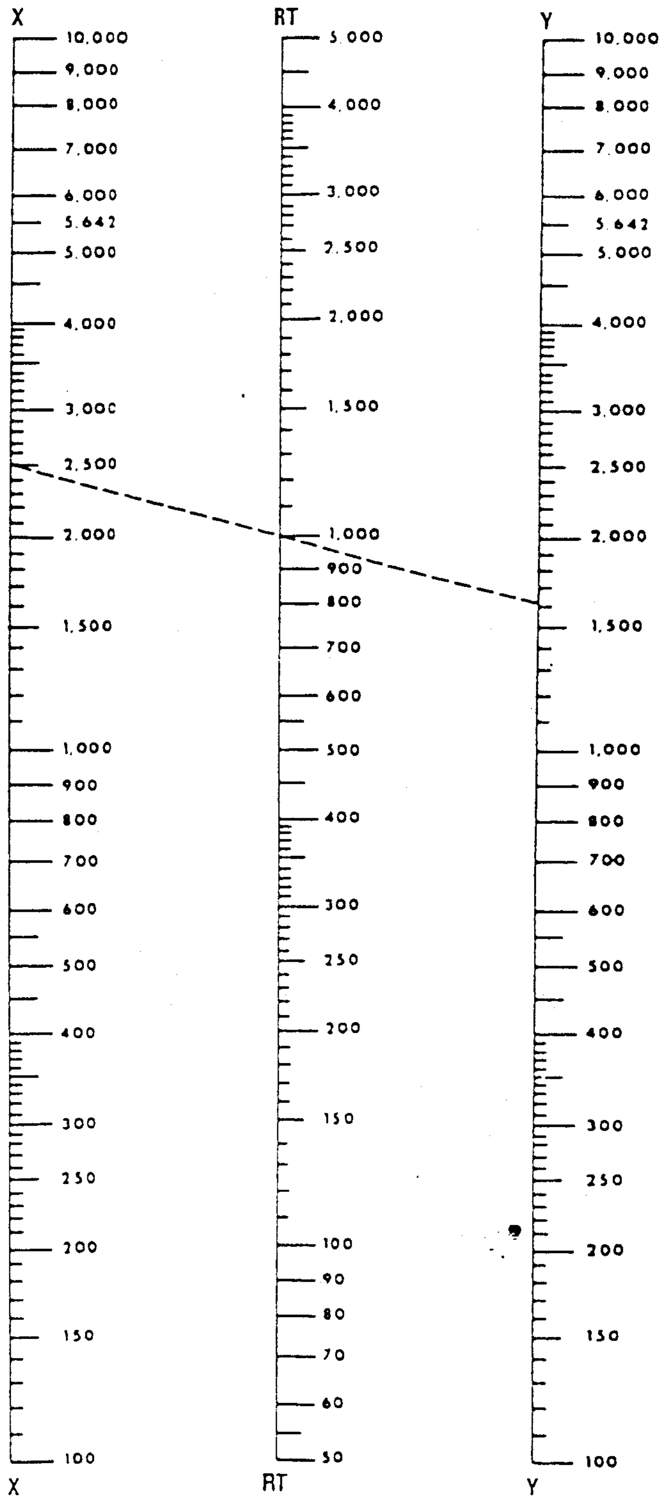


Figure IV-5. Equivalent Target Area Conversion Nomograph

This manual presents data for only six primary target categories in the coverage tables. However, other targets respond quite similarly to one of them. The comparable target table (see below) makes such comparisons. To use it, analysts inspects the secondary target column to determine if the target of interest is considered a secondary target. If it is listed, they can then move across to see if yield and damage constraints are met. If so, the analyst then moves into the body of the chart to find the primary target category and response to which the secondary target is comparable.

Secondary Targets (From Effects Tables)			Primary Targets in Coverage Tables					
			Exposed Personnel LI	Personnel in Open Foxholes ITI	Personnel in Tanks ITI	Moderate Damage to Tanks	Moderate Damage to APCs	Moderate Damage to Wheeled Vehicles
Factories (25-50 ton Crane Capacity)	All Yields	Severe Damage				●		
Fixed Bridges	≤ 55 KT	Severe Damage					●	
Floating Bridges	≤ 55 KT	Severe Damage					●	
Missiles/Rockets in Open	≤ 100 KT	Severe Damage						●
Railroad Boxcars and Flat Cars (loaded)	All Yields	Severe Damage						●
Tracked Vehicles (not tanks)	All Yields	Severe Damage					●	
Heavy Towed and Self-Propelled Artillery	All Yields	Moderate Damage				●		
Personnel in Brick Apartment Buildings	≤ 55 KT	LI	●					
	≤ 10 KT	IPI			●			
Personnel in APCs	≤ 100 KT	IPI		●				
Personnel in Earth Shelters	All Yields	LI		●				

For preclusion of damage to naval ships, the LSDs to use are
≤100kT Light Damage To Buildings
>100kT Forest Debris Fires, Deciduous

Figure IV-6. Comparable Target Table

PROBLEM

Find the expected fractional coverage for Exposed Personnel, Latent Ineffectiveness with an RT of 1600.

GIVEN

Delivery System: Big Bomb
RT: 1600
Yield: 10 KT
CEP: **225**

SOLUTION

Since the CEP is exactly halfway between two listed, then we enter with the CEP which has the smaller RD. Since the RDs are the same at both CEPs we enter with the larger CEP. RT 1600 falls between 1500 and 1750. Linear interpolation is required.

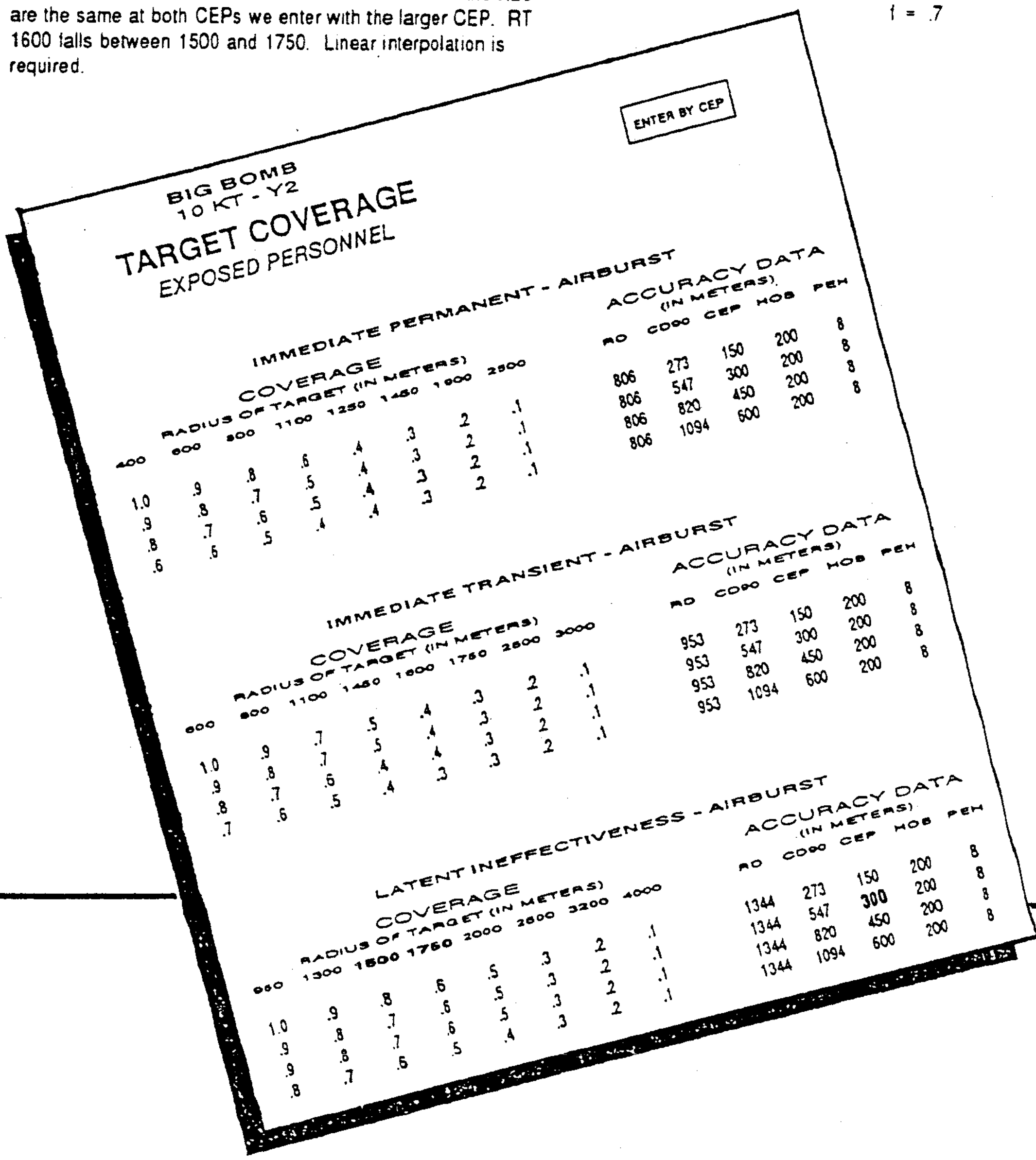
$$(250)\left[\begin{array}{l}1500\\ 1600\\ 1750\end{array}\right](150) \qquad (u)\left[\begin{array}{l}.7\\ \bar{f}\\ .6\end{array}\right](.1)$$

$$u = \frac{150}{250} \times .1$$

u = .06 (nearest hundreth)

$\bar{f}$ = .6 + .06 = .66 (round up to .7)

f = .7



ENTER BY CEP

BIG BOMB
10 KT - Y2
TARGET COVERAGE
EXPOSED PERSONNEL

IMMEDIATE PERMANENT - AIRBURST

COVERAGE – RADIUS OF TARGET (IN METERS) 400	600	800	1100	1250	1450	1900	2500	ACCURACY DATA (IN METERS) RD	CDDO	CEP	HOB	PEH
1.0	.9	.8	.6	.4	.3	.2	.1	806	273	150	200	8
.9	.8	.7	.5	.4	.3	.2	.1	806	547	300	200	8
.8	.7	.6	.5	.4	.3	.2	.1	806	820	450	200	8
.6	.6	.5	.4	.4	.3	.2	.1	806	1094	600	200	8

IMMEDIATE TRANSIENT - AIRBURST

COVERAGE – RADIUS OF TARGET (IN METERS) 600	800	1100	1450	1600	1750	2600	3000	ACCURACY DATA (IN METERS) RD	CDDO	CEP	HOB	PEH
1.0	.9	.7	.5	.4	.3	.2	.1	953	273	150	200	8
.9	.8	.7	.5	.4	.3	.2	.1	953	547	300	200	8
.8	.7	.6	.4	.4	.3	.2	.1	953	820	450	200	8
.7	.6	.5	.4	.3	.3	.2	.1	953	1094	600	200	8

LATENT INEFFECTIVENESS - AIRBURST

COVERAGE – RADIUS OF TARGET (IN METERS) 950	1300	1500	1750	2000	2600	3200	4000	ACCURACY DATA (IN METERS) RD	CDDO	CEP	HOB	PEH
1.0	.9	.8	.6	.5	.3	.2	.1	1344	273	150	200	8
.9	.8	.7	.6	.5	.3	.2	.1	1344	547	**300**	200	8
.9	.8	.7	.6	.5	.3	.2	.1	1344	820	450	200	8
.8	.7	.6	.5	.4	.3	.2	.1	1344	1094	600	200	8

Figure IV-7. Expected Fractional Coverage (Index)

UNCLASSIFIED

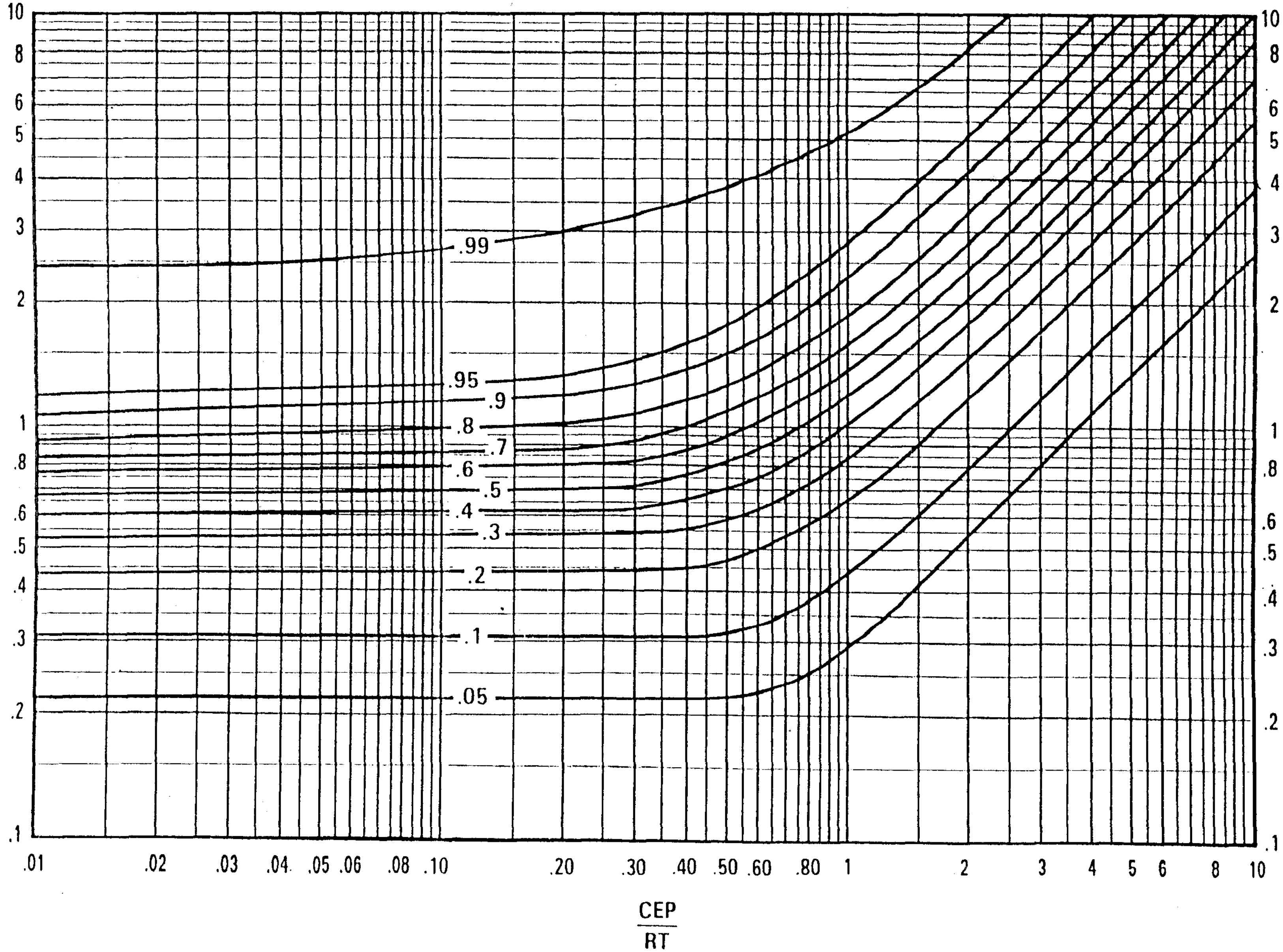
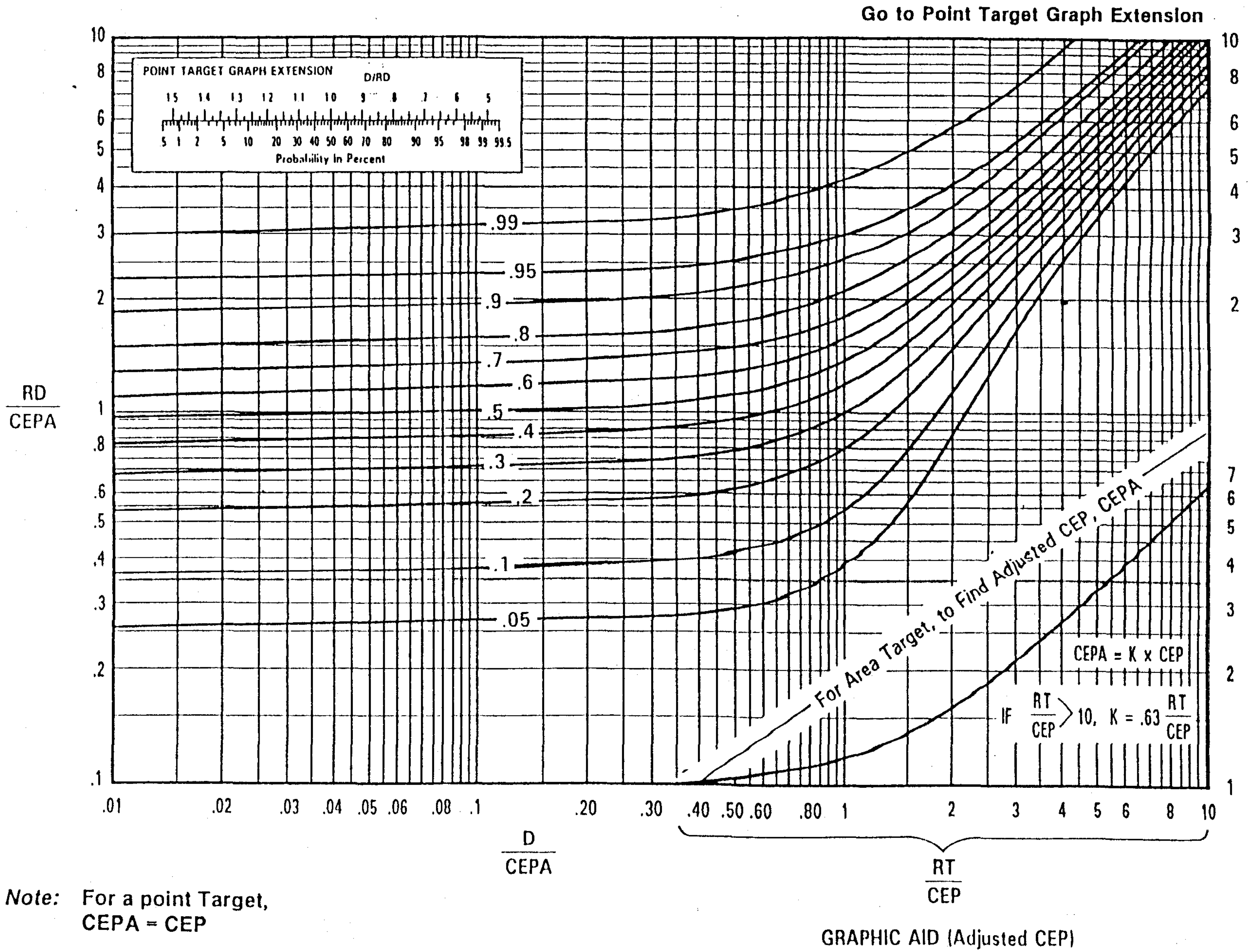


Figure IV-8. Area Target Graph-(Expected Coverage) DGZ @ Target Center

UNCLASSIFIED



Note: For a point Target, CEPA = CEP

Figure IV-9. Area Target Graph-(Expected Coverage) Displaced DGZ and Point Target Graph

UNCLASSIFIED

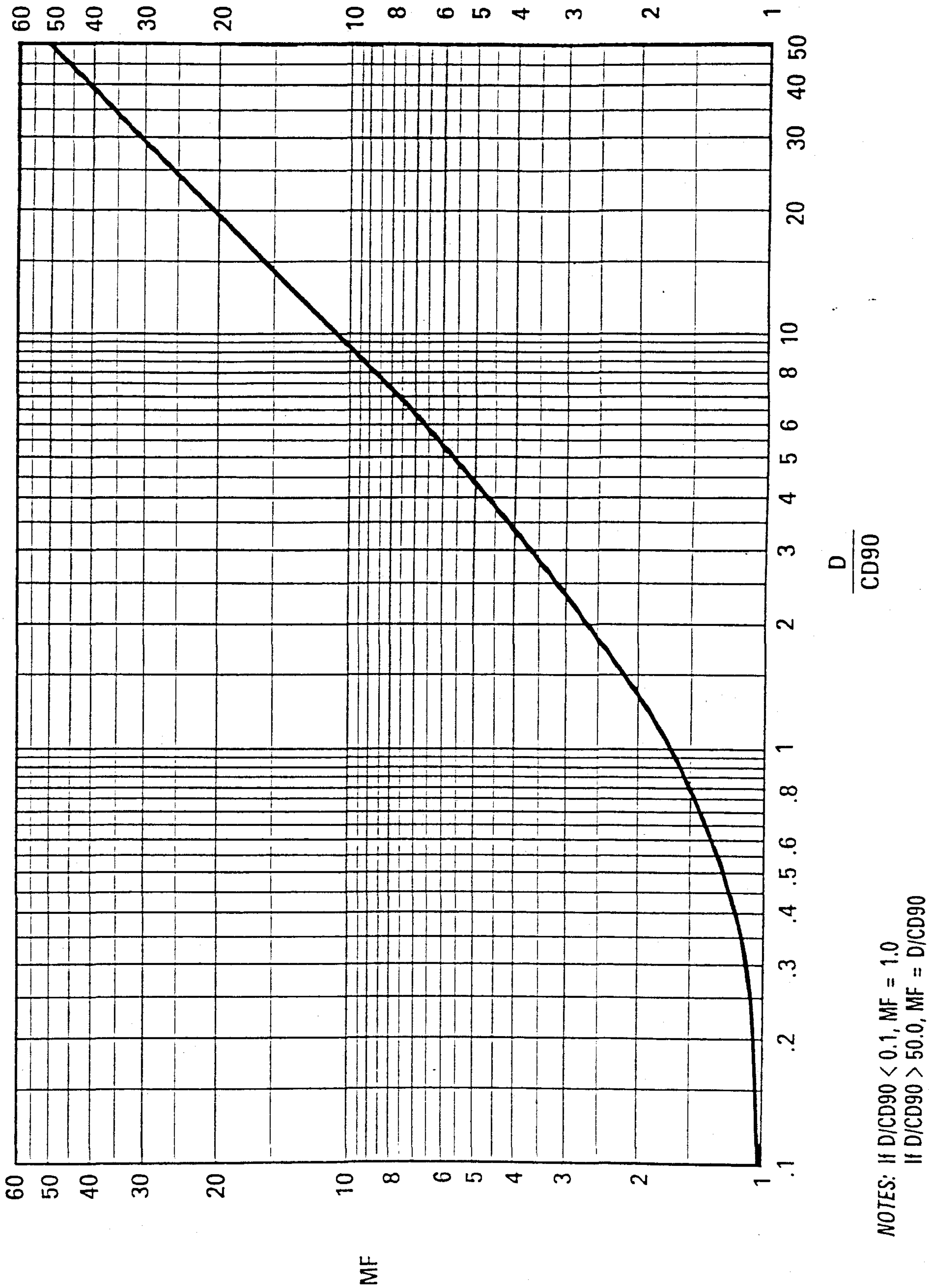


Figure IV-10. CD90 Multiplication Factor (MF) for High Assurance Probability of Damage to Point Targets

Problem

Find the expected fractional coverage

Given

RT: 800 meters

RD: 600 meters

CEP: 200 meters

D: 1000 meters

Solution

1. RD, RT, CEP, and D given
2. D + RD + CEP = 1000 + 600 + 200 = 1800 > RT (800 meters)
3. Compute CEPA

$$\frac{RT}{CEP} = \frac{800}{200} = 4$$

•Multiplier (k) = 2.7 (expressed to nearest tenth; if halfway, round up to worst case)

CEPA = 2.7 × CEP = 540 meters

4. $$\frac{RD}{CEPA} = \frac{600}{540} = 1.11$$

$$\frac{D}{CEPA} = \frac{1000}{540} = 1.85$$

5. Enter the area target graph, expected coverage displaced DGZ below and find the point where RD/CEPA and D/CEPA intersect. Since the value is closer to the .1 curve, $\overline{f}$ = .1.

