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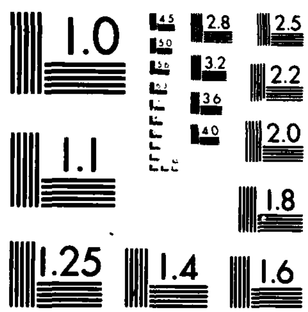

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

NUCLEAR NOTES NUMBER 7

COLLATERAL DAMAGE

NUMBER SEVEN IN A SERIES OF INFORMATION PAPERS ON TOPICS ASSOCIATED WITH NUCLEAR WEAPONS, PRINCIPALLY DESIGNED FOR USE BY TRADOC SCHOOL INSTRUCTORS AND MAJOR COMMAND STAFF OFFICERS.

U.S. ARMY NUCLEAR AND CHEMICAL AGENCY
Fort Belvoir, Virginia

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U.S. ARMY NUCLEAR AND CHEMICAL AGENCY
FORT BELVOIR, VIRGINIA 22060

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FOREWORD

The series of papers, "Nuclear Notes," prepared by the US Army Nuclear and Chemical Agency is intended to clarify and explain various aspects of nuclear weapons phenomenology and usage. These papers are prepared in as nontechnical a fashion as the subject matter permits. They are oriented toward an audience that is involved with teaching, learning or applying the tactics and techniques of employing nuclear weapons in a conflict situation. The dissemination of these nuclear notes will hopefully provide to the US Army accurate, up-to-date information of importance in understanding the use of nuclear weapons on the battlefield.

The principal author of this paper is Major Frank W. Thornhill, Jr. of the US Army Nuclear and Chemical Agency. Comments and views of readers are desired and should be forwarded to Commander, US Army Nuclear and Chemical Agency, 7500 Backlick Road, Building 2073, Springfield, VA 22150.

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Deputy Commander

The US Army Nuclear and Chemical Agency recommends that issues of Nuclear Notes be retained and filed in a loose leaf binder. Previous issues are:

Nuclear Notes Number 1 - The Electromagnetic Pulse (EMP), June 1974

Nuclear Notes Number 2 - The Army Nuclear Survivability Program, October 1974

Nuclear Notes Number 3 - The New Nuclear Radiation Casualty Criteria, May 1975

Nuclear Notes Number 4 - Nuclear Blackout of Tactical Communications, August 1976

Nuclear Notes Number 5 - Rainout, December 1976

Nuclear Notes Number 6 - A Primer on Nuclear Weapons Capabilities, June 1977

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COLLATERAL DAMAGE

I INTRODUCTION.

In the 1950's and early 1960's the national and NATO visualization of nuclear warfare was to consider the initial use of nuclear weapons as a signal for the onset of general nuclear war - the "tripwire" concept. This philosophy obscured the importance of maintaining a viable ground force, capable of fighting against a sophisticated, nuclear armed enemy on a tactical nuclear battlefield. Now that strategic nuclear parity exists between the two superpowers, the long neglected aspects of tactical nuclear warfare are being examined closely. The change in our national policy from the "tripwire" philosophy to "flexible response" places more emphasis on the roles of theater nuclear and conventional forces.

In developing the Army's nuclear employment doctrine and procedures to respond in a "flexible" manner, few considerations are as important as "COLLATERAL DAMAGE."

What is Collateral Damage?

Collateral damage is undesirable civilian materiel damage or personnel injuries produced by the effects of friendly nuclear weapons. (Figure 1). For a nation on whose soil a nuclear weapon is detonated, any damage, other than damage to enemy military resources, may well be viewed as collateral damage.

Why is the Consideration of Collateral Damage Important?

There is probably no more important a consideration to the political acceptance of nuclear weapons use on the tactical battlefield than the reduction of collateral damage. The importance to our allies of minimizing collateral damage was clearly stated by the Right Honorable Dennis W. Healy when he was British Secretary of State and Chairman of the NATO Nuclear Committee: "If... you would envisage fighting and winning a campaign in Europe with tactical nuclear weapons as if they were a sort of advanced type of artillery, you would have to use a very, very large number to affect a campaign, and in the course of that campaign, the losses to the civilian population of Europe would be so great that the war would not be worth fighting." It is easy to understand Mr. Healy's concern; it is the same as ours would have been if we planned the use of a large number of nuclear weapons in the defense of one of our medium-sized states. The capability to reduce collateral damage makes more credible to the Warsaw Pact the Allied option to use nuclear weapons in a tactical mode on the battlefield. Furthermore, if deterrence fails, an employment methodology that reduces collateral damage would reduce significantly the potential casualties of the civilian population.