Go to Figure IV-9

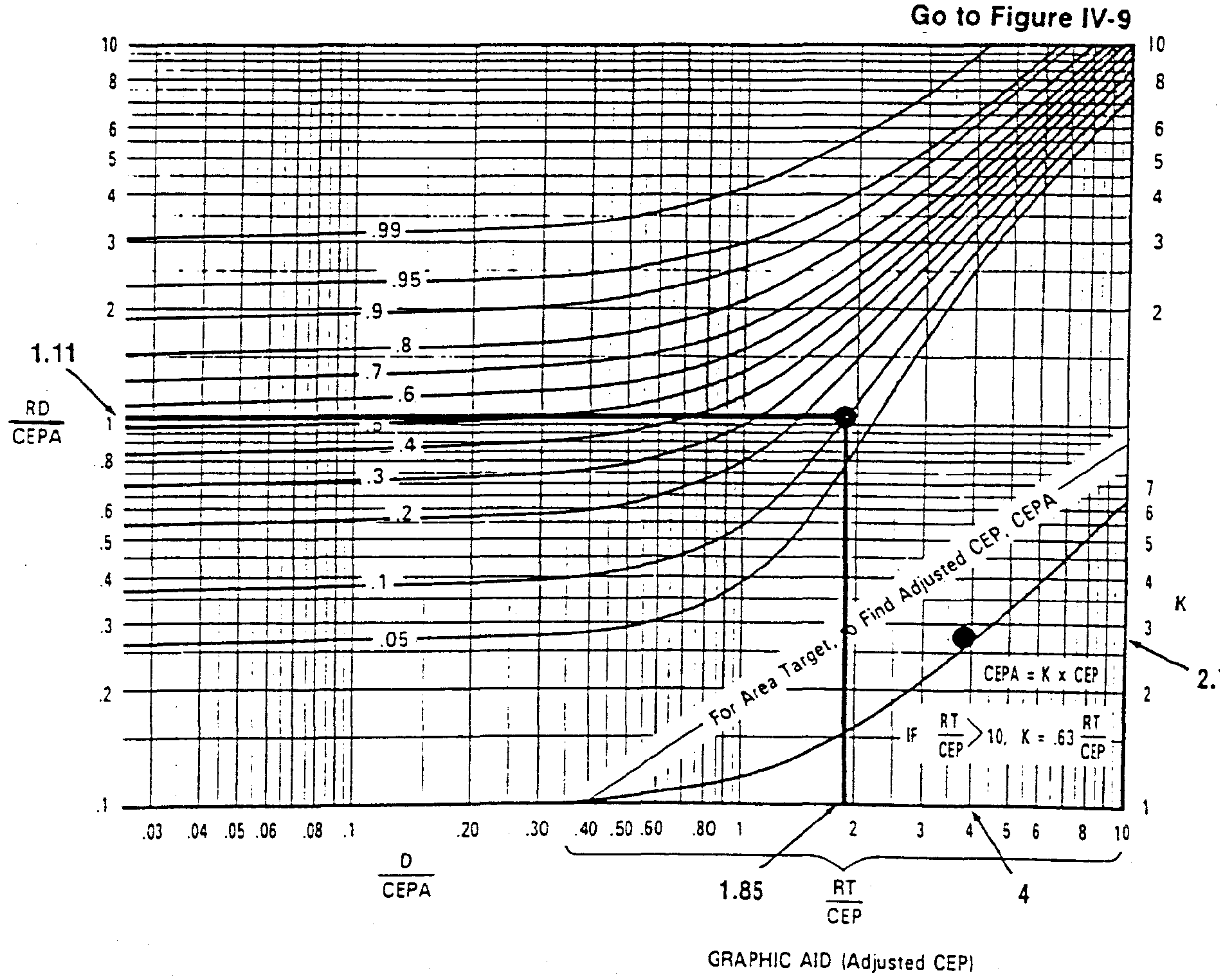


Figure IV-11. Example of Area Target, Expected Coverage with Displaced DGZ (Numerical)

Problem:

Find DMAX for an area target, expected coverage

Given:

RT: 1,000 meters

RD: 800 meters

CEP = 300 meters

Desired: f =.4

Solution

1. RD, CEP, and RT given
2. CEPA = k × CEP or

   $CEPA = \sqrt{CEP^2 + .4\,(RT^2)}$

   CEPA = 700
3. RD / CEPA = 800 / 700 = 1.14
4. Enter area target graph (Expected Coverage) Displaced DGZ) with 1.14 and extend to the right to the .4 curve.
5. From the intersection found in step 4, drop vertically to the D/CEPA axis and read D/CEPA as .80.
6. DMAX = D/CEPA × CEPA = .80 × 700 = 560 meters.

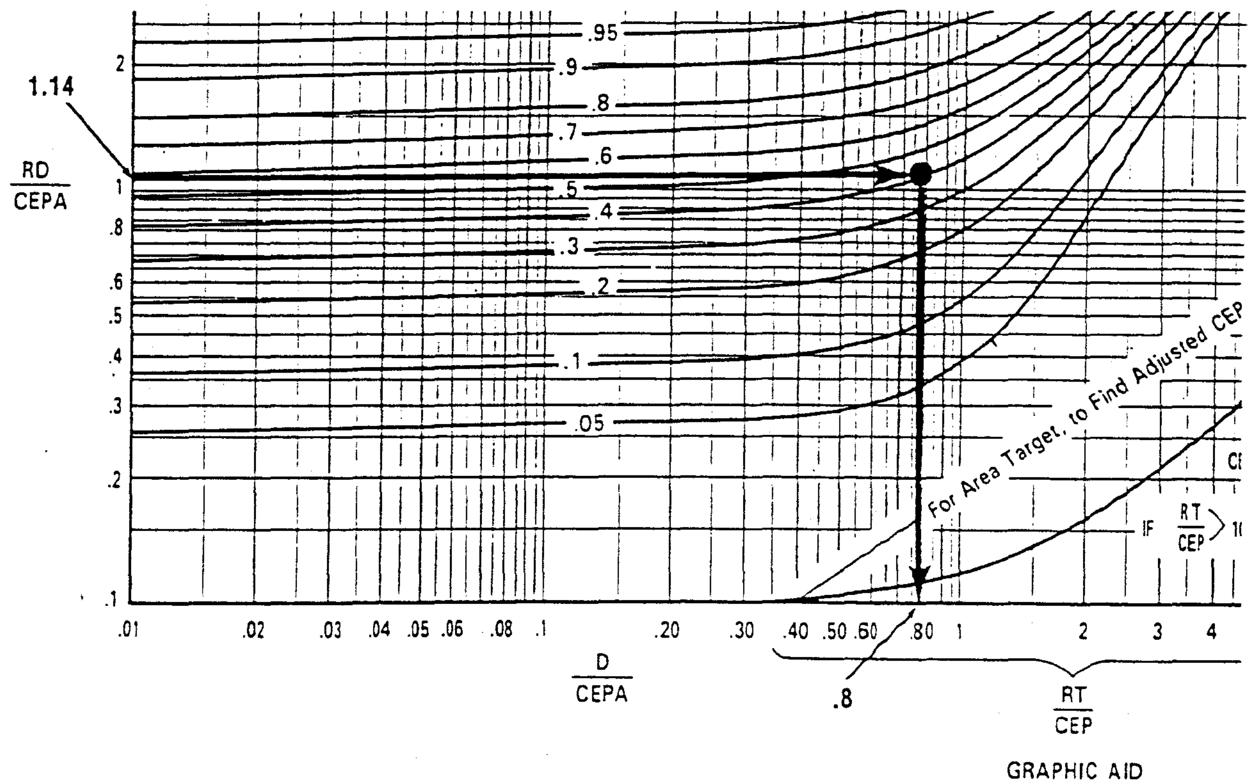


Figure IV-12. Example of Area Target Expected Coverage - Determine DMAX

Find Probability of Damage with No DGZ Displacement

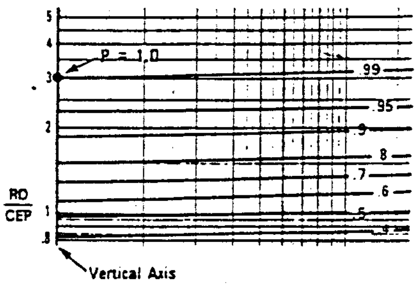
Given

RD: 600 meters

CEP: 200 meters

Solution

1. RD and CEP given
2. $\frac{RD}{CEP} = \frac{600}{200} = 3$
3. When RD/CEP = 3, P = 1.0 rounded to the nearest tenth



Find Probability of Damage Using Point Target Graph Extension

Given

RD: 1,200 meters

CEP: 100 meters

D: 900 meters

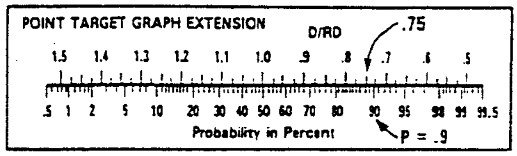
Solution

1. RD and CEP given
2. $\frac{RD}{CEP} = \frac{1,200}{100} = 12.$

   $\frac{D}{CEP} = \frac{900}{100} = 9.$
3. Since this value for RD/CEP is greater than 10, use the point target graph extension. Calculate D/RD.

   $\frac{D}{RD} = \frac{900}{1,200} = .75$

   Entering the point target graph extension with D/RD = .75 on the top line, read the probability to the lower whole percent, and round to one digit. P = .9



Find Probability of Damage with DGZ Displacement

Given

RD: 500 meters

CEP: 200 meters

D: 300 meters

Solution

1. RD and CEP given
2. $\frac{RD}{CEP} = \frac{500}{200} = 2.5$

   $\frac{D}{CEP} = \frac{300}{200} = 1.5$
3. At the intersection point of RD/CEP and D/CEP, P = .8 since the intersection point is closer to the .8 curve.

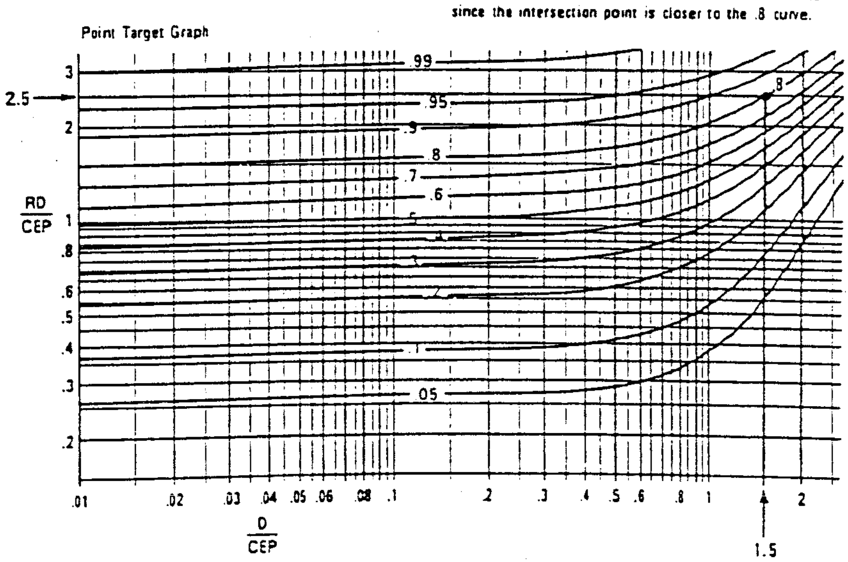


Figure IV-13. Example of Point Target Expected Probability of Damage Calculations

DMAX When RD/CEP < 10

Given

RD: 500 meters

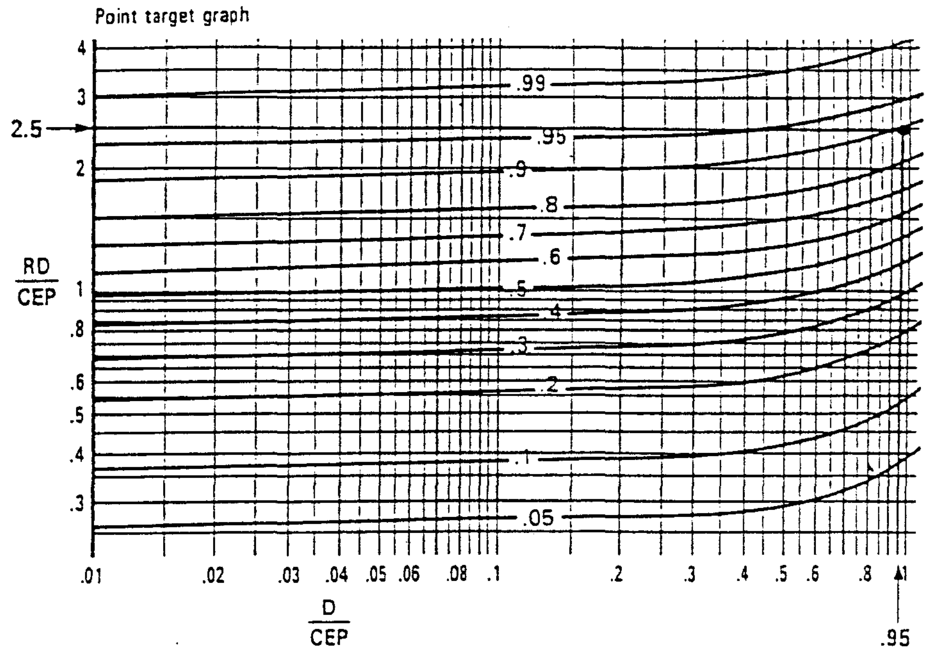
CEP: 200 meters

P: .9

Solution

1. RD and CEP given
2. $\frac{RD}{CEP} = \frac{500}{200} = 2.5$
3. Read the D/CEP value at the point of intersection of the RD/CEP value and the .9 probability curve.
4. DMAX = D/CEP × CEP

   DMAX = .95 × 200 = 190 Meters



DMAX When RD/CEP > 10

Given

RD: 1,200 meters

CEP: 100 meters

P: .9

Solution

1. RD and CEP given
2. $\frac{RD}{CEP} = \frac{1,200}{100} = 12$
3. Because the RD/CEP ratio is greater than 10, use the point target graph extension.
4. Enter the point target graph extension with a P = .9 and read D/RD = .73
5. DMAX = D/RD × RD

   = .73 × 1,200 = 876 meters

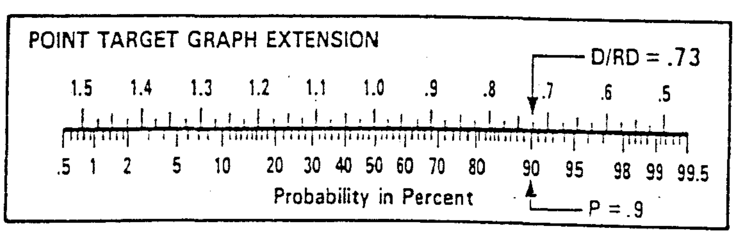


Figure IV-14. Examples for a Point of Target Graph - Determine DMAX (Use Figure IV-9)

When D = 0

Given

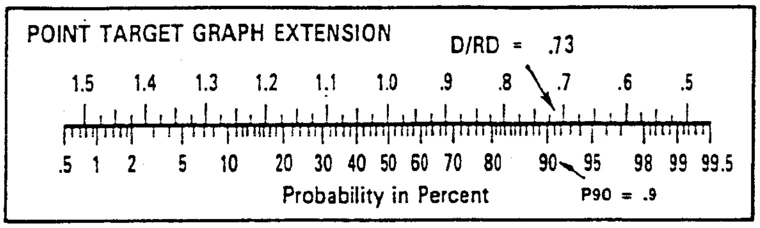
RD: 1,200 meters

CD90: 876 meters

D: 0

Solution

1. RD and CD90 Given
2. $\frac{CD90}{RD} = \frac{876}{1200} = .73$
3. Enter the point target graph extension with a CD90/RD (D/RD) = .73 and read P90 = .9.



When D > 0

Given

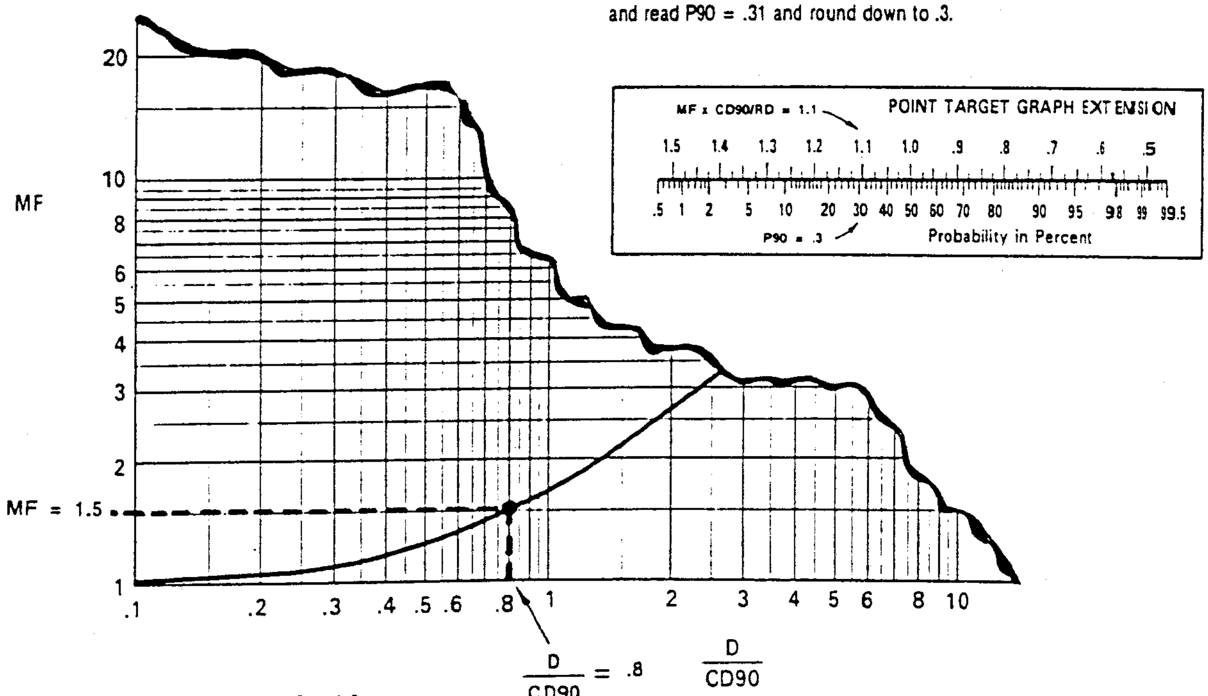
RD: 1,200 meters

CD90: 876

D: 701 meters

Solution

1. $\frac{D}{CD90} = \frac{701}{876} = .8$
2. Enter the multiplication factor (MF) graph with D/CD90 = .8 and read MF = 1.5 from the vertical axis.
3. $\frac{MF \times CD90}{RD} = \frac{1.5 \times 876}{1200} = 1.1$
4. Enter the point target graph extension with MF x CD90/RD = 1.1 and read P90 = .31 and round down to .3.



NOTES: If D/CD90 < 0.1, MF = 1.0
If D/CD90 > 50.0, MF = D/CD90

Figure IV-15. Examples of High Assurance Probability of Damage to a Point Target

Given

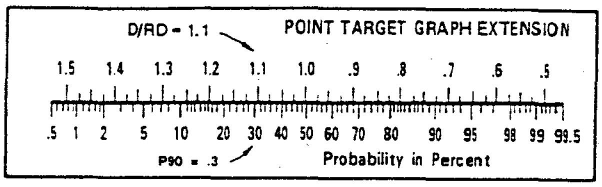
RD: 1,200 meters

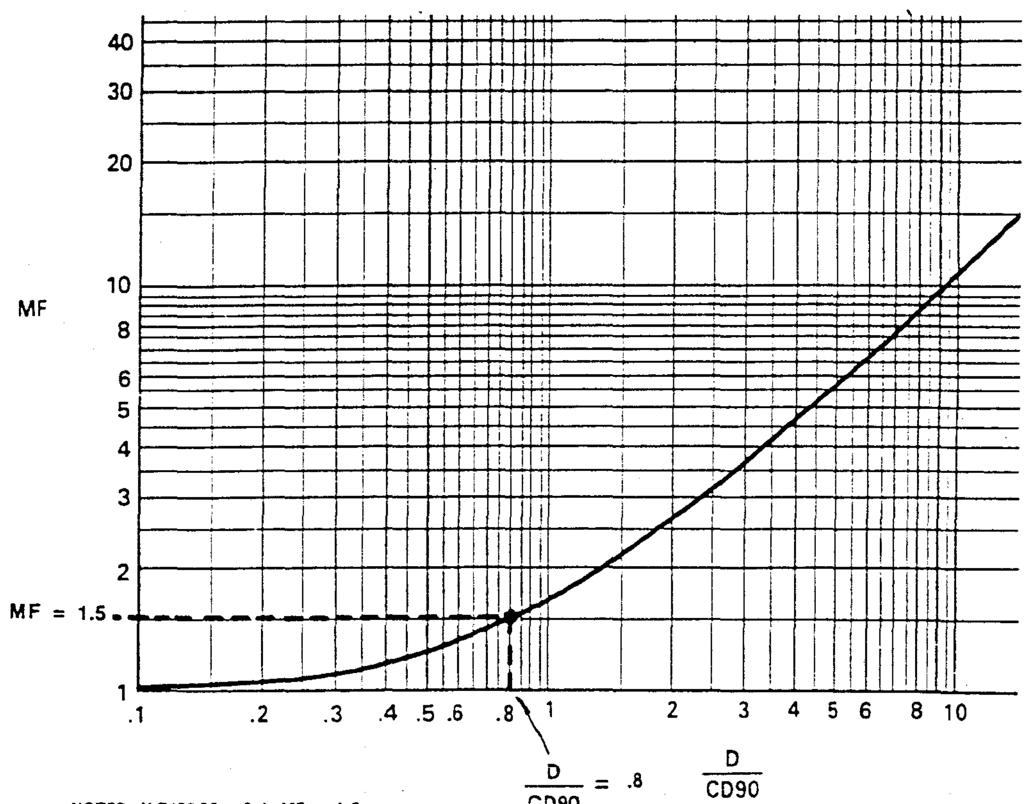
CD90: 876 meters

P90: .3

Solution

1. RD and CD90 Given
2. Enter the point target graph extension with P90 = .3 and extract D/RD = 1.1
3. $\frac{D}{RD} \times RD = 1.1 \times 1200 = 1320$
4. $MF = \frac{1320}{CD90} = \frac{1320}{876} = 1.5$
5. Enter the multiplication factor (MF) graph with MF = 1.5 and read D/CD90 = .8 from the horizontal axis.
6. DMAX = .8 x 876 = 701 meters.





NOTES: If D/CD90 < 0.1, MF = 1.0
If D/CD90 > 50.0, MF = D/CD90

Figure IV-16. Examples of DMAX for High Assurance Probability of Damage to a Point Target

ADDITIONAL DATA

PRESET HOB	PEH
100	4

Delivery Notes:

Freefall and Retarded Air Burst
Contact and Laydown Option

BIG BOMB
1 KT - Y1

Safety Yield - 1.1 $W^{1/3}$ - 1.032

SAFETY DISTANCE
(WITH BUFFER)

	(U) PERSONNEL SAFETY (99%)(MSD) (DISTANCE IN METERS)				(U) PRECLUDE (99%)(LSD) (DISTANCE IN METERS)							
	UNWARNED EXPOSED		WARNED PROTECTED		MOD DAM FIXED BRG	LT DAM TO BLDG	ACFT IN FLIGHT		FOREST BLOWDOWN		FOREST DEBRIS FIRES	
CEP	NEG *	EMER	NEG *	EMER *			ASLT HEL	OTHER HEL	DECID	CONIF	DECID	CONIF
150	1500	1500	1300	1200	800	1900	1700	6700	1300	1000	2100	1500
300	1800	1700	1600	1500	1100	2200	2000	6900	1600	1300	2400	1800
450	2100	2000	1900	1800	1400	2500	2300	7200	1900	1600	2700	2100
600	2400	2300	2200	2100	1700	2800	2600	7500	2200	1900	3000	2400

* NUCLEAR RADIATION EFFECTS ARE SIGNIFICANT.
SEE TABLE V-6 FOR MODIFICATION OF RISK RADII FOR PREVIOUSLY EXPOSED PERSONNEL.

Figure IV-17. Typical Safety Distance Table

RADIATION EXPOSURE STATE	TOTAL PAST CUMULATIVE DOSE (RAD) (cGy)	COMMANDER'S RISK GUIDANCE		
		Negligible	Moderate	Emergency
RES 0	0	NEG	MOD	EMER
RES 1	> 0. ≤ 70	NEG + 100 M	NEG	MOD
RES 2	> 70. ≤ 150	NEG + 200 M	NEG + 100 M	NEG
RES 3	> 150	NEG + 300 M	NEG + 200 M	NEG + 100 M

Figure IV-18. MSD Modification as a Function of Previous Exposure

COLLATERAL DAMAGE DISTANCE (99%)(CDD)

(DISTANCE IN METERS)

	PERSONNEL INJURY 5% INCIDENCE			MODERATE DAMAGE 5% INCIDENCE					THERMAL IGNITION 5% INCIDENCE		
CEP	URBAN	RURAL	IN OPEN	SINGLE STORY FRAME BUILDING	SINGLE STORY MASONRY BUILDING	LIGHT STEEL INDUST BUILDING	FIXED BRIDGES	RAIL ROAD EQUIP	WOOD SHINGLES	HEAVY COTTON DRAPES	NEWSPAPERS AND DEBRIS
150	1100	1400	1400	1800	1300	900	800	1200	1500	1800	1900
300	1400	1700	1700	2100	1600	1200	1100	1500	1800	2100	2200
450	1700	2000	2000	2400	1900	1500	1400	1800	2100	2400	2500
600	2000	2300	2300	2700	2200	1800	1700	2100	2400	2700	2800

Figure IV-19. Typical Collateral Damage Distance Table

PRECLUDE (99%)(LSD)
(DISTANCE IN METERS)

MOD DAM FIXED BRG	LT DAM TO BLDG	ACFT IN FLIGHT: ASLT HEL	ACFT IN FLIGHT: OTHER HEL	FOREST BLOWDOWN: DECID	FOREST BLOWDOWN: CONIF	FOREST DEBRIS FIRES: DECID	FOREST DEBRIS FIRES: CONIF
800	1900	1700	6700	1300	1000	2100	1500
1100	2200	2000	6900	1600	1300	2400	1800
1400	2500	2300	7200	1900	1600	2700	2100
1700	2800	2600	7500	2200	1900	3000	2400

FOR PREVIOUSLY EXPOSED TROOPS.

Figure IV-20. Least Separation Distance

Problem

Find the DGZ using single limiting requirements

Given

Delivery System: Big Bomb
CEP: 450
HOB: low air
Exposure status: RES 0

Degree of risk and vulnerability condition: no more than negligible risk to unwarned, exposed troops located 1,300 meters south of the target center.

Solution

1. Determine the displacement required. Enter the safety distance table for the Big Bomb, 1 kT, with the CEP of 450. Extract the MSD of 2,100 meters. Because friendly troops are located 1,300 meters south of the target center, DGZ is displaced 800 meters north of the target center. The troop safety calculations entered in the target analysis work sheet are -

   - o MSD: 2,100 meters.
   - o Troop distance from the DGZ: 1,300 meters.
   - o Displacement of DGZ: 800 meters north.

2. Locate the DGZ. When the DGZ must be moved from the target center because of a single limiting requirement, the displacement computed is the distance used in computing the final coverage.

3. Compute the final coverage. After the DGZ is displaced, determine the final coverage using the visual or numerical technique of damage estimation.

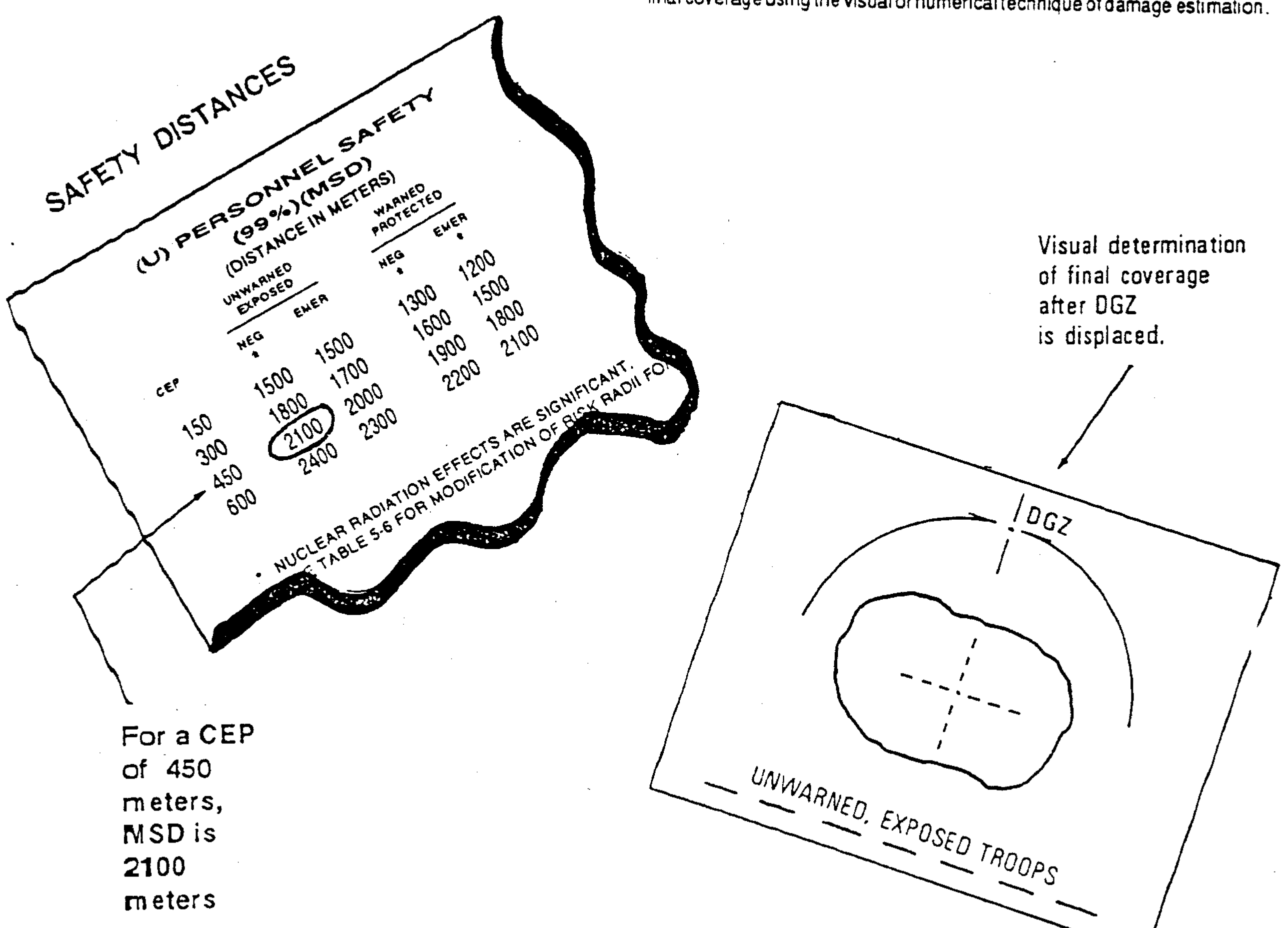


Figure IV-21. Example of DGZ Placement for Single Limiting Requirement

Problem

Find the DGZ using multiple limiting requirements.

Given

Delivery System: Big Bomb

Yield: 1 kT

CEP: 300 meters

HOB: low air

Exposure Status: RES 0

Degree of risk and vulnerability condition: no more than negligible risk to warned, protected personnel located 1,200 meters south of the target center.

Limiting requirements: none of the coniferous trees blown down at the intersection of Highways 12 and 14, 300 meters east of the target center.

Solution

1. Determine the displacement required. Enter the safety distance table for the Big Bomb, 1 kT, with the CEP 300 meters. Extract the MSD of 1,600 and the LSD of 1,300 from the appropriate columns. Because friendly troops are 1,200 meters south of the target center, displace the DGZ 400 meters north. To avoid blowing down trees at the intersection 300 meters east of the target center: displace the DGZ 1,000 meters west of the target center.

2. Locate the DGZ. Because the DGZ is displaced in more than one direction, the mathematical technique is not used. Locate the DGZ graphically by plotting preclusion and safety distances. Draw a line parallel to the friendly forward areas at a distance equal to the MSD (1,100 meters in this case). Because the LSD for precluding obstacles is 1,300 meters, draw an arc 1,300 meters from the intersection of Highways 12 and 14. Locate the DGZ by selecting a point as close as possible to the target center yet outside the line for troop safety and the arc for preclusion of obstacles. Normally, this point will be at the intersection of the line and the arc. Measure the distance from the DGZ to the target center to determine the distance to use in computing the final coverage.

3. Compute the final coverage, using either the numerical of the visual technique of damage estimation.

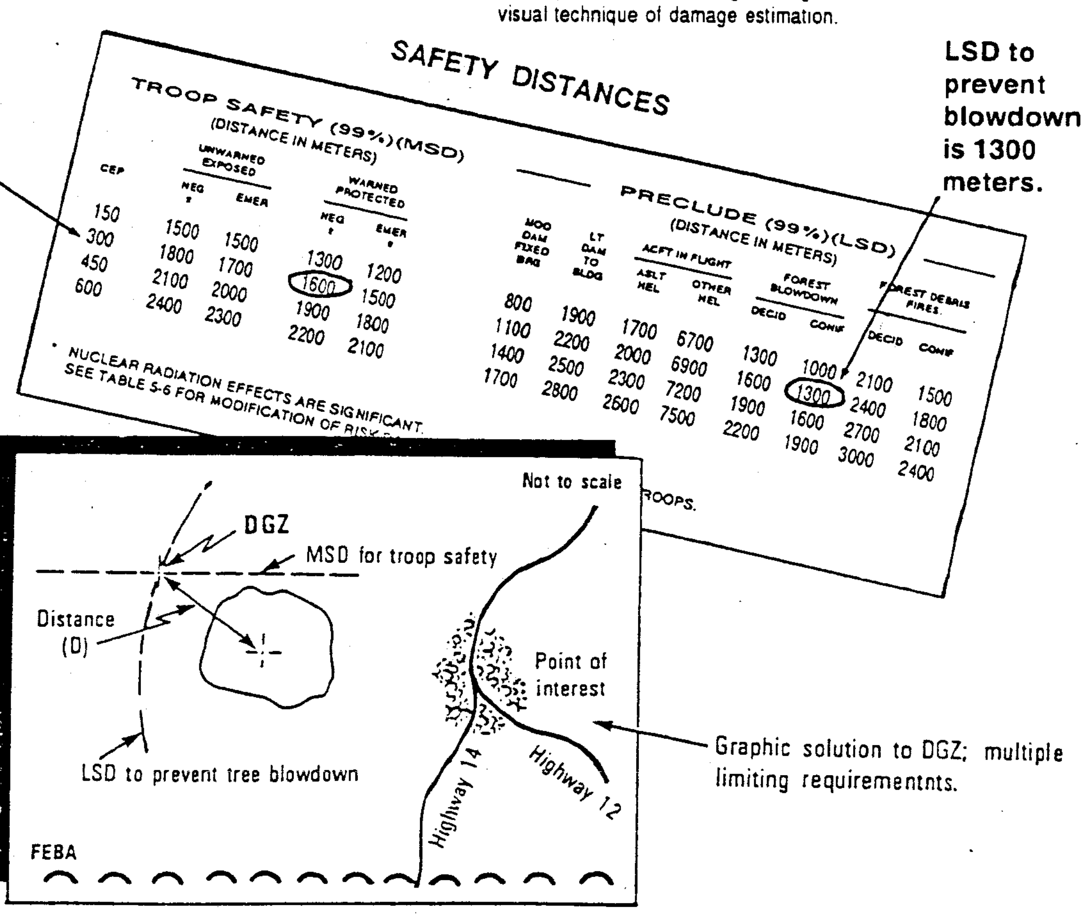


Figure IV-22. Example of DGZ Placement for Multiple Limiting Requirements

Problem

Find the DGZ and final coverage of targets A and B for a single weapon.

Given

Two area targets

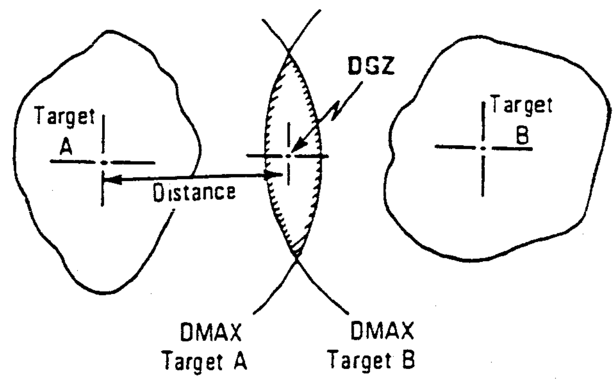
Solution

A single weapon may be used to attack multiple targets, either area targets or point targets. In such a case, the DGZ may be between targets if their relative locations permit. See Diagram Ⓐ right.

1. Determine the displacement required. In analyzing multiple targets of the same type, find the DMAX for displacing the DGZ and that still provides the necessary coverage. Compute the DMAX for target A. Compute the DMAX for target B.
2. Locate the DGZ. Draw arcs from target A, a distance equal to the computed DMAX for target A, and from target B, a distance equal to the DMAX for target B. The shaded area of overlap is the area in which the DGZ can be located to provide the required coverage. The best location for the DGZ is the closest point to each of the target centers, in this example, the midpoint between them. After selecting the DGZ, measure the distance between the DGZ and each target center to determine the distance to use in computing the final coverage for each target.
3. Compute the final coverage for each target individually, using either the numerical or the visual method of damage estimation.
4. When there are more than two targets, the overlap area for locating the DGZ is determined by the DMAX of all targets under consideration. See Diagram Ⓑ

(Diagrams are not to scale)

Ⓐ MULTIPLE TARGETS, SINGLE WEAPON



Ⓑ DGZ: MULTIPLE TARGETS

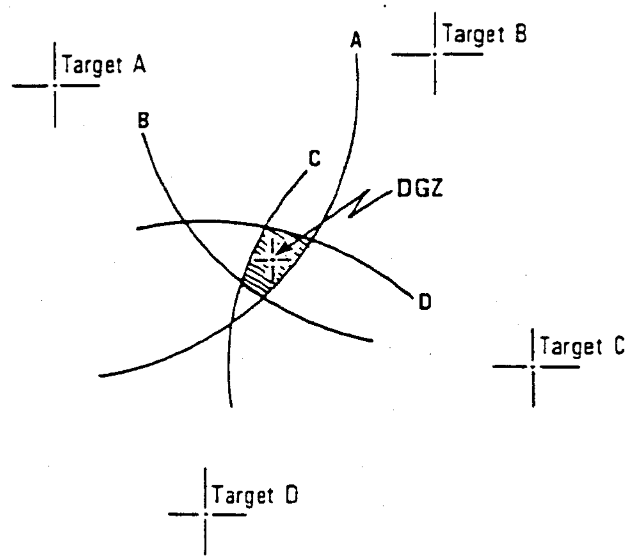


Figure IV-23. Example of DGZ Placement for Multiple Targets.

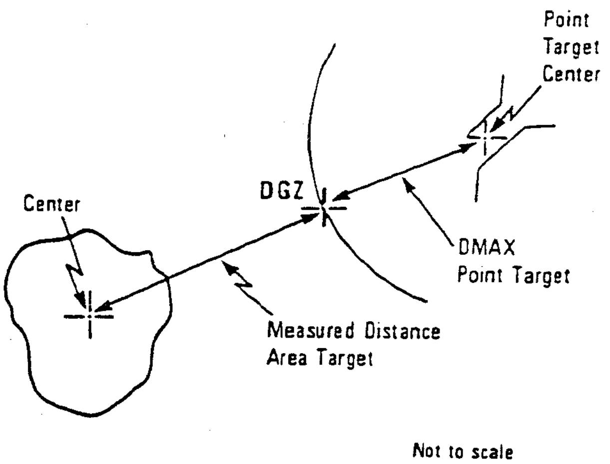
Multiple Mixed Targets

Problem

For a single weapon attacking a combination of one point target and one area target, find the DMAX for the point target only

Solution

1. Along a line connecting the point target center and the area target center, plot the DGZ at the DMAX from the point target (see below).
2. Measure the distance from the area target center to the DGZ, and compute the final coverage for the area target only.
3. If a single weapon cannot provide the required coverage, compute the DMAX for the target of highest priority. Then measure the displacement distance from the other target, and compute the final coverage or effectiveness.



Combination of Targets - Limiting Requirements

Problem

Find the DGZ for a combination of multiple targets and limiting requirements

Solution

The techniques used in each step are the same as those discussed above.

1. Compute the distance and the direction the DGZ is to be displaced. Determine MSD, CDD, LSD, and DMAX.
2. Determine the coverage overlap for multiple targets. A limiting requirement may restrict where the DGZ can be located. Although this DGZ may not provide maximum coverage, it will have to be accepted because of the limiting requirement (see below). If a limiting requirement forces the DGZ outside the area of coverage overlap, a command decision will determine which requirement or restriction will be changed.
3. Measure the distance to the DGZ from each target center, and compute the final coverage, using either the numerical or the visual technique of damage estimation.