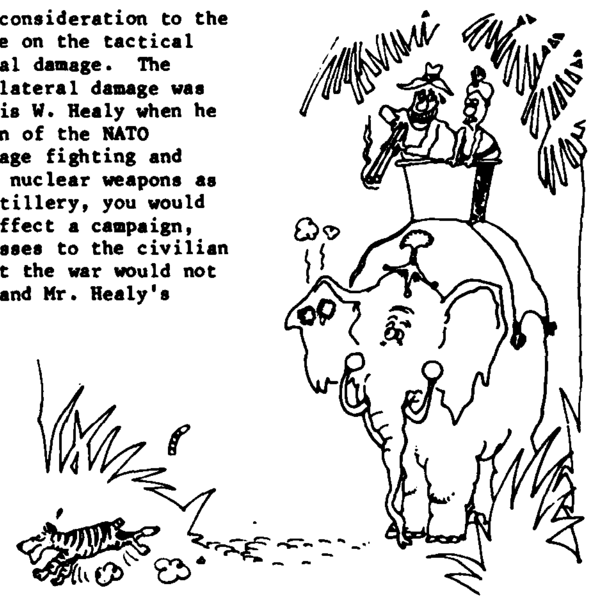


Figure 1. Collateral Damage!!!

II WHAT FACTORS ARE INSTRUMENTAL IN CAUSING COLLATERAL DAMAGE?

Nuclear Weapons Effects. Even the lowest yield nuclear weapon has the potential for causing injury to personnel or damage to structures at ranges considerably farther from the point of detonation than the ranges at which we can guarantee militarily significant damage to the target. This potentially large collateral damage effects area will produce damage to friendly populated areas close enough to be affected.

Proximity of Military Targets to Population Centers. The movement of and positions taken by military units will tend to be on or near the road and rail network connecting population centers. Thus, military units which should be targeted with nuclear weapons may often, deliberately in some cases, be close to population centers, exposing people and structures in those areas to risk.

The Military Mission. Determination of collateral damage constraints is a command responsibility. Collateral damage avoidance considerations will often be based on incomplete information concerning population locations and vulnerability. Furthermore, political considerations or agreements may significantly affect the selection of collateral damage constraints. The selection of specific constraints will normally be the responsibility of a corps or higher commander, since he is ultimately responsible for minimizing collateral damage consistent with the accomplishment of his mission.

III WHAT MEASURES CAN BE TAKEN TO REDUCE COLLATERAL DAMAGE?

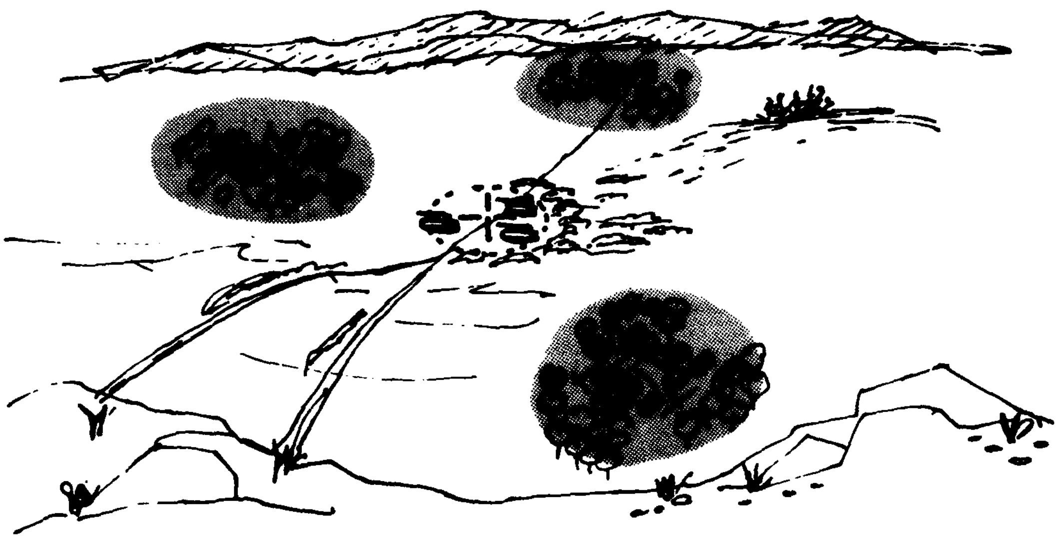
Use of Expected Coverage Versus High Assurance Criteria (90/30) to Defeat Area Targets. For years, the high assurance method for target analysis tended to force analysts to use higher yields for specific targets than necessary. Procedures were developed to guarantee minimum acceptable levels of damage to a target. The resulting criterion for target attack, known as the high assurance or 90% assured criterion, provided a 90% probability of achieving at least the desired results. That is, the odds are 9 to 1 that the nuclear detonation will cause more damage to the target area than was requested. This method of assuring that some minimum target coverage will be exceeded contributes to the employment of unnecessarily high yields, and their associated collateral damage implications. To help alleviate this, the new (1977) FM 101-31 series of manuals emphasizes the use of expected coverage, rather than the 90% assurance coverage criteria. The purpose of target analysis is to indicate to the commander what he can reasonably expect to achieve from a nuclear strike so that he can make decisions as to alternate courses of action and plan for future operations. Consistent with this purpose of indicating reasonable expectations is the use of expected rather than 90% assured values of coverage.