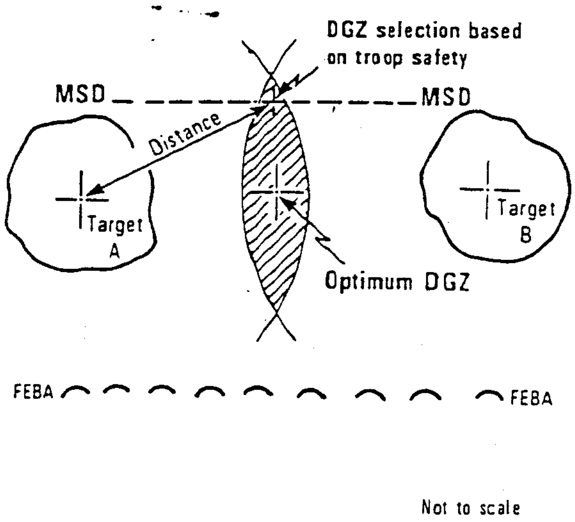


Figure IV-24. Example of DGZ Placement for Multiple Mixed Targets and Combinations of Targets and Limiting Requirements

Problem

Estimate the damage

Given

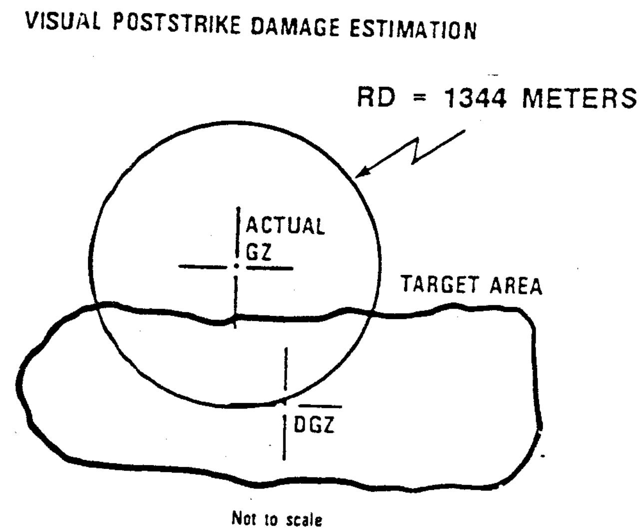
Delivery system: Big Bomb
Yield: 10 kT
CEP: 300
HOB: low air
Target category: exposed personnel, latent ineffectiveness

Poststrike Data

Target: shown at right
GZ: known
HOB: normal
Yield: normal

Solution

1. Enter the proper coverage table (see below) with a CEP of 300 meters. Moving to the right under the column for the RD, extract an RD of 1,344 meters.
2. Draw the RD on the template, place the center of the template over the actual GZ and visually estimate a fractional coverage of 20 percent.



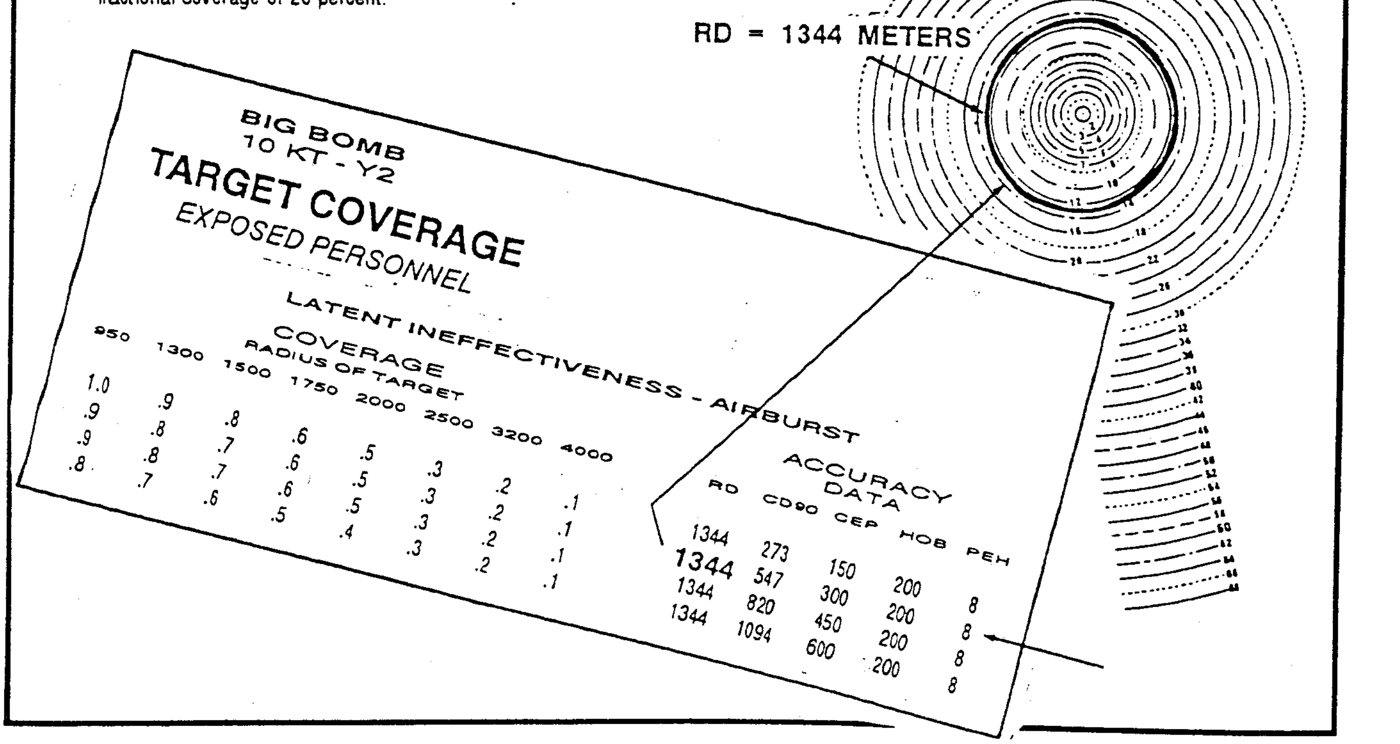


Figure IV-25. Example of Visual Poststrike Damage Estimation

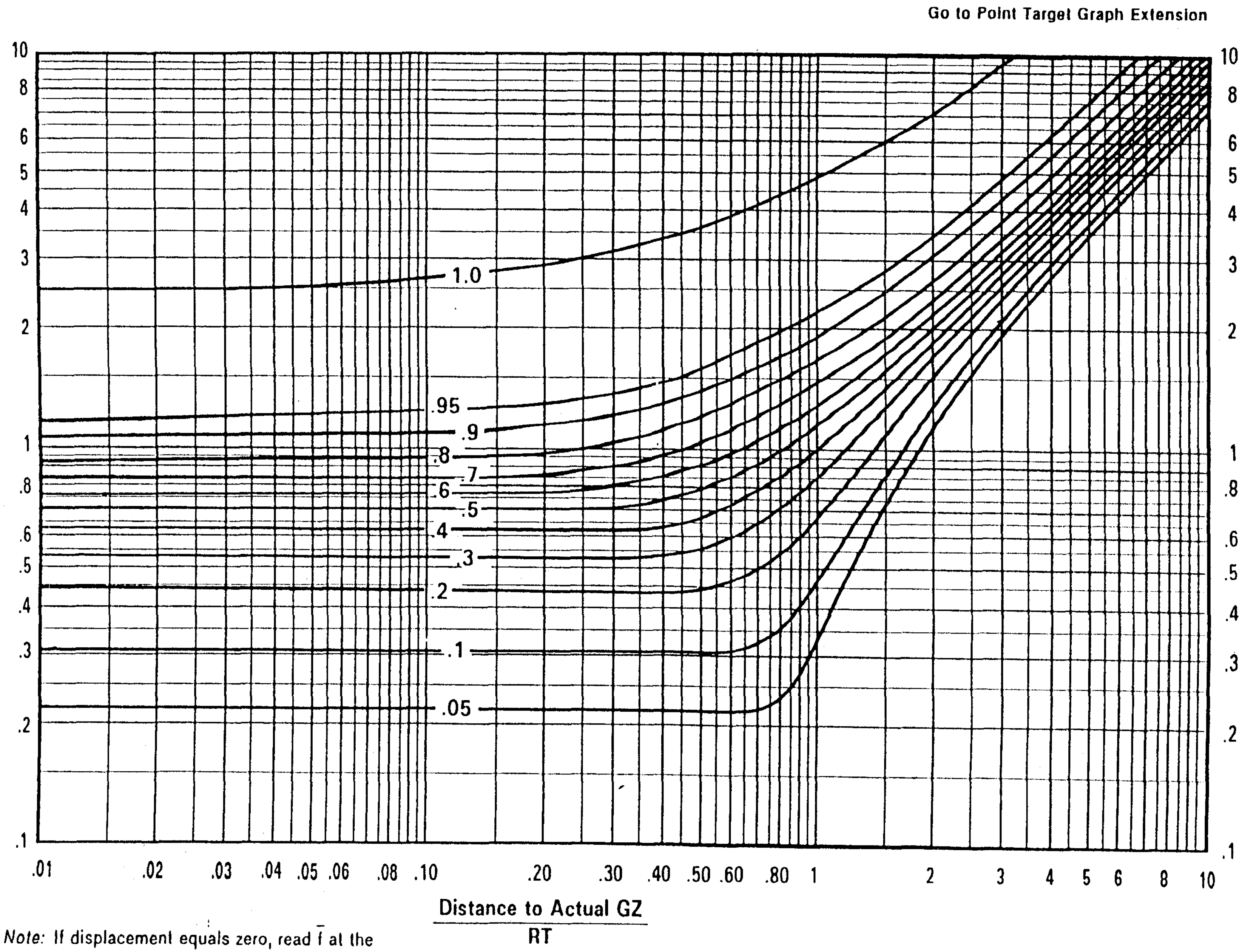


Figure IV-26. Area Target Graph - Poststrike Analysis

Note: If displacement equals zero, read $\bar{f}$ at the intersection of the vertical axis.

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Problem

Estimate the Damage

Given

Delivery System: Big Bomb
Yield: 10 kT
CEP: 300
HOB: air burst
RT: 1530 meters
Target Category: exposed personnel latent ineffectiveness

Poststrike data

GZ: 300 meters north of target area
HOB: normal
Yield: normal

Solution

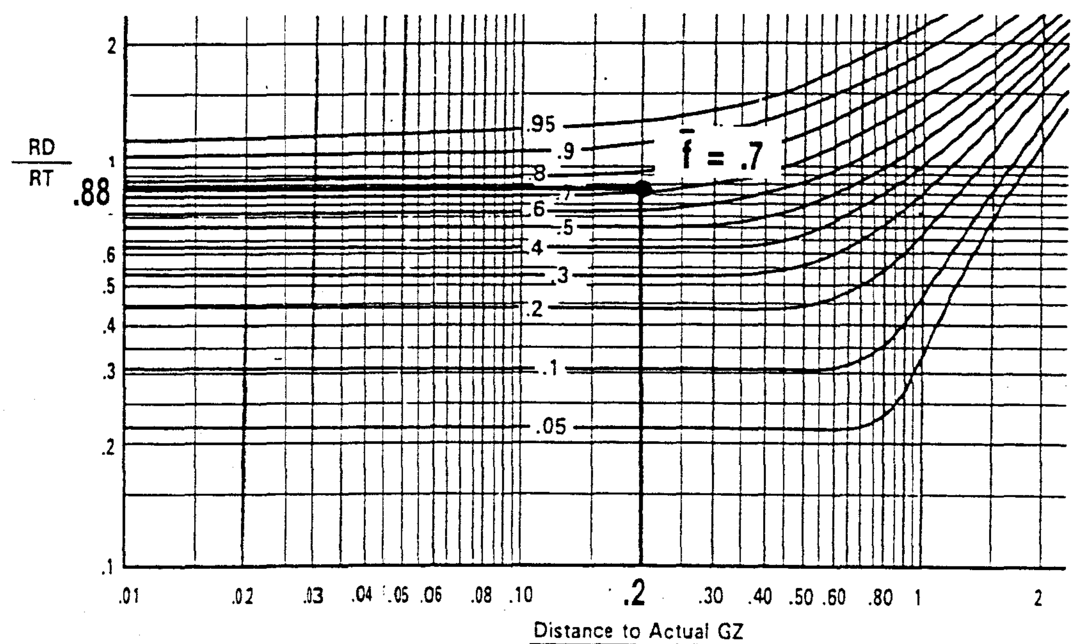
1. Enter the proper coverage table (Figure IV-25) with the CEP of 300 meters. Moving to the right, under the column for RD, extract an RD of 1,344 meters.
2. Using the numerical technique, enter the area target graph below (actual GZ known) with the ratios below.

$$\frac{RD}{RT} = \frac{1344}{1530} = .88$$

$$\frac{D}{RT} = \frac{300}{1530} = .2$$

At the intersection of the two ratios, read the fractional coverage ($\bar{f}$= .7). Do not consider probable errors in the delivery system.

AREA TARGET GRAPH POSTSTRIKE ANALYSIS



Note: If displacement equals zero, read $\bar{f}$ at the intersection of the vertical axis.

Figure IV-27. Example of Numerical Poststrike Analysis of an Area Target

Problem

Estimate the Damage

Given

Deliver System: Big Bomb
Yield: 10 kT
CEP: 300 meters
HOB: air burst
Target Category: missle launcher. severe damage

Poststrike Data

GZ: 975 meters north of target center
HOB: normal
Yield: normal

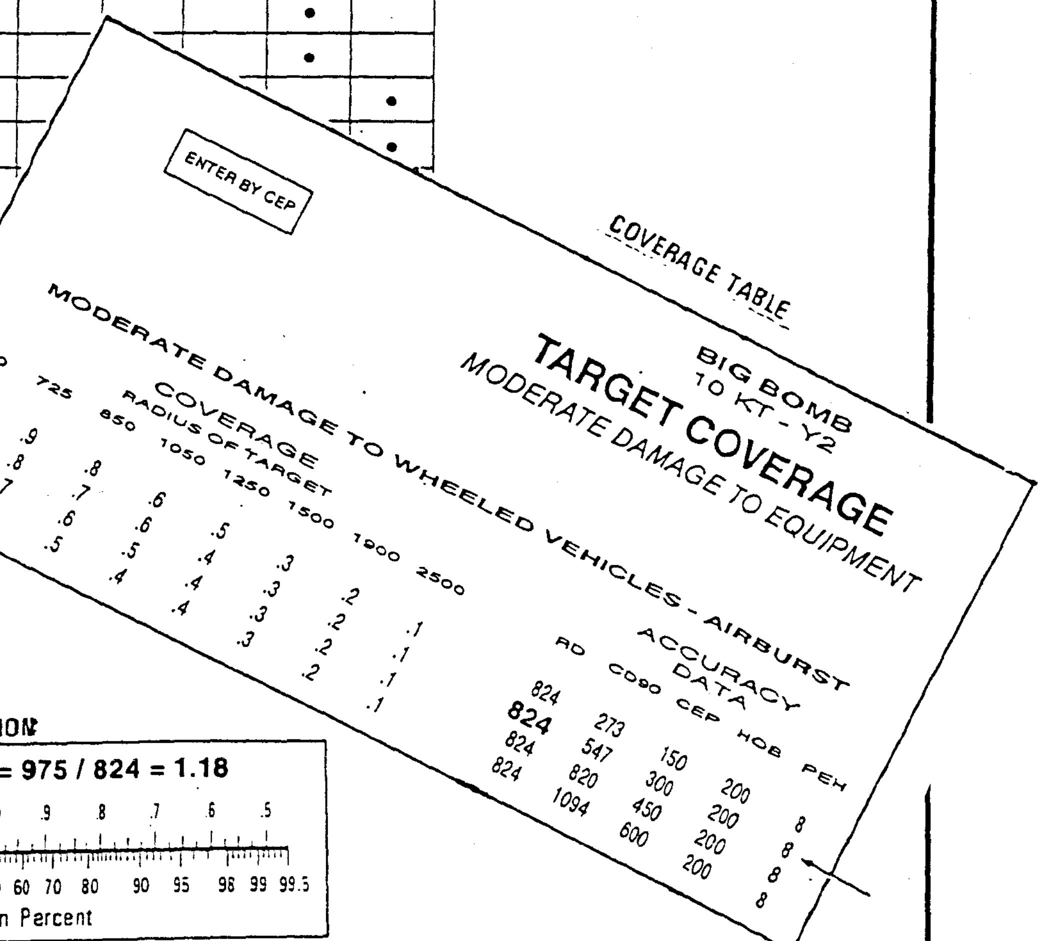
Solution

1. The comparable target table (figure V-6) equates severe damage to missle launchers with moderate damage to wheeled vehicles. Enter the proper coverage table (see below) with the range of 8.000 meters. Moving to the right under the column for RD. extract an RD of 824 meters.

2. Using the point target extension below enter the ratio D/RD = 975/824 = 1.18 and read the probability at 20 percent (rounded up from 18).

COMPARABLE TARGET TABLE

Secondary Targets (From Effects Tables)			Primary Targets in Coverage Tables					
			Exposed Personnel	Personnel in Open Foxholes	Personnel in Tanks	Moderate Damage to Tanks	Moderate Damage to APCs	Moderate Damage to Wheeled Vehicles
			u	m	m			
Factories (25-50 ton Crane Capacity)	All Yields	Severe Damage				●		
Fixed Bridges	≤ 55 KT	Severe Damage					●	
Floating Bridges	≤ 55 KT	Severe Damage					●	
Missiles/Rockets in Open	≤ 100 KT	Severe Damage						●
Railroad Boxcars and Flat Cars (loaded)	All Yields	Severe Damage						●
Tracked Vehicles (not tanks)	All Yields	Severe Damage						
Heavy Towed and Self-Propelled Artillery	All Yields	Moderate Damage						
Personnel in Brick Apartment Buildings	≤ 55 KT	u						
	≤ 10 KT	m						
Personnel in APCs	≤ 100 KT	m						
Personnel in Earth Shelters	All Yields							



POINT TARGET GRAPH EXTENSION

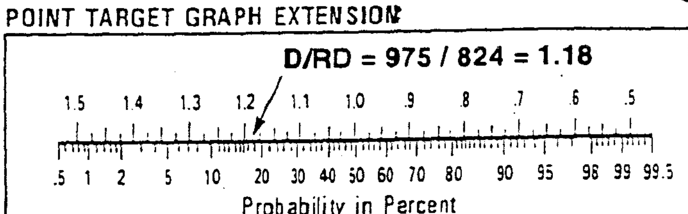


Figure IV-28. Example of Numerical Poststrike Analysis of a Point Target

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CHAPTER V
GRAPHS AND TABLES (U)

1. (U) General. This chapter collects the target graphs and tables that are necessary to perform a complete target analysis. The contents of this chapter are:

Figures:

Tables:

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Date of source: Apr., 1992

Table V-2. (U) Comparable Target Table (For Use With Index Method)

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This manual presents data for only six primary target categories in the coverage tables. However, other targets respond quite similarly to one of them. The comparable target table (see below) makes such comparisons. To use it, analysts inspects the secondary target column to determine if the target of interest is considered a secondary target. If it is listed, they can then move across to see if yield and damage constraints are met. If so, the analyst then moves into the body of the chart to find the primary target category and response to which the secondary target is comparable.

Secondary Targets (From Effects Tables)			Primary Targets in Coverage Tables					
			Exposed Personnel	Personnel in Open Foxholes	Personnel in Tanks	Moderate Damage to Tanks	Moderate Damage to APCs	Moderate Damage to Wheeled Vehicles
			LI	ITI	ITI			
Factories (25-50 ton Crane Capacity)	All Yields	Severe Damage				●		
Fixed Bridges	≤ 55 KT	Severe Damage					●	
Floating Bridges	≤ 55 KT	Severe Damage					●	
Missiles/Rockets in Open	≤ 100 KT	Severe Damage						●
Railroad Boxcars and Flat Cars (loaded)	All Yields	Severe Damage						●
Tracked Vehicles (not tanks)	All Yields	Severe Damage					●	
Heavy Towed and Self-Propelled Artillery	All Yields	Moderate Damage				●		
Personnel in Brick Apartment Buildings	≤ 55 KT	LI	●					
	≤ 10 KT	IPI			●			
Personnel in APCs	≤ 100 KT	IPI		●				
Personnel in Earth Shelters	All Yields	LI		●				

For preclusion of damage to naval ships, the LSDs to use are:

≤100kT Light Damage To Buildings
>100kT Forest Debris Fires, Deciduous

Table V-4. (U) Residual Radiation Protection Factors for US Equipment

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M1 Tank	25
M60 Tank	25
M60A2 Tank	33
M2 IFV	5
M3 CFV	5
M113 APC	3.33
M116 Cargo Carrier	1.67
M548 Cargo Carrier	1.5
M577 Command Post Carrier	3.33
M109 SP Howitzer	5
M110 SP Howitzer	2.5
M106 SP Mortar	3.33
M125A SP Mortar	3.33
M88 Recovery Vehicle	11
M578 Recovery Vehicle	3.33
M20 Combat Engineer Vehicle	25
M551 Armored Reconaissance/ Airborne Assault Vehicle	5
HMMWV	1.67
CUCV	1.67
M9 ACE	3.33
Grader	2
Bulldozer	2
Scraper	2
OH-58	1.25
UH-60	1.5
CH-47	1.67

Table V-6. (U) MSD Modification as a Function of Previous Exposure

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Radiation Exposure State	Total Past Cumulative Dose (cGy)	Commanders Risk Guidance Negligible	Moderate	Emergency
RES-0	<0	NEG	MOD	EMER
RES-1	>0, ≤70	NEG + 100 m	NEG	MOD
RES-2	>70, ≤150	NEG + 200 m	NEG + 100 m	NEG
RES-3	>150	NEG + 300 m	NEG + 200 m	NEG + 100 m

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(See Page vi for Released Figure/Table Labels)

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CHAPTER VI
SIMPLIFIED REFERENCE DATA (U)

1. (U) General. This chapter provides a quick reference and ready summary of selected nuclear effects for all weapons included in this publication. These simplified tables permit the analyst to make rapid comparisons between systems using the listed data directly and/or by conducting a modified visual analysis (see below) during initial planning for the attack of a specific target. Once this procedure has identified a possible solution, the target should then be carefully reanalyzed using more detailed procedures described in this publication or by the use of an approved automated target analysis aid.

2. (U) Modified Visual Analysis Procedure

a. (U) STEP 1. Extract the RD for each available yield and delivery system under consideration from Table VI-1.

b. (U) STEP 2. Next obtain the MSD from Table VI-2 and the CDD from Table VI-3.

c. (U) STEP 3. Using circular map scales, construct a weapon template for each available weapon system and yield. Place the weapon radius of damage and relevant limiting requirements distances (MSD, CDD) on the circular map scale. These linear distances identify a series of concentric circles. Templates may be constructed ahead of time for the most likely targets based on the assumed or actual threat. The distance drawn on the circular map scale may be color coded for easier use. An alternative is to draw on the planning map the appropriate limiting requirement distances as contours around those areas of preclusion that will be relatively stationary even on a mobile battlefield. This keeps the weapons template from becoming cluttered with several radii or preclusion distances.

d. (U) STEP 4. Place the template over a target on the planning map. The radius of damage circle indicates approximate coverage of the target without taking into account all of the delivery errors of the weapon system. To simulate delivery errors, the center of the template is moved approximately 100 meters from the center of the target in the direction that results in the least coverage. If sufficient coverage is not obtained, follow the same process using a template for another weapon system with a different radius of damage and limiting distances.

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CHAPTER VII

B61 MOD 3 BOMB
SYSTEM CAPABILITIES AND EMPLOYMENT CONSIDERATIONS (U)

1. ~~(S-RD)~~ General. [redacted]

2. (U) Reaction Time. Reaction times are extremely variable. Takeoff can occur in less than 30 seconds if the crew is in the aircraft with engines running, ready to takeoff. Up to several hours may be required if the bomb is located in a storage area partially assembled and tested to allow the shortest assembly time. In addition, the distance and condition of the route to the bomb storage area and the flight time to the target must be considered.

3. (U) Accuracy. Accuracy is dependent upon the aircraft, the delivery technique, and the training of the crew among other factors. See the coverage tables for a range of CEP.

4. (U) Reference. DNA Nuclear Weapon Characteristics Report.

5. ~~(S)~~ Aircraft Certification. [redacted]

6. [redacted]

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CHAPTER VII

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CHAPTER VIII

B61 MOD 4 BOMB
SYSTEM CAPABILITIES AND EMPLOYMENT CONSIDERATIONS (U)

1. (S-RD) General. [redacted]

2. (U) Reaction Time. Reaction times are extremely variable. Takeoff can occur in less than 30 seconds if the crew is in the aircraft with engines running, ready to takeoff. Up to several hours may be required if the bomb is located in a storage area partially assembled and tested to allow the shortest assembly time. In addition, the distance and condition of the route to the bomb storage area and the flight time to the target must be considered.

3. (U) Accuracy. Accuracy is dependent upon the aircraft, the delivery technique, and the training of the crew among other factors. See the coverage tables for a range of CEP.

4. (U) Reference. DNA Nuclear Weapon Characteristics Report.

5. (S) Aircraft Certification. [redacted]

6. (S-RD) [redacted]

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CHAPTER IX

B61 MOD 7 BOMB SYSTEM CAPABILITIES AND EMPLOYMENT CONSIDERATIONS (U)

1. (~~S-RD~~) General [redacted]

2. (U) Reaction Time. Reaction times are extremely variable. Takeoff can occur in less than 30 seconds if the crew is in the aircraft with engines running, ready to takeoff. Up to several hours may be required if the bomb is located in a storage area partially assembled and tested to allow the shortest assembly time. In addition, the distance and condition of the route to the bomb storage area and the flight time to the target must be considered.

3. (U) Accuracy. Accuracy is dependent upon the aircraft, the delivery technique, and the training of the crew among other factors. See the coverage tables for a range of CEP.

4. (U) References. DNA Nuclear Weapon Characteristics Report.

5. (~~C~~) Aircraft Certification. [redacted]

6. (~~S-RD~~) [redacted]

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CHAPTER X

B61 MOD 10 BOMB SYSTEM CAPABILITIES AND EMPLOYMENT CONSIDERATIONS (U)

1. (~~S-RD~~) General. [redacted]

2. (U) Reaction Time. Reaction times are extremely variable. Takeoff can occur in less than 30 seconds if the crew is in the aircraft with engines running, ready to takeoff. Up to several hours may be required if the bomb is located in a storage area partially assembled and tested to allow the shortest assembly time. In addition, the distance and condition of the route to the bomb storage area and the flight time to the target must be considered.

3. (U) Accuracy. Accuracy is dependent upon the aircraft, the delivery technique, and the training of the crew among other factors. See the coverage tables for a range of CEP.

4. (U) Reference. DNA Nuclear Weapon Characteristics Report.

5. (~~C~~) Aircraft Certification. [redacted]

6. (~~S-RD~~) [redacted]

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CHAPTER XI

SEA LAUNCHED CRUISE MISSILE (TOMAHAWK LAND ATTACK MISSILE (NUCLEAR)) (TLAM-N)(W80-0) SYSTEM CAPABILITIES AND EMPLOYMENT CONSIDERATIONS (U)

1. (S-RD) General. [redacted]

2. (S-RD) Reaction Time. [redacted]

3. (S-RD) Accuracy. [redacted]

4. (U) Reference. The SWOP W80.82 series manuals contain technical information on the TLAM-N system.

5. (U) [redacted]

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CHAPTER XII

AIR LAUNCHED CRUISE MISSILE (ALCM)(W80-1) SYSTEM CAPABILITIES AND EMPLOYMENT CONSIDERATIONS (U)

1. (S-RD) General. [redacted]

2. (U) Reaction Time. Times are provided by the supporting unit.

3. (S-RD) Accuracy. [redacted]

4. (U) References. Tech Order (T.O.) 1B-52G-30-4-2 and Evaluation of Aircraft Weapon System Performance, 1 June 1993, HQ ACC/XP-JSG.

5. (C) Aircraft Certification. [redacted]

6. (S-RD) [redacted]

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CHAPTER XIII

ADVANCED CRUISE MISSILE (ACM)(W80-1) SYSTEM CAPABILITIES AND EMPLOYMENT CONSIDERATIONS (U)

1. (~~S-RD~~) General. [redacted]

2. (U) Reaction Time. Times are provided by the supporting unit.

3. (~~S-RD~~) Accuracy. [redacted]

4. (U) References. Tech Order (T.O.) 1B-52H-30-1-1 and Evaluation of Aircraft Weapon System Performance, 1 June 1993, HQ ACC/XP-JSG.

5. (~~C~~) Aircraft Certification. [redacted]

6. (~~S-RD~~) [redacted]

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CHAPTER XIV

B83 BOMB, MODS 0 AND 1
SYSTEM CAPABILITIES AND EMPLOYMENT CONSIDERATIONS (U)

1. (S-RD) General. [redacted]

2. (U) Reaction Time. Reaction times are extremely variable. Takeoff can occur in less than 30 seconds if the crew is in the aircraft with engines running, ready to takeoff. Up to several hours may be required if the bomb is located in a storage area partially assembled and tested to allow the shortest assembly time. In addition, the distance and condition of the route to the bomb storage area and the flight time to the target must be considered.

3. (U) Accuracy. Accuracy is dependent upon the aircraft, the delivery technique, and the training of the crew among other factors. See the coverage tables for a range of CEP.

4. (U) Reference. DNA Nuclear Weapon Characteristics Report.

5. (S) Aircraft Certification. [redacted]

6. (S-RD) [redacted]

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CHAPTER XV

MINUTEMAN III with MK-12 (LGM-30G)(W62) SYSTEM CAPABILITIES AND EMPLOYMENT CONSIDERATIONS (U)

1. (~~S-FRD~~) General. [redacted]

2. (U) Reaction Time. Not available.

3. (U) Accuracy. Accuracy is a function of fuze option. Since the fuzes have a detonation bias, and since the settings are usually given in feet whereas the altitudes for detonation are in meters for this publication, the table on page XV-2 provides the relationship between fuze-setting heights of burst (feet) and damage-calculation heights of burst (meters).

4. (U) References. DNA Nuclear Weapon Characteristics Report, Issue 61, 1 October 1988.

5. (~~S-RD~~) [redacted]

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* - Enactment of the various START treaties may modify the number of RVs allowed at future dates.

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CHAPTER XVI

TRIDENT I with MK-4 (C4)(W76) SYSTEM CAPABILITIES AND EMPLOYMENT CONSIDERATIONS (U)

1. (S-FRD) General. [redacted]

2. (U) Reaction Time. Not available.

3. (U) Accuracy. Accuracy is a function of fuze option. Since the fuzes have a detonation bias, and since the settings are usually given in feet whereas the altitudes for detonation are in meters for this publication, the table on page XVI-2 provides the relationship between fuze-setting heights of burst (feet) and damage-calculation heights of burst (meters).

4. (U) Reference. DNA Nuclear Weapon Characteristics Report, Issue 61, 1 October 1988.

5. (S-RD) [redacted]

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CHAPTER XVII

MINUTEMAN III with MK-12A (W78) SYSTEM CAPABILITIES AND EMPLOYMENT CONSIDERATIONS (U)

1. (~~S-FRD~~) General. [redacted]

2. (U) Reaction Time. Not available.

3. (U) Accuracy. Accuracy is a function of fuze option. Since the fuzes have a detonation bias, and since the settings are usually given in feet whereas the altitudes for detonation are in meters for this publication, the table on page XVII-2 provides the relationship between fuze-setting heights of burst (feet) and damage-calculation heights of burst (meters).

4. (U) Reference. DNA Nuclear Weapon Characteristics Report, Issue 61, 1 October 1988.

5. (~~S-RD~~) [redacted]

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CHAPTER XVIII

PEACEKEEPER with MK-21 (W87 MOD 0) SYSTEM CAPABILITIES AND EMPLOYMENT CONSIDERATIONS (U)

1. (S-FRD) General. [redacted]

2. (U) Reaction Time. Not available.

3. (U) Accuracy. Accuracy is a function of fuze option. Since the fuzes have a detonation bias, and since the settings are usually given in feet whereas the altitudes for detonation are in meters for this publication, the table on page XVIII-2 provides the relationship between fuze-setting heights of burst (feet) and damage-calculation heights of burst (meters).

4. (U) Reference. DNA Nuclear Weapon Characteristics Report, Issue 61, 1 October 1988.

5. (S-RD) [redacted]

[redacted]

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CHAPTER XIX

TRIDENT II with MK-5
(D5)(W88)
SYSTEM CAPABILITIES AND EMPLOYMENT CONSIDERATIONS (U)

1. ~~(S-FRD)~~ General. [redacted]

2. (U) Reaction Time. Not available.

3. (U) Accuracy. Accuracy is a function of fuze option and range. Since the fuzes have a detonation bias, and since the settings are usually given in feet whereas the altitudes for detonation are in meters for this publication, the table on page XIX-2 provides the relationship between fuze-setting heights of burst (feet) and damage-calculation heights of burst (meters). [redacted]

4. (U) Reference. DNA Nuclear Weapon Characteristics Report, Issue 61, 1 October 1988.

5. ~~(S-RD)~~ [redacted]

[redacted]

[redacted]

Classified By: CG-W-5

~~RESTRICTED~~ DATA
This material ~~contains~~ Restricted Data as defined in the ~~Atomic Energy~~ Act of 1954. Unauthorized disclosure ~~subject~~ to administrative and criminal sanctions.

CHAPTER XIX

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Table Locations:

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APPENDIX A

REFERENCES

1. Joint Pub 0-2, "Unified Action Armed Forces (UNAAF)".

2. Joint Pub 1-02, "DOD Dictionary of Military and Associated Terms".

3. Joint Pub 1-03.1 and 1-03.2, JRS, "SOP for Coordination of Atomic Operations".

4. Joint Pub 3-11, "Joint Doctrine for Nuclear, Biological and Chemical (NBC) Defense".

5. Joint Pub 3-12, "Doctrine for Joint Nuclear Operations".

6. Joint Pub 3-12.1, "Doctrine for Joint Nonstrategic Nuclear Weapons Employment".

7. Joint Pub 3-12.3, "Nuclear Weapons Employment and Effects Data (Notional)".

8. "Joint Strategic Capabilities Plan (JSCP)".

9. OGA-2800-23-92, "Physical Vulnerability Handbook fo: Nuclear Weapons", Defense Intelligence Agency.

10. "Defense Nuclear Agency Air Transport of Radiation (ATR)", Version 6.

11. "Defense Nuclear Agency Effects Manual Number 1, Capabilities of Nuclear Weapons".

12. HQDNA-AR-48M, "Nuclear Weapon Characteristics Report", Defense Nuclear Agency.

13. AFP 200-18, "USAF Intelligence Targeting Handbook".

14. DA Pamphlet 50-3, "The Effects of Nuclear Weapons".

15. DST-1510S-199-93, "Vulnerability of FSU Armor Systems to Nuclear Radiation and Blast Effects".

16. FM 3-3-1/FMFM 11-8, "Nuclear Contamination Avoidance".

17. FM 3-4/FMFM 11-9, "NBC Protection".

18. FM 3-100/FMFM 11-2, "NBC Defense, Chemical Warfare, Smoke and Flame Operations".

19. "Personnel Risk and Casualty Criteria (PRCC) for Nuclear Weapons Effects", US Army Nuclear and Chemical Agency.

20. STANAG 2083, "Commander's Guide on Nuclear Radiation Exposure of Groups".

21. STANAG 2103, "Reporting Nuclear Detonations, Biological and Chemical Attacks and Predicting and Warning of Associated Hazards and Hazard Areas".

22. STANAG 2104, "Friendly Nuclear Strike Warnings".

23. STANAG 2111, "Target Analysis - Nuclear Weapons".

24. STANAG 2112, "NBC Reconnaissance".

25. STANAG 2874, "Planning Guide for Estimation of Battle Casualties (Nuclear)".

26. STANAG 2910, "Nuclear Casualties and Damage Assessment for Exercises".

APPENDIX B
NUCLEAR WEAPONS: EFFECTS AND RESPONSES

1. General. 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 A. EFFECTS

2. Nuclear Energy Partition. The energy released in a nuclear explosion far exceeds the energy released in a conventional explosion. Nuclear explosions also differ from conventional explosions in that both thermal and nuclear radiation are emitted as well as blast. This energy, or yield, is measured in kT or megatons (MT). A kiloton refers to the amount of energy released by 1,000 tons of TNT. A megaton equates to the energy released by 1,000,000 tons of TNT. The initial temperatures range into millions of degrees, and initial pressures range into millions of atmospheres. Energy released by a nuclear weapon is typically in the form of X-rays, ultraviolet light, kinetic energy of debris, and nuclear radiation. At low altitudes, the X-rays and kinetic energy of the weapon debris heat the surrounding air to form a fireball and a shock wave. In the target area, most of the energy from a nuclear weapon detonation will appear as three distinct forms:

a. Blast. A blast wave with accompanying high velocity winds and drag effects travels outward from the burst faster than the speed of sound, crushing, and translating objects in the surrounding area.

b. Thermal Radiation. The fireball emits intense thermal radiation at the speed of light, heating, and burning objects in the surrounding area.

c. 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, that may interfere with the propagation of electromagnetic waves associated with communication systems and radars.

3. <u>Weapon Type</u>. The partition of energy received by the target as blast, thermal radiation, and nuclear radiation depends primarily on whether the weapon uses fission or a combination of fission and fusion. Fission is the splitting of heavy atoms of uranium or plutonium. Fission produces neutrons, gamma rays, and fission products, of which many are radioactive. Fusion is the combination of two light elements, typically hydrogen isotopes such as deuterium and tritium. Fusion produces neutrons as well as helium and hydrogen isotopes. For fusion to occur, extremely high temperatures are required; thus, fusion is typically referred to as a thermonuclear process.

a. <u>Fission Weapons</u>. Percentages of total energy appearing at the target in the form of blast, thermal radiation, and nuclear radiation depend on the height of burst and physical design of the weapon. Approximately 80 percent of the energy released is initially in the form of X-rays and ultraviolet light with the remainder being nuclear radiation and kinetic energy of debris. For airbursts near the earth's surface, the X-rays and debris heat the surrounding air to form a fireball and shock wave. At the target, slightly more than 50 percent of the energy may appear as blast, about 35 percent as thermal radiation, and the remaining 15 percent as nuclear radiation (5 percent initial and 10 percent residual). Some fission weapons may be referred to as a boosted fission weapon. A boosted fission weapon contains a small amount of fusion in order to provide additional neutrons to improve the efficiency, thus yield, of the fission process.

b. <u>Fission-Fusion Weapons</u>. [redacted]

4. Blast

a. 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 (wind gust) 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-kT weapon might produce an overpressure of about 5 pounds per square inch (psi) at 500 meters from the burst; whereas a 10-kT 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.

b. 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 B-1).

(1) Overpressure. Intensely hot gasses 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 B-1). 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 B-1). The peak overpressure decreases with

distance. 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 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.

(2) 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 targets of military materiel are drag-sensitive. Personnel can also become casualties when they are pushed about by dynamic pressure 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.

c. HOB Influences

(1) 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. For large area targets not blast-resistant, such as buildings and forests, a high airburst will likely increase the area coverage. This is because with the higher HOB the combined reflected and incident waves will

produce higher pressures, and thus produce damage at a greater distance.

(2) Surface Burst. A SB produces less total air blast area coverage to most military targets than an AB because there is less reinforcement of the blast wave. Moreover, since some of the weapon's energy creates a crater and generates ground shock, the amount of energy in the blast wave is reduced.

(3) 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 ABs and SBs. As a result, only small amounts of damage can generally be expected from the air blast produced by a subsurface burst.

d. Modifying Influences

(1) Weather. Rain and fog may attenuate the blast wave in the low-overpressure region because heating and evaporating the moisture in the atmosphere dissipate energy.

(2) 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 thermal energy and subsequently the blast wave is not modified. Overpressure is maximized for such surfaces. Conversely, surfaces with thick, low, combustible vegetation, dry soils with sparse vegetation, and desert sand are nonideal. They absorb some of the thermal energy and create a thermal layer. The thermal layer corrupts the blast wave. The result is greatly increased dynamic pressure or wind and less overpressure. This phenomenon often provides increased damage to most targets.

(3) 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.

(4) 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.

e. 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, that 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 1-kiloton burst at a depth of 40 meters in wet soil forms a crater about 65 meters in radius and nearly 35 meters deep. In rocky or cohesive soil, material thrown from the crater ranges from a fraction of a pound to many tons. These ejecta pose a hazard to personnel, materiel, and structures. Generally speaking, more than half of the crater ejecta is contained in the crater lip, which extends from the rim to about 3 crater radii from GZ. The remaining ejecta fall to the ground out to ranges where the overpressure is less than 1 psi. 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.

5. 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 B-2 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 mostly x-ray and ultraviolet radiations and very little energy of the visible thermal type. The x-ray and ultraviolet radiation is attenuated rapidly in the air and causes the enormous heating of the atmosphere. This results in the second pulse that emits mostly visible light and infrared radiation and has much more energy than the first pulse. 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 B-2, 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 B-2. The second pulse lasts nominally 10 times as long as it takes to reach its maximum intensity. Figure B-2 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.

a. Characteristics. Within the atmosphere, the principal characteristics of thermal radiation are that it: travels at the speed of light; travels in straight lines; and, can be scattered, reflected, and easily absorbed (attenuated).

b. Modifying Influences

(1) 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.

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

(3) 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 AB. A SB produces about one-half the amount of the thermal radiation that an AB 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.

6. 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. The absorbed nuclear radiation is measured and expressed in the unit cGy (also known as the "RAD"). Dosimeters and other radiac meters may be calibrated in RADs, but for practical military use they should be read directly in cGy. Nuclear radiationemitted in the first minute after the burst is initial radiation. The nuclear radiation emitted after the first minute is residual radiation.

a. 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.

(1) 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; and, 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.

(2) 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.

(a) 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.

(b) 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.

(c) Height of Burst. For surface and subsurface bursts, initial radiation is sharply attenuated by the surrounding ground.

(d) 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.

(e) 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 outside to the dose inside is called the protection factor.

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

Protection factor tables in Chapter V of this publication list the protection factors for neutron, initial gamma ray, and residual radiation for different equipment and protection postures. These protection factors are used to calculate the dose that may be received through the shielding material.

Dose Inside = Dose Outside/Protection Factor

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

b. 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, fallout, rainout, and base surge.

(1) Neutron-Induced Radiation. This is radiation from radioactive materials produced within a relatively small circular pattern hundreds of meters in radius around GZ. 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 Army FM 3-3-1 for details about predicting induced soil radiation.

(2) Fallout. Fallout is usually found in a large, elongated pattern around and outward from GZ. 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. 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 10 as the time after the burst increases by multiples of 7. 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 3-3-1 contains 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.

(3) Fallout Safe Height of Burst. The fallout safe height of burst (FSHOB) is the HOB at which no military significant fallout will occur. It is computed by one of the equations below in which W stands for safety yield in kilotons. Safety yields and $W^{1/3}$ values are listed in Table I-1 of this publication.

For $W \leq 100$ kT; FSHOB = 30 ($W^{1/3}$) (meters)

or

For $W > 100$ kT; FSHOB = 55 ($W^{1/3}$) (meters)

The vertical dispersion of the delivery system is accounted for by adding 3.5 times the PEH to the FSHOB. This provides an aimed HOB that precludes significant fallout with a 99 percent assurance.

(4) Rainout. Rainout 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 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.

(5) 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.

(6) Common Characteristics. 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.

(7) HOB Influence. 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 produceinduced radiation, base surge, and fallout in and around the crater. If the proper atmospheric conditions exist, rainout may occur for each of these HOBs.

c. Electromagnetic Pulse (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; nevertheless, the results can be momentary or permanent.

(1) 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 due to the interaction with the earth's magnetic field. Additionally, this pulse of electric current in the air will radiate an electromagnetic wave as an antenna does. These local and radiated fields constitute the EMP. Both are extremely intense and last for only a fraction of a second. Detonations at HOBs ranging from very shallow subsurface bursts to high airburst 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 inversely with the square of the distance from the burst point. 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 due to the field cancellations from the spherical symmetry of the detonation. EMP from detonations at extremely high altitudes, tens to hundreds of kilometers, will travel long distances in the rarefied atmosphere and will produce electric currents in the upper regions of the atmosphere. These currents create intense radiated fields that will cover areas of hundreds of thousands of square kilometers at the surface of the earth with significant levels of EMP.

(2) 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 free electrons and electrical currents that generate an electromagnetic pulse in the system

itself. For low-altitude bursts, SGEMP occurs in the source region at the same time as EMP. In some instances, intense electric fields could be generated when these electrons are emitted into system enclosures and cavities.

(3) 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 short lived. The effects on materiel, however, can be either temporary or permanent. Semiconductors and other electronic components are especially sensitive to TRE. When electronic equipment is damaged by radiation, this damage is commonly referred to as transient radiation effects on electronics.

(4) 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. Very low-altitude bursts or surface 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 can be disrupted or totally blacked out. High frequency (HF) to super high frequency (SHF) radio systems are usually affected. Detonations at high altitudes will primarily affect HF skywave and satellite transmissions. Blackout depends on the HOB, the yield, condition of the atmosphere, 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.

7. Special Considerations

a. Extremely Cold Environments. Ice, snow, high winds, and low temperatures can alter nuclear weapon effects. An understanding of these alterations is essential in making realistic operational decisions.

(1) Blast. At temperatures of about -45° C (-49°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.

(2) Thermal Radiation. In extremely cold environments, a significant adjustment may be required in personnel safety distances. For example, when surfaces are covered with snow and ice and atmospheric conditions are clear, the minimum safe distances for unwarned, exposed personnel must be increased by 30 percent. Additionally, 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.

b. Hot Environments. Weapons effects do not vary as 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 B. RESPONSES

8. Response to Blast. Air blast, cratering, ground shock, and indirect effects can damage materiel and injure personnel.

a. 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.

(1) 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 overpressure.

(2) Personnel Injury. Very high overpressure (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 pressure can build up from multiple reflections inside such enclosures. Injuries from

the above effects are called primary blast injuries. 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. Translational casualty criteria are evaluated on a mix of translational injuries consisting of 75 percent of injuries caused by decelerative tumbling and 25 percent of injuries caused by solid impact. The third source of blast injuries that are considered are missiling injuries, that is, injuries caused by objects hitting personnel. The blast personnel safety criteria used in this manual for exposed personnel are the maximum of the above three discussed blast casualty mechanisms. Blast casualty criteria for exposed personnel are the maxima of the first two mechanisms.

b. 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 ejecta 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 targeting requirements.

c. 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. Sand and dust may limit visibility and movement in the target area for tens of minutes. 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.

9. 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.

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

(1) 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 uncertain because personnel can gain protection easily. Given this uncertainty, thermal radiation casualty criteria are determined only for latent ineffectiveness to exposed personnel, assuming personnel are wearing the battledress uniform with no skin exposed. Flash burns occur on bare skin or through clothing. Personnel safety criteria developed for thermal radiation exposures are based upon thermal radiation being transmitted to bare skin or 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.

(2) 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 in direct 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.

(a) 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 could severely impair the conduct of night aviation operations.

(b) 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.

b. Environment

(1) 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.

(2) Urban Fires. In cities, direct thermal radiation can ignite such fuels as paper, trash, window curtains, dry grass or leaves, and dry 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.

10. 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 nuclear attacks or radiation exposures. Personnel safety from nuclear radiation is a major consideration. Adequate protective shielding is difficult to acquire. Both friendly personnel and the enemy may 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 personnel can be exposed during a nuclear attack and still remain operationally effective.

a. 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 in Figure B-3.

b. Individual Response. For yields of about 10 kilotons or less, initial nuclear radiation is the dominant casualty producing effect. 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. Personnel response to nuclear radiation depends on several factors, including:

(1) The composition of nuclear radiation (gamma and neutron) to which an individual is exposed.

(2) The total dose accumulated, including previous radiation exposures.

(3) The periods over which the doses are received, that is the radiation dose rate.

(4) The recuperation time between exposures.

(5) The individual's physical condition, gender and age.

(6) The presence of any additional injuries.

c. Typical Responses. 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 B-4 shows the expected typical responses of groups of individuals to radiation. The predicted response ranges estimate how typical groups will respond if exposed to ionizing radiation. The response ranges, 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. The data in this table are based on the following assumptions:

(1) The individuals are healthy, rested, and well-fed.

(2) They have had no previous exposure.

(3) They have received uniform whole-body exposures.

(4) They have received an acute dose.

(5) They have received no other injuries.

(6) Equal doses of neutrons and gamma rays produce the same effect.

d. Expected Response. Figures B-5 and B-6 show the expected response of personnel for various combinations of dose and time elapsed following exposure. Figure B-5 is for physically demanding tasks such as loading weapon systems; Figure B-6 is for physically undemanding tasks such as working in a fire direction center or commanding a vehicle. To better understand the use of these figures, consider the example of the expected responses of a group of people whose jobs involve physically demanding tasks and who receive 1,500 cGy of radiation. The dashed line in Figure B-5 shows that typical group members will be temporarily effective until about 35 minutes after the exposure. This group will become performance-degraded until about 5 hours, after which people in the group will have declined sufficiently to be categorized as CI. The group will remain CI for about 1 and one-half days, after which typical group members will recover enough to be placed in the PD category. They will remain PD for approximately 8 days. At approximately 9-10 days after exposure, they will become CI and remain so until they die. Death can be expected about 17 days after exposure for the entire group. Similar information can be derived from Figure B-6 for physically undemanding tasks.

e. 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. Past 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. 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.

(1) RES 0. A unit that has never been exposed to nuclear radiation, a unit which has received no dose.

(2) RES 1. A unit that has received a dose greater than 0, but less than or equal to 70 cGy.

(3) RES 2. A unit that has received a significant but not dangerous dose of radiation, a dose greater than 70 cGy, but less than or equal to 150 cGy. 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.

(4) RES 3. A unit that has already received a dose of radiation greater than 150 cGy; 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.

f. Recovery and Late Effects. Persons surviving exposures of 450 cGy 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.

g. Combined Injury. The simultaneous injury of personnel by blast, thermal and ionizing radiation effects is expected to be common on the nuclear battlefield. Synergistic interactions between these injuries are expected to produce much higher levels of performance degradation among units than would be expected from the presence of single effect injuries, alone. Combined injuries will result in increased numbers of performance degraded and combat ineffective personnel as early as 30-60 minutes after a unit is exposed to the initial effects of a nuclear detonation.

11. Additional Responses

a. 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. Figure B-7 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 certain levels of effects on personnel.

b. 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 the state of circuits without damaging components. Lower effect levels may disorder digital circuitry and cause memory loss. Solid state components and microcircuitry are more vulnerable to permanent damage than vacuum tubes in older equipment. Optical and infrared components may also be susceptible to TRE. The levels of equipment damage depend on the type of equipment, its external 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 can be estimated on the basis of its sensitivity levels to electromagnetic fields. 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 effective military operations of survivors. See Appendix E of this publication for information pertaining to EMP damage and the established safety radii for some systems using electrical components.

c. Blackout of Communications. Radio waves transmitted near or through a region of the atmosphere disturbed by a nuclear fireball may be disrupted or blacked out totally (see Figure B-8). 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 battlefield will depend on the number of nuclear detonations, the time period of the detonations, the bursts' altitudes, and the atmospheric and environmental conditions. 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:

(1) Wire communications systems. However, systems with wires, especially long wires, are more susceptible to EMP.

(2) Alternate routing through a manual relay or retransmission station to bypass the blackout region.

(3) 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.

d. Combined Nuclear and Chemical Exposure. Chemical weapons may be employed 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.

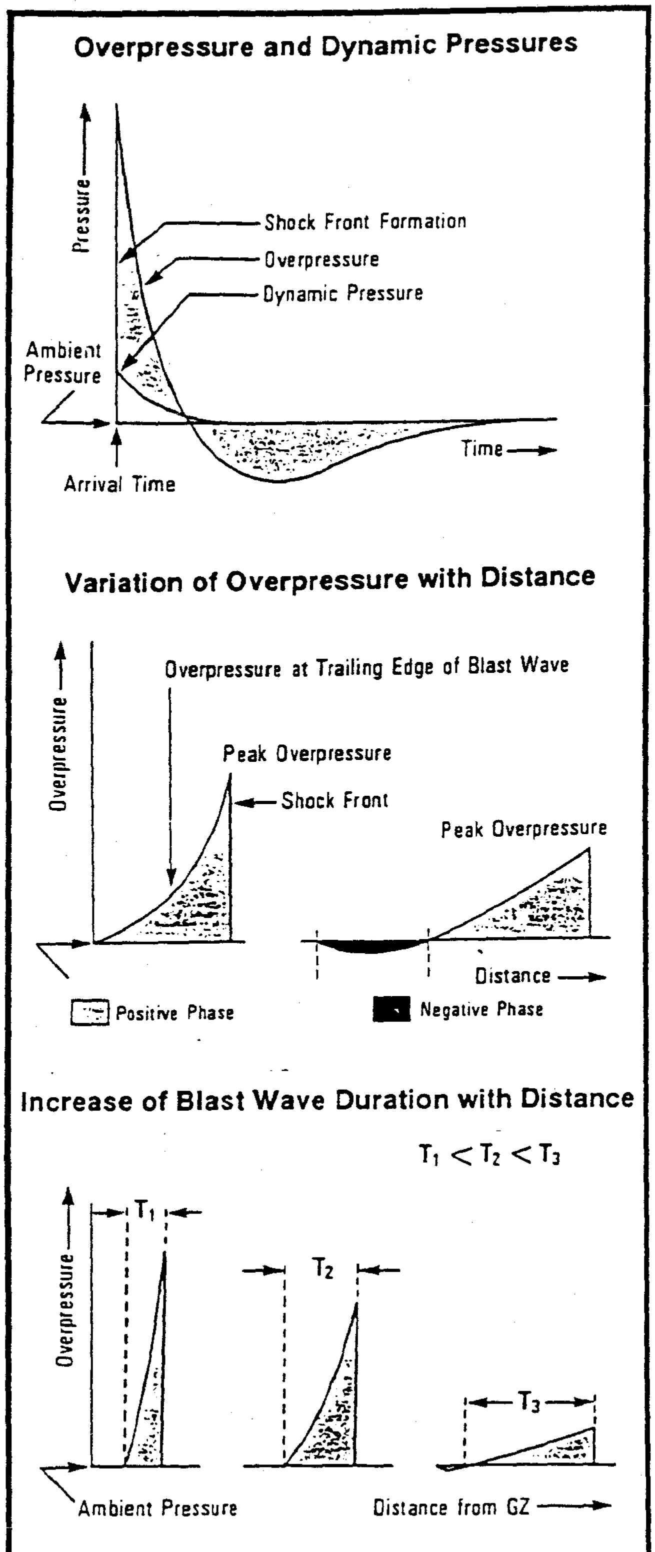
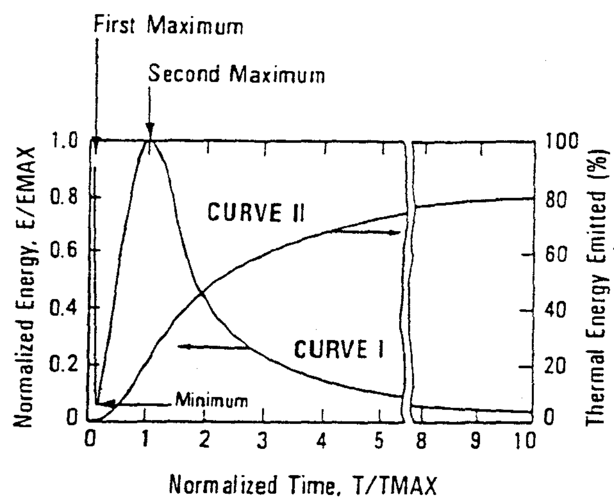


Figure B-1. Pressure Relationships

Thermal Radiation Versus Time for a Given Yield



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

Figure B-2. Thermal Radiation Relationships

COMBAT-INEFFECTIVE	Combat-ineffective (CI) personnel function at less than 25 percent 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, hypertension, dry heaving, nausea, lethargy, depression, and mental disorientation.
IMMEDIATE PERMANENT INEFFECTIVENESS	Immediate permanent ineffectiveness (IPI) is the physiological response to radiation at levels of 8,000 cGy for both physically demanding and physically undemanding tasks. 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	Immediate transient ineffectiveness (ITI) is the physiological response to radiation of levels of 3,000 cGy for physically demanding tasks or 3,800 cGy for physically undemanding tasks. 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 INEFFECTIVENESS	Latent Ineffectiveness (LI) is the physiological response to radiation at levels of 450 cGy for physically demanding tasks or 600 cGy for physically undemanding tasks. Personnel will become PD within 3 hours and remain so until death some weeks post-exposure, or become CI at any time within 6 weeks post-exposure.

Figure B-3. Response to Acute Doses of Nuclear Radiation

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 24 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 until death: 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 until death: 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 until death: 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 until death. 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

Figure B-4. Biological Effects of Nuclear Radiation. (STANAG 2083 Edition 5)

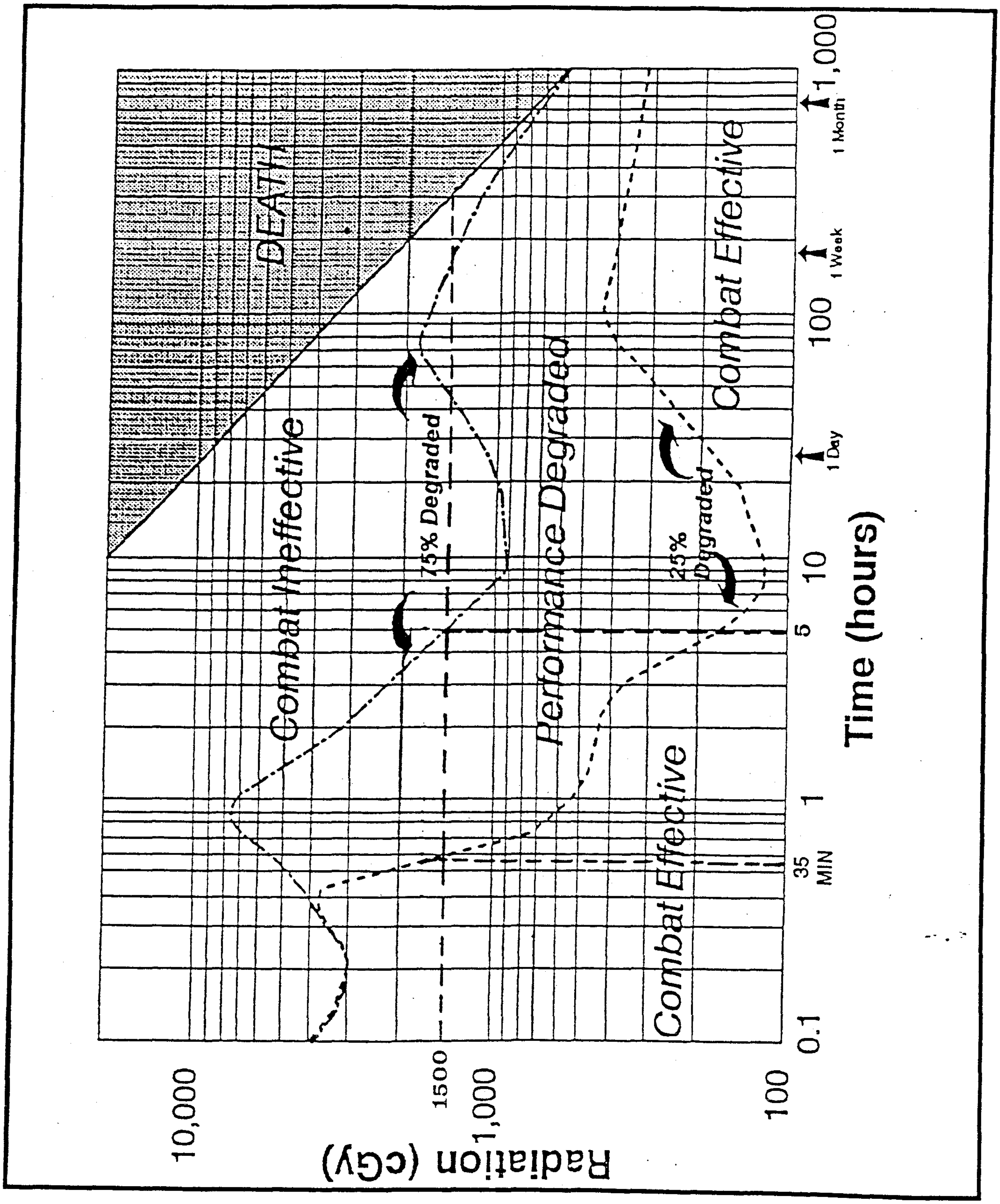


Figure B-5. Expected Response to Radiation (cGy) - Physically Demanding Tasks

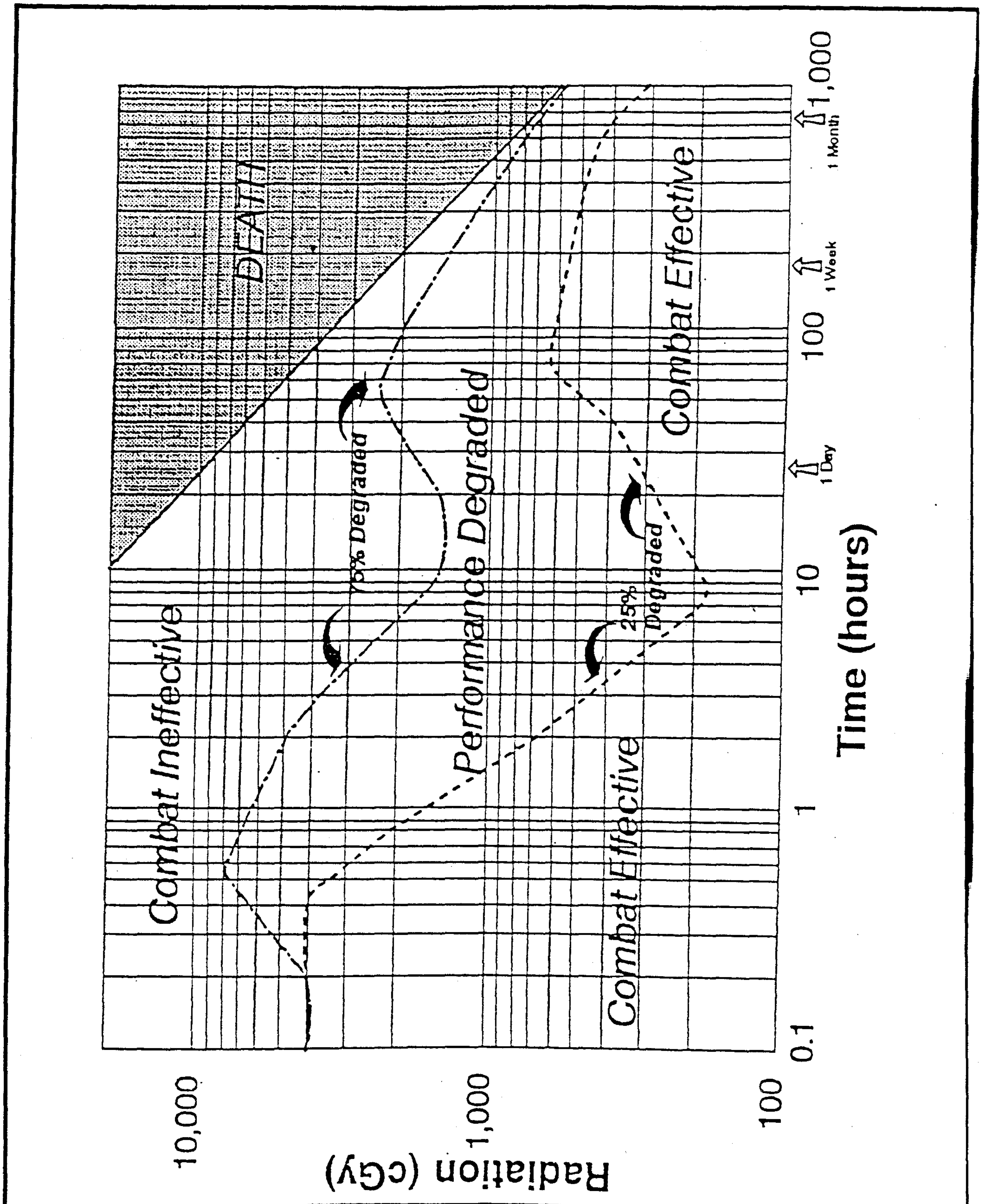


Figure B-6. Expected Response to Radiation (cGy) - Physically Undemanding Tasks

Assuming that the criteria are met. Diagram A illustrates that immediate transient casualties from nuclear radiation (a dose of 3,000 cGy) occur over 30 percent of the target. It also shows that the latent ineffective criterion (450 cGy) will occur over an additional 20 percent of the target and that personnel 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.

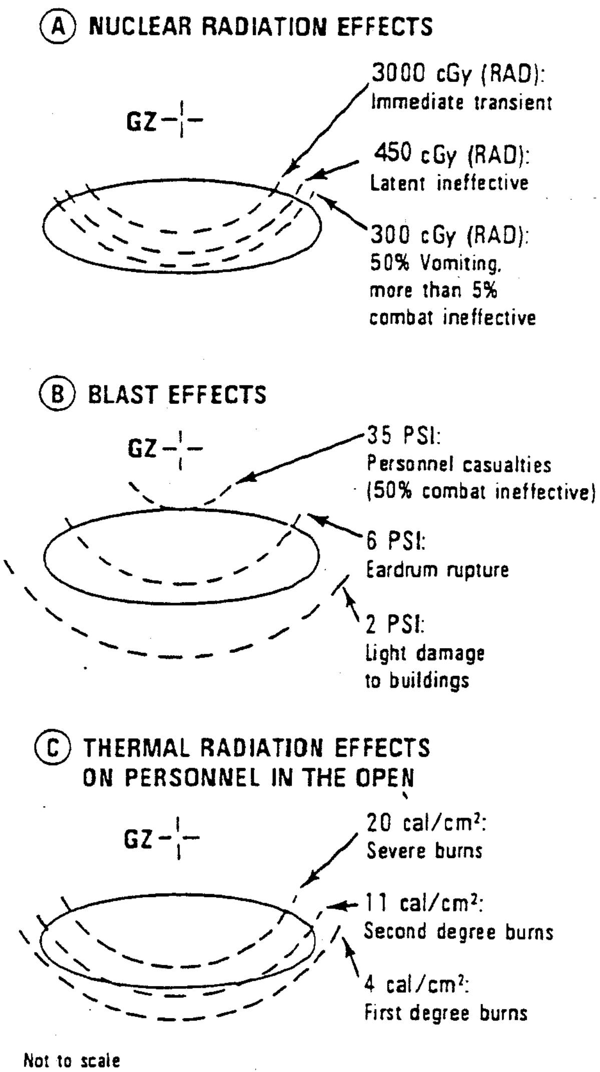


Figure B-7. Weapon Effect

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

Figure B-8. Blackout of Radio Communications

APPENDIX C
ANALYSIS OF FRIENDLY VULNERABILITY (U)

1. (U) General. Large units, that 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.

2. (U) 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 personnel concentrations that are profitable targets. Commanders must resolve these conflicts by making a risk benefit analysis for each specific situation.

3. (U) 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 personnel will be exposed to a risk equal to, or greater than, the emergency risk criterion (5 percent LI, see the Glossary for definition) and/or within which materiel will be subjected to a 5 percent probability of the specified degree of damage. Figure C-1 is the RV table, and it also appears in Chapter V of this publication with the other graphs and tables. 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:

a. (U) Determining the appropriate threat yields based on current intelligence.

b. (U) Determining the disposition of personnel in friendly units.

c. (U) Obtaining the appropriate vulnerability radii from the RV table.

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Date of source: Apr., 1992

d. (U) Estimating the fractional coverage of the unit using the visual techniques discussed in Chapters II through IV. 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.

e. (U) Recommending ways to decrease vulnerability or increase protection if the estimated damage exceeds the acceptable loss criteria established by the commander.

4. (U) Poststrike Hasty Estimation. Analysts may also use the 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 personnel 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.

Table C-1. (U) Radii of Friendly Vulnerability to Threat Nuclear Systems (Distances in Meters)

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APPENDIX D
BLACKOUT EFFECTS OF NUCLEAR DETONATIONS ON RADIO COMMUNICATIONS AND RADAR TRANSMISSION/RECEPTION

1. Commanders should be aware that the fireball and dust clouds resulting from a nuclear burst may degrade or completely interrupt the operation of their communications systems and radars without doing physical harm to their equipment. This interference results from:

a. Absorption or changes in the characteristics of electromagnetic waves from a communications transmitter or radar or dust cloud.

b. Electromagnetic noise from the fireball being picked up by the receiver.

2. The durations of these effects are of chief interest and are summarized in Table D-1 for communications systems. Interference from low-altitude bursts may last a few seconds to a few minutes for most communications systems. Effects produced by high-altitude bursts may range from a few seconds to hours. The duration of such interference for radar systems is comparable.

3. Increasing transmitter power or the use of alternate routing may be employed to mitigate blackout effects to radio communications. Alternate routing may be difficult since communications traffic is apt to be very heavy at the time of nuclear employment. When a frequency is blacked out in a system that can transmit at several frequencies, other frequencies should be tried.

Table D-1. 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 E
VULNERABILITY OF ELECTRONIC EQUIPMENT TO
ELECTROMAGNETIC PULSE EFFECTS (U)

1. (U) General. In addition to personnel casualties and damage to equipment caused by initial radiation, blast, and thermal radiation, a unit may receive damage to some of its electrical and electronic equipment due to the effects of the EMP. Because of the uncertainties involved in the generation physics of the pulse within the earth's atmosphere and in the response of specific equipment items to the pulse, EMP is not considered a reliable kill mechanism for targeting purposes. However, EMP effects can be significant when dealing with friendly unit vulnerability and damage preclusions. Their significance is a function of both equipment vulnerability and extent of the environment.

2. (U) Equipment Vulnerability. In general, three categories of estimated risk of equipment failure to EMP can be considered: low, medium, and high. This distinction is based on the relative electronic complexity of the system, and the coupling mode with the external electromagnetic environment. Examples for each category are presented in Table E-1.

3. (U) Environment. EMP exposure can originate from two possible sources: a high altitude (above 30 km.) nuclear detonation, or from a surface (or near surface) burst.

a. (U) High Altitude EMP (HEMP). The magnitude of the radiation that a particular equipment may see from HEMP is a strong function of the location of the equipment in reference to the burst point. Because HEMP can cover very large areas on the surface of the earth when the weapon is strategically placed, it is difficult to define exclusion ranges from GZ where the effect would be negligible. For this reason, to obtain a low probability of equipment failure under this exposure, it is assumed that the equipment is properly hardened to EMP. This appendix provides a straight forward method for battlefield planners to establish the HEMP environment that might be imposed by a nuclear-capable third world country (fission devices with yields less than 100 kT). A flow chart is presented to determine whether HEMP should be considered, and graphs are provided to enable the planner to estimate areas of coverage of the HEMP that could potentially upset or damage electronic equipment on the ground or at aircraft altitudes. Use Figure E-1 to determine the need to

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proceed further and which graph (Figure E-2 or E-3) should be used to provide the area coverage of the HEMP. Figures E-2 and E-3 display the area coverage of a peak HEMP electric field level that could cause upset or damage in modern electronic systems that are not hardened to EMP. Because the HEMP fields change as a function of burst location over the world, different curves are provided for different "geomagnetic dip" angles. Figure E-4 illustrates the geomagnetic dip angles as a function of world location. Using Figure E-4 for a location of interest, the dip angle θ will be found in terms of degrees North or South (e.g. 60N is 60 degrees North). Three categories of dip angles are established as follows:

Category 1 - θ between 10S and 10N
Category 2 - θ between 10N and 40N, or 10S and 40S
Category 3 - θ greater than 40N or 40S

Each of the curves in Figures E-2 and E-3 is marked with the labels 1, 2, or 3. If θ is north, the axis at the top of the figure should be oriented to the north; if θ is south, the top axis should be oriented to the south.

b. (U) Low-Altitude EMP. On the other hand, in case of a low/surface burst, probable safe radii as a function of yield can be established on the basis of man's survivability to initial radiation which was used to develop the low altitude EMP criteria for electronic equipment. Considering all nuclear effects for range vs. yield, appropriate numerical values are presented in Table E-2 for the estimates of safe radii for equipment exposed to an endoatmospheric EMP environment.

Table E-1. (U) Equipment Vulnerability Categories

UNCLASSIFIED

Low Risk Equipment:

Largely self-contained equipment which has cables of very short length or has no external connections.

Examples are:

- Air Defense Systems
- Nuclear Delivery Systems
- Close Combat Systems (Tanks, Vehicles)
- Common Items (Hand Calculators, Compass)

Medium Risk Equipment:

Electronic equipment with short antennas or cable connections (less Than 15m).

Examples are:

- Satcom Terminals
- C4I Systems (Firefinder, TRI-TAC)
- MEP Generators
- Telephone Handsets

High Risk Equipment:

Electronic systems with large antennas or long cable runs.

Examples are:

- Radio Sets
- Teletypes
- Computer Systems (CSS Computer)
- C4I Systems (Quick Look, Teampack, Trailblazer, TCAC, Electronic Processing and Dissemination System, Guardrail, TUT)

Table E-2. (U) Estimated Safe Radii for Equipment in an Endoatmospheric EMP Environment

CONFIDENTIAL

[redacted]

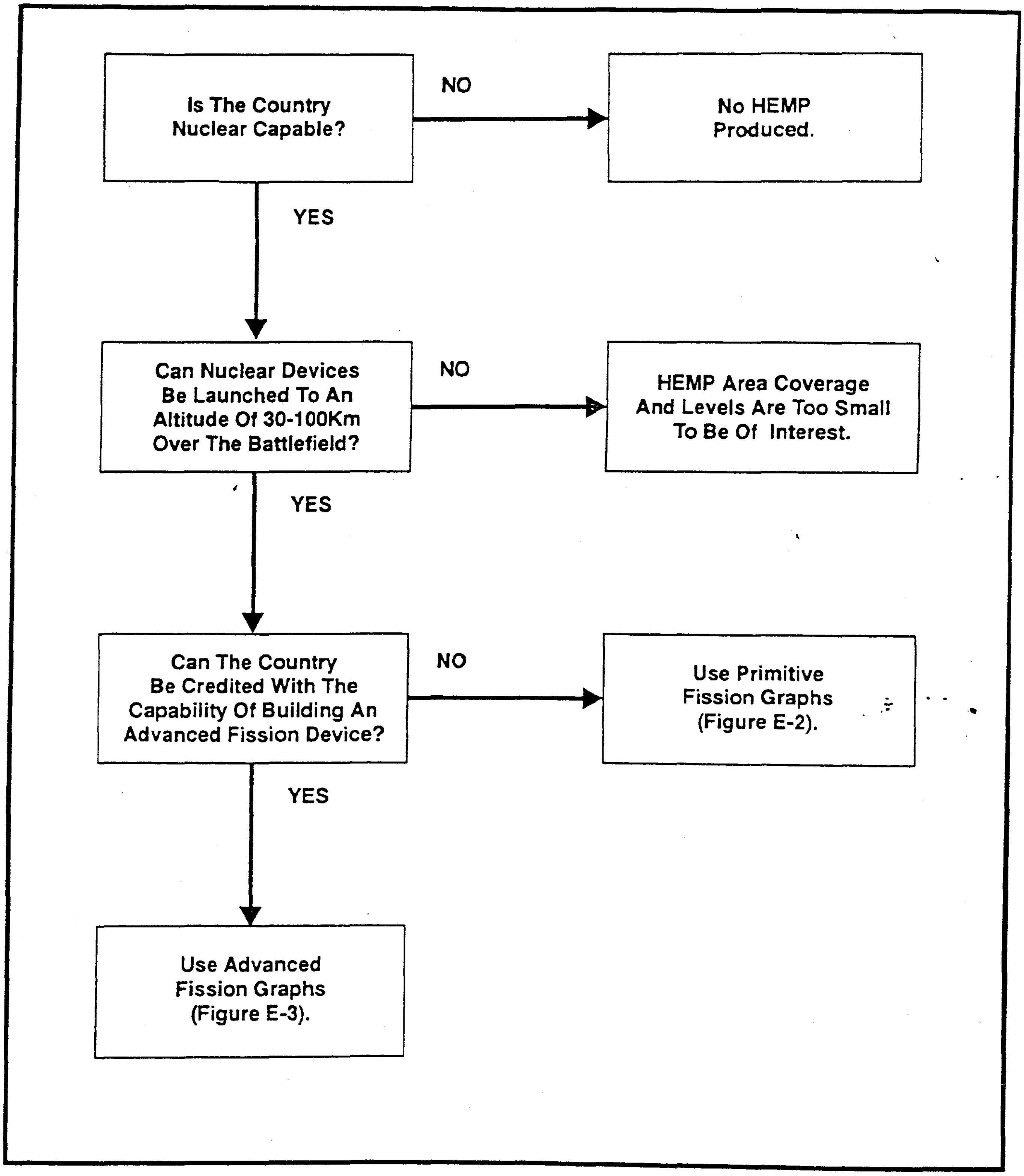

Figure E-1. (U) Flow Chart for Battlefield HEMP

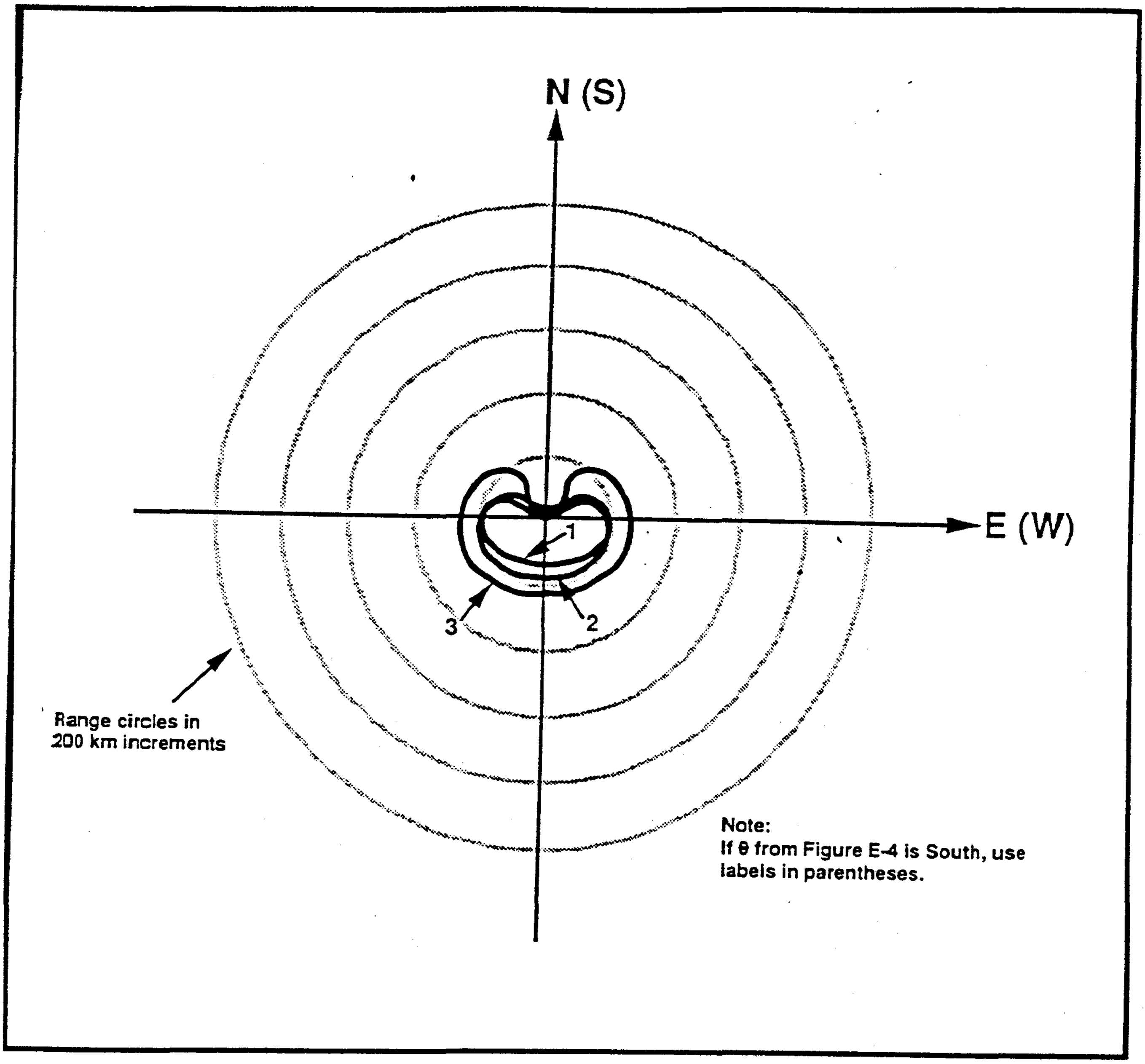

Figure E-2. Primitive Fission HEMP Contours for Categories 1 - 3

UNCLASSIFIED

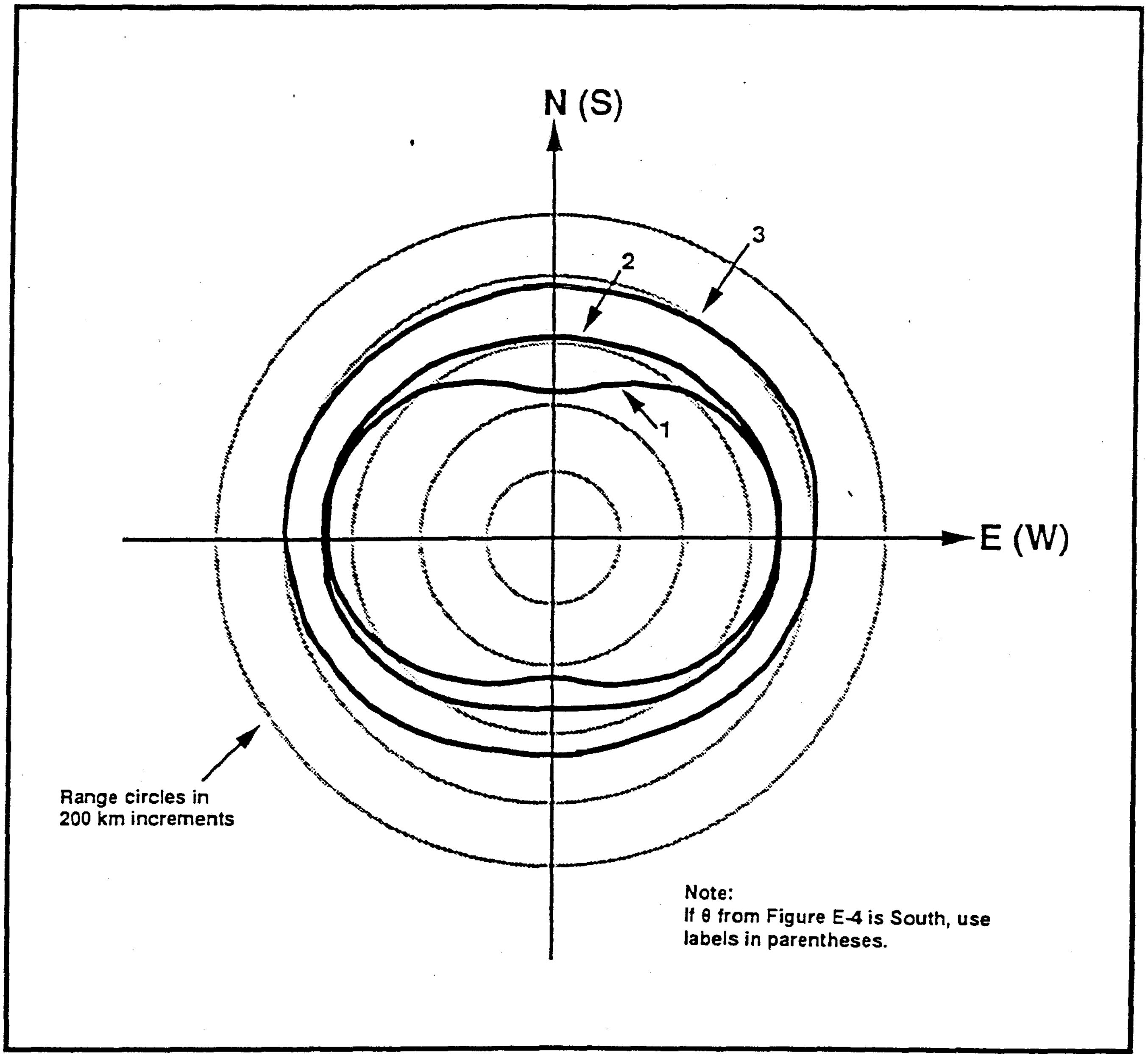

Figure E-3. (U) Advanced Fission HEMP Contours for Categories 1 - 3

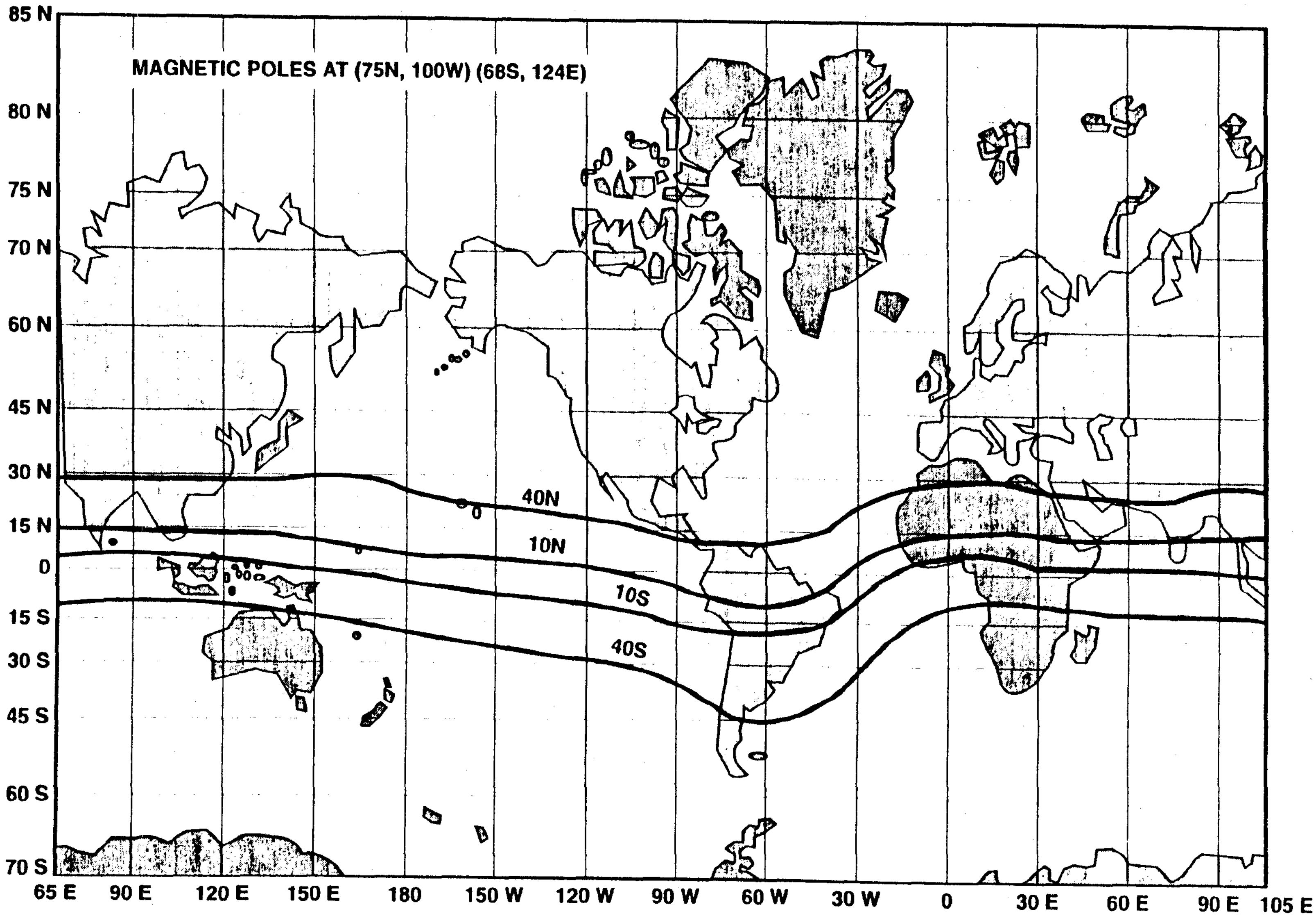

Figure E-4. (U) Dip Angle, θ, of Earth's Magnetic Field

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Glossary

PART I - ABBREVIATIONS AND ACRONYMS

AB	airburst
ACM	Advanced Cruise Missile
ALCM	Air Launched Cruise Missile
APC	armored personnel carrier
ATR	air transport of radiation
B	blast
BD	buffer distance
BDO	battle dress overgarment
BDU	battle dress uniform
CD90	circular distribution 90
CDD	collateral damage distance
CEP	circular error probable
CEPA	adjusted circular error probable
cGy	centigray
CI	combat-ineffective
D	ground zero to target center offset distance
DGZ	desired ground zero
DMAX	maximum ground zero to target center offset distance for a specified damage probability
DNA	Defense Nuclear Agency
DNA EM-1	DNA Effects Manual Number 1 (EM-1), Capabilities of Nuclear Weapons
ED50	effective dose 50
EMP	electromagnetic pulse
ER	enhanced radiation
EXPO	exposed
f	expected fractional coverage to an area target
FSHOB	fallout safe height of burst
GPF	gamma protection factor
GZ	ground zero
HAB	high airburst
HAF	high-altitude fuze
HEMP	high-altitude electromagnetic pulse
HF	high frequency
HOB	height of burst

IAB	inertial airburst
IB	impact burst
IF	impact fuze
INR	initial nuclear radiation
IPB	intelligence preparation of the battlespace
IPI	immediate permanent ineffectiveness
ITI	immediate transient ineffectiveness
kT	kiloton
LAB	low-altitude burst
LAF	low-altitude fuze
LI	latent ineffectiveness
LSD	least separation distance
MAB	medium airburst
MEP	mobile electric power
MF	multiplication factor
MIRV	multiple independently targeted reentry vehicle
MOD	modification
MSD	minimum safe distance
MT	megaton
NATO	North Atlantic Treaty Organization
NBC	nuclear, biological, and chemical
NIGA	neutron induced gamma activity
NPF	neutron protection factor
NSB	near surface burst
NSF	near surface fuze
P	probability of damage to a point target
P90	high assurance probability of damage to a point target
PD	performance degraded
PEH	probable error in height of burst
PLF	path length fuze
PLIF	path length interactive fuze
POL	petroleum, oils, and lubricants
PRCC	Personnel Risk and Casualty Criteria
psi	pounds per square inch
RB	reentry body
RD	radius of damage
RR	railroad
RT	radius of circular area target
RUPL	radar updated path length fuze

RV	radius of vulnerability, reentry vehicle
RVTTD	revetted
SAM	surface-to-air missile
SB	surface burst
SGEMP	system-generated electromagnetic pulse
SHF	super-high frequency
SHLD	shielded
SQR	square root
TAE	target area error
TAE90	target area error 90
TERCOM	terrain contour matching
TLAM(N)	Tomahawk Land Attack Missile (Nuclear)
TLE	target location error
TRE	transient radiation effects
UHF	ultra-high frequency
UNAAF	United Action Armed Forces
USMC	United States Marine Corps
USN	United States Navy
V	variability
VLS	vertical launch system

PART II - TERMS AND DEFINITIONS

actual ground zero. The point on the surface of the Earth at, or vertically below or above, the center of an actual nuclear detonation. See also desired ground zero; ground zero. (Joint Pub 1-02)

adjusted circular error probable. Mathematical parameter which couples a weapon's circular error probable with the radius of a circular error target in order to estimate the fractional coverage of the target. Also called CEPA. (Approved for inclusion in the next edition of Joint Pub 1-02.)

airburst. An explosion of a bomb or projectile above the surface as distinguished from an explosion on contact with the surface or after penetration. See also air; types of burst. (Joint Pub 1-02)

buffer distance (nuclear). 1. The horizontal distance which, when added to the radius of safety, radius of preclusion, or radius of collateral damage, will give 99 percent assurance that the specified degree of risk or damage will not be exceeded. The buffer distance is normally expressed quantitatively in multiples of the delivery error. 2. The vertical distance which is added to the fallout safe-height of burst in order to determine a desired height of burst which will provide the desired assurance that militarily significant fallout will not occur. It is normally expressed quantitatively in multiples of the vertical error. (Approved for inclusion in the next edition of Joint Pub 1-02.)

centigray. A unit of absorbed dose of radiation (one centigray equals one rad). (Joint Pub 1-02)

circular distribution 90. 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 ninety percent of a missile's projectiles are expected to fall. Also called CD90. (Approved for inclusion in the next edition of Joint Pub 1-02.)

circular error probable. 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. Also called CEP. See also delivery error; deviation; dispersion error; horizontal error. (Joint Pub 1-02)

collateral damage. See nuclear collateral damage.

collateral damage distance. The minimum distance that a desired ground zero must be separated from civilian personnel and materiel to ensure with a 99 percent assurance that a 5 percent incidence of injuries or property damage will not be exceeded. It is the sum of the radius of collateral damage and the buffer distance. (Approved for inclusion in the next edition of Joint Pub 1-02.)

combat effective. Personnel function at or above 75 percent of their normal (pre-exposure) performance level. (Approved for inclusion in the next edition of Joint Pub 1-02.)

combat ineffective. Personnel function at 25 percent or less of their normal (pre-exposure) performance level. (Approved for inclusion in the next edition of Joint Pub 1-02.)

contamination. 1. The deposit, absorption, or adsorption of radioactive material, or of biological or chemical agents on or by structures, areas, personnel, or objects. See also induced radiation; residual radiation.

2. Food and/or water made unfit for consumption by human or animals because of the presence of environmental chemicals, radioactive elements, bacteria or organisms, the byproduct of the growth of bacteria or organisms, the decomposing material (to include the food substance itself), or waste in the food or water. (Joint Pub 1-02)

dazzle. Temporary loss of vision or a temporary reduction in visual acuity. See also flash blindness. (Joint Pub 1-02)

degree of risk. As specified by the commander, the risk to which friendly forces may be subjected from the effects of the detonation of a nuclear weapon used in the attack of a close-in enemy target; acceptable degrees of risk under differing tactical conditions are emergency, moderate, and negligible. See also emergency nuclear risk; moderate nuclear risk; negligible nuclear risk. (Joint Pub 1-02)

delivery error. The inaccuracy associated with a given weapon system resulting in a dispersion of shots about the aiming point. See also circular error probable; deviation; dispersion; dispersion error; horizontal error. (Joint Pub 1-02)

desired ground zero. The point on the surface of the Earth at, or vertically below or above, the center of a planned nuclear detonation. Also called DGZ. See also actual ground zero; ground zero. (Joint Pub 1-02)

deviation. 1. The distance by which a point of impact or burst misses the target. See also circular error probable; delivery error; dispersion error; horizontal error. 2. The angular difference between magnetic and compass headings. (Joint Pub 1-02)

dispersion. 1. A scattered pattern of hits around the mean point of impact of bombs and projectiles dropped or fired under identical conditions. 2. In antiaircraft gunnery, the scattering of shots in range and deflection about the mean point of explosion. 3. The spreading or separating of troops, materiel, establishments, or activities which are usually concentrated in limited areas to reduce vulnerability. 4. In chemical and biological operations, the dissemination of agents in liquid or aerosol form. 5. In airdrop operations, the scatter of personnel and/or cargo on the drop zone. 6. In naval control of shipping, the reberthing of a ship in the periphery of the port area or in the vicinity of the port for its own protection in order to minimize the risk of damage from attack. See also convoy dispersal point. See also circular error probable; delivery error; deviation; dispersion error; horizontal error. (Joint Pub 1-02)

dispersion error. The distance from the point of impact or burst of a round to the mean point of impact or burst. (Joint Pub 1-02)

dynamic pressure. Pressure resulting from some medium in motion, such as the air following the shock front of a blast wave. (Joint Pub 1-02)

emergency risk (nuclear). A degree of risk where anticipated effects may cause some temporary shock, casualties and may significantly reduce the unit's combat efficiency. See also degree of risk; moderate risk (nuclear); negligible risk (nuclear). (Joint Pub 1-02)

expected fractional coverage. The expected coverage percentage of an area target damaged to a specified level. The average includes both the weapon's horizontal and vertical delivery errors as well as the target's size. (Approved for inclusion in the next edition of Joint Pub 1-02.)

fallout. The precipitation to Earth of radioactive particulate matter from a nuclear cloud: also applied to the particulate matter itself. (Joint Pub 1-02)

fallout safe height of burst. The height of burst at or above which no militarily significant fallout will be reproduced as a result of a nuclear weapon detonation. See also types of burst. (Joint Pub 1-02)

flash blindness. Impairment of vision resulting from an intense flash of light. It includes temporary or permanent loss of visual functions and may be associated with retinal burns. See also dazzle. (Joint Pub 1-02)

governing effect. The nuclear effect which extends the farthest from ground zero. (Approved for inclusion in the next edition of Joint Pub 1-02.)

ground range. The line of sight distance between two points located on the ground. (Approved for inclusion in the next edition of Joint Pub 1-02.)

ground zero. The point on the surface of the Earth at, or vertically below or above, the center of a planned or actual nuclear detonation. See also actual ground zero; desired ground zero. (Joint Pub 1-02)

height of burst. The vertical distance from the Earth's surface or target to the point of burst. See also optimum height of burst; safe burst height; types of burst. (Joint Pub 1-02)

high airburst. The fallout safe height of burst for a nuclear weapon that increases damage to or casualties on soft targets, or reduces induced radiation contamination at actual ground zero. See also types of burst. (Joint Pub 1-02)

high altitude burst. The explosion of a nuclear weapon which takes place at a height in excess of 100,000 feet (30,000 meters). See also types of burst. (Joint Pub 1-02)

high assurance probability of damage. A conservative estimate of the probability of damage to a point target based upon the assumption that the weapon will detonate no closer horizontally to the target than one circular distribution 90. (Approved for inclusion in the next edition of Joint Pub 1-02.)

horizontal error. The error in range, deflection, or in radius, which a weapon may be expected to exceed as often as not. Horizontal error of weapons making a nearly vertical approach to the target is described in terms of circular error probable. Horizontal error of weapons producing elliptical dispersion pattern is expressed in terms of probable error. See also circular error probable; delivery error; deviation; dispersion error. (Joint Pub 1-02)

immediate permanent ineffectiveness. The physiological response to radiation at levels of 8,000 cGy for both physically demanding and physically undemanding tasks. Personnel become ineffective within three minutes of exposure and remain ineffective until death. Death occurs within one day. (Approved for inclusion in the next edition of Joint Pub 1-02.)

immediate transient ineffectiveness. The physiological response to radiation at levels of 3,000 cGy for physically demanding tasks or 3,800 cGy for physically undemanding tasks. Personnel become ineffective for any task within three minutes of exposure and remain so for approximately seven minutes, independent of the physical demands of the task. Personnel recover to greater than 75 percent of the pre-exposure performance levels at around 10 minutes after post-exposure and remain so for around 30 minutes. At around 40 minutes post-exposure, personnel become performance degraded and remain so for around five hours for undemanding tasks (two hours for demanding tasks), at which time it is expected that radiation sickness symptoms will be present in sufficient severity to render the personnel ineffective. The personnel will remain ineffective until death occurs in five to six days. (Approved for inclusion in the next edition of Joint Pub 1-02.)

induced radiation. Radiation produced as a result of exposure to radioactive materials, particularly the capture of neutrons. See also contamination; initial radiation; residual radiation; residual radioactivity. (Joint Pub 1-02)

initial radiation. The radiation, essentially neutrons and gamma rays, resulting from a nuclear burst and emitted from the fireball within one minute after burst. See also induced radiation; residual radiation. (Joint Pub 1-02)

kiloton weapon. A nuclear weapon, the yield of which is measured in terms of thousands of tons of trinitrotoluene explosive equivalents, producing yields from 1 to 999 kilotons. See also megaton weapon; nominal weapon; subkiloton weapon. (Joint Pub 1-02)

latent ineffectiveness. The minimum exposure which will result in the average Service member becoming performance degraded within three hours and remaining so until death some weeks post-exposure, or the minimum exposure which will result in the average Service member becoming combat ineffective at any time within six weeks post-exposure. (Approved for inclusion in the next edition of Joint Pub 1-02.)

least separation distance. The minimum distance that a desired ground zero must be separated from an object to ensure no more than a 10 percent chance of damage or obstacles with 99 percent assurance. It is the sum of the radius of preclusion and the buffer distance. (Approved for inclusion in the next edition of Joint Pub 1-02.)

limiting requirements. Restrictions placed upon the use of nuclear weapons in order to ensure personnel safety, limit collateral damage, preclude obstacle creation, and/or to meet command-established yield constraints. (Approved for inclusion in the next edition of Joint Pub 1-02.)

low airburst. The fallout safe height of burst for a nuclear weapon which maximizes damage to or casualties on surface targets. See also types of burst. (Joint Pub 1-02)

maximum offset distance. The maximum desired ground zero to target center offset distance for which a specified target coverage or probability of damage can be achieved. (Approved for inclusion in the next edition of Joint Pub 1-02.)

megaton weapon. A nuclear weapon, the yield of which is measured in terms of millions of tons of trinitrotoluene explosive equivalents. See also kiloton weapon; nominal weapon; subkiloton weapon. (Joint Pub 1-02)

militarily significant fallout. Radioactive contamination capable of inflicting radiation doses on personnel which may result in a reduction of their combat effectiveness. (Approved for inclusion in the next edition of Joint Pub 1-02.)

minimum safe distance (nuclear). It is the distance from desired ground zero at which a specific degree of personnel risk and vulnerability will not be exceeded with a 99 percent assurance. The sum of the radius of safety and the buffer distance. (Approved for inclusion in the next edition of Joint Pub 1-02.)

moderate risk (nuclear). A degree of risk where anticipated effects are tolerable, or at worst a minor nuisance. See also degree of risk; emergency risk (nuclear); negligible risk (nuclear). (Joint Pub 1-02)

negligible risk (nuclear). A degree of risk where personnel are reasonably safe, with the exceptions of dazzle or temporary loss of night vision. See also degree of risk (nuclear); emergency risk (nuclear); moderate risk (nuclear). (Joint Pub 1-02)

nominal weapon. A nuclear weapon producing a yield of approximately 20 kilotons. See also kiloton weapon; megaton weapon; subkiloton weapon. (Joint Pub 1-02)

nuclear airburst. The explosion of a nuclear weapon in the air, at a height greater than the maximum radius of the fireball. See also types of burst. (Joint Pub 1-02)

nuclear bonus effects. Desirable damage or casualties produced by the effects from friendly nuclear weapons that cannot be accurately calculated in targeting as the uncertainties involved preclude depending on them for a militarily significant result. (Joint Pub 1-02)

nuclear burst. See types of burst. (Joint Pub 1-02)

nuclear collateral damage. Undesired damage or casualties produced by the effects from friendly nuclear weapons. (Joint Pub 1-02)

nuclear damage. 1. Light Damage — Damage which does not prevent the immediate use of equipment or installations for which it was intended. Some repair by the user may be required to make full use of the equipment or installations. 2. Moderate Damage — Damage which prevents the use of equipment or installations until extensive repairs are made. 3. Severe Damage — Damage which prevents use of equipment or installations permanently. (Joint Pub 1-02)

nuclear exoatmospheric burst. The explosion of a nuclear weapon above the sensible atmosphere (above 120 kilometers) where atmospheric interaction is minimal. See also types of burst. (Joint Pub 1-02)

nuclear radiation. Particulate and electromagnetic radiation emitted from atomic nuclei in various nuclear processes. The important nuclear radiations, from the weapon standpoint, are alpha and beta particles, gamma rays, and neutrons. All nuclear radiations are ionizing radiations, but the reverse is not true: X-rays for example, are included among ionizing radiations, but they are not nuclear radiations since they do not originate from atomic nuclei. (Joint Pub 1-02)

nuclear surface burst. An explosion of a nuclear weapon at the surface of land or water; or above the surface, at a height less than the maximum radius of the fireball. See also types of burst. (Joint Pub 1-02)

nuclear underground burst. The explosion of a nuclear weapon in which the center of the detonation lies at a point beneath the surface of the ground. See also types of burst. (Joint Pub 1-02)

nuclear underwater burst. The explosion of a nuclear weapon in which the center of the detonation lies at a point beneath the surface of the water. See also types of burst. (Joint Pub 1-02)

nuclear yields. The energy released in the detonation of a nuclear weapon, measured in terms of the kilotons or megatons of trinitrotoluene required to produce the same energy release. Yields are categorized as: very low — less than 1 kiloton. low — 1 kiloton to 10 kilotons. medium — over 10 kilotons to 50 kilotons. high — over 50 kilotons to 500 kilotons. very high — over 500 kilotons. See also nominal weapon; subkiloton weapon. (Joint Pub 1-02)

offset distance (nuclear). The distance the desired ground zero or actual ground zero is offset from the center of an area target or from a point target. (Joint Pub 1-02)

optimum height of burst. For nuclear weapons and for a particular target (or area), the height at which it is estimated a weapon of a specified energy yield will produce a certain desired effect over the maximum possible area. (Joint Pub 1-02)

overpressure. The pressure resulting from the blast wave of an explosion. It is referred to as "positive" when it exceeds atmospheric pressure and "negative" during the passage of the wave when resulting pressures are less than atmospheric pressure. (Joint Pub 1-02)

performance degraded. Personnel function at between 25 and 75 percent of their normal (pre-exposure) performance levels. (Approved for inclusion in the next edition of Joint Pub 1-02.)

probable error. See horizontal error. (Joint Pub 1-02)

probable error deflection. Error in deflection which is exceeded as often as not. (Joint Pub 1-02)

probable error height of burst. Error in height of burst which projectile/missile fuzes may be expected to exceed as often as not. (Joint Pub 1-02)

probable error range. Error in range which is exceeded as often as not. (Joint Pub 1-02)

radiation dose. The total amount of ionizing radiation absorbed by material or tissues, expressed in centigrays. (DOD) The term radiation dose is often used in the sense of the exposure dose expressed in roentgens, which is a measure of the total amount of ionization that the quantity of radiation could produce in air. This could be distinguished from the absorbed dose, also given in rads, which represents the energy absorbed from the radiation per gram of specified body tissue. Further, the biological dose, in rems, is a measure of the biological effectiveness of the radiation exposure. (Joint Pub 1-02)

radiation dose rate. The radiation dose (dosage) absorbed per unit of time. (DOD) A radiation dose rate can be set at some particular unit of time (e.g., H + 1 hour) and would be called H + 1 radiation dose rate. (Joint Pub 1-02)

radiation exposure state. The condition of a unit, or exceptionally an individual, deduced from the cumulative whole body radiation dose(s) received. It is expressed as a symbol which indicates the potential for future operations and the degree of risk if exposed to additional nuclear radiation. (Joint Pub 1-02)

radiation sickness. An illness resulting from excessive exposure to ionizing radiation. The earliest symptoms are nausea, vomiting, and diarrhea, which may be followed by loss of hair, hemorrhage, inflammation of the mouth and throat, and general loss of energy. (Joint Pub 1-02)

radius of collateral damage. The distance from the desired ground zero to a 5 percent incidence of personnel injuries requiring hospitalization, to a 5 percent incidence of moderate damage from blast to facilities, or to a 5 percent incidence of thermal ignition of debris. (Approved for inclusion in the next edition of Joint Pub 1-02.)

radius of damage. The distance from ground zero at which there is a 0.5 probability of achieving the desired damage. (Joint Pub 1-02)

radius of preclusion. The distance from the desired ground zero to a 10 percent incidence of damage or obstacle creation. (Approved for inclusion in the next edition of Joint Pub 1-02.)

radius of safety. The horizontal distance from ground zero beyond which the weapon effects on friendly troops are acceptable. (Joint Pub 1-02)

radius of vulnerability. The radius of a circle about ground zero within which friendly personnel will be exposed to a risk equal to, or greater than, the emergency risk criterion and/or within which materiel will be subjected to a 5 percent probability of the specified degree of damage. (Approved for inclusion in the next edition of Joint Pub 1-02.)

rainout. Radioactive material in the atmosphere brought down by precipitation. (Joint Pub 1-02)

residual radiation. Nuclear radiation caused by fallout, artificial dispersion of radioactive material, or irradiation which results from a nuclear explosion and persists longer than one minute after burst. See also contamination; induced radiation; initial radiation. (Joint Pub 1-02)

residual radioactivity. Nuclear radiation that results from radioactive sources and which persists for longer than one minute. Sources of residual radioactivity created by nuclear explosions include fission fragments and radioactive matter created primarily by neutron activation, but also by gamma and other radiation activation. Other possible sources of residual radioactivity include radioactive material created and dispersed by means other than nuclear explosion. See also contamination; induced radiation; initial radiation. (Joint Pub 1-02)

safe burst height. The height of burst at or above which the level of fallout, or damage to ground installations is at a predetermined level acceptable to the military commander. See also types of burst. (Joint Pub 1-02)

subkiloton weapon. A nuclear weapon producing a yield below one kiloton. See also kiloton weapon; megaton weapon; nominal weapon. (Joint Pub 1-02)

surface burst. See nuclear surface burst. (Joint Pub 1-02)

target area error. Mathematical parameter that incorporates weapon circular error probable and target location error. Target area error is used in lieu of weapon circular error probable in damage calculations. (Approved for inclusion in the next edition of Joint Pub 1-02.)

target area error 90. Mathematical parameter that incorporates weapon circular distribution 90 and target location error. Target area error 90 is used in lieu of weapon circular distribution 90 in damage calculations. (Approved for inclusion in the next edition of Joint Pub 1-02.)

target location error. An indicator of the accuracy of the specified location of the center of a target. It is the radius of a circle which includes 50 percent of all possible target center locations. (Approved for inclusion in the next edition of Joint Pub 1-02.)

troop safety (nuclear). An element which defines a distance from the proposed burst location beyond which personnel meeting the criteria described under degree of risk will be safe to the degree prescribed. (Joint Pub 1-02)

types of burst. See airburst; fallout safe height of burst; height of burst; high airburst; high altitude burst; low airburst; nuclear airburst; nuclear exoatmospheric burst; nuclear surface burst; nuclear underground burst; nuclear underwater burst; optimum height of burst; safe burst height. (Joint Pub 1-02)

unwarned exposed. The vulnerability of friendly forces to nuclear weapon effects. In this condition, personnel are assumed to be standing in the open at burst time, but have dropped to a prone position by the time the blast wave arrives. They are expected to have areas of bare skin exposed to direct thermal radiation, and some personnel may suffer dazzle. See also warned exposed; warned protected. (Joint Pub 1-02)

variability. The manner in which the probability of damage to a specific target decreases with the distance from ground zero; 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. (Joint Pub 1-02)

vertical probable error. The product of the range probable error and the slope of fall. (Joint Pub 1-02)

warned exposed. The vulnerability of friendly forces to nuclear weapon effects. In this condition, personnel are assumed to be prone with all skin covered and with thermal protection at least that provided by BDU and T-shirt. See also unwarned exposed; warned protected. (Joint Pub 1-02)

warned protected. The vulnerability of friendly forces to nuclear weapon effects. In this condition, personnel are assumed to have some protection against heat, blast, and radiation such as that afforded in closed armored vehicles or crouched in fox holes with improvised overhead shielding. See also unwarned exposed; warned exposed. (Joint Pub 1-02)

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