Use of Preclusion Oriented Analysis. For years, the Army has stressed the offset procedure to reduce nuclear effects on friendly military personnel and to avoid obstacles to the movement of friendly troops. Little emphasis was placed on the use of this same procedure to reduce collateral damage. Development of the preclusion oriented method as one of the primary methods of target analysis is a direct result of the increasing importance of collateral damage.

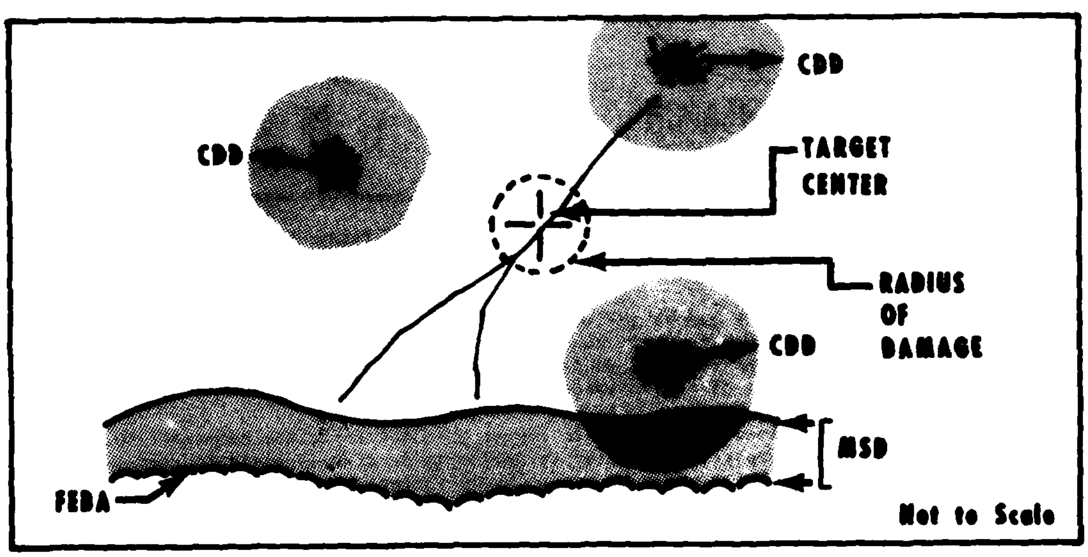
This method consists of calculating the appropriate collateral damage distance (CDD) for a given weapon system and yield. These CDD are then applied around those populated or built-up areas which are of concern. This technique is illustrated in Figure 2 for a hypothetical 1 KT weapon system. Any aimpoint outside the shaded areas encompassed by these preclusion distances is allowable with the particular combination of yield and weapon system plotted.

Use of Complementary Conventional Fires. Many people are under the impression that once nuclear weapons are introduced on the battlefield, conventional fires are relegated to a position of unimportance. Fully integrated conventional fires are mandatory if battlefield nuclear weapons are to be effective. As an example, the effectiveness of city hugging tactics can be reduced by the use of conventional fires in areas in close proximity to the city -- areas which might not otherwise be targeted. Thus, by the use of conventional fires to complement the nuclear fires, more military destruction is produced in the target area, while still abiding by collateral damage constraints.

Civil Defense. The evacuation of the civilian population from the battlefield area, or from small towns to a lesser number of larger towns, would increase the area in which nuclear weapons could be employed and reduce the probability of collateral damage. Realistically speaking, however, a significant civil defense effort for countries involved would be required. Also, an early and correct assessment must be made, as delayed action could result in increased constraints due to refugee movement.



Ground View (Target and Populated Areas)



Map View

Note: Shading represents nuclear no-fire areas.

Figure 2. Collateral Damage Analysis.
(1 KT Weapon System)

Increased Military Effectiveness of Weapons Employment through Improved Target Acquisition and Surveillance. Improvements in target acquisition and surveillance capability can have a considerable impact on the control of collateral damage. In some cases, uncertainties in target locatic and type are compensated for by the use of larger yields. Since collateral damage may be reduced by decreasing the yield required, improvements in target acquisition and surveillance which locate and define the threat more accurately, particularly at longer ranges, would improve effectiveness and lower collateral damage.

Improved Warhead Design and System Accuracy. Nuclear warheads can be designed to produce more initial nuclear radiation relative to the other effects than a fission warhead of the same total energy. As depicted in Figure 3, this feature may be used to optimize military casualty effectiveness and at the same time reduce the risk of collateral damage and friendly troop safety by allowing for the selection of lesser yield enhanced radiation (ER) weapons.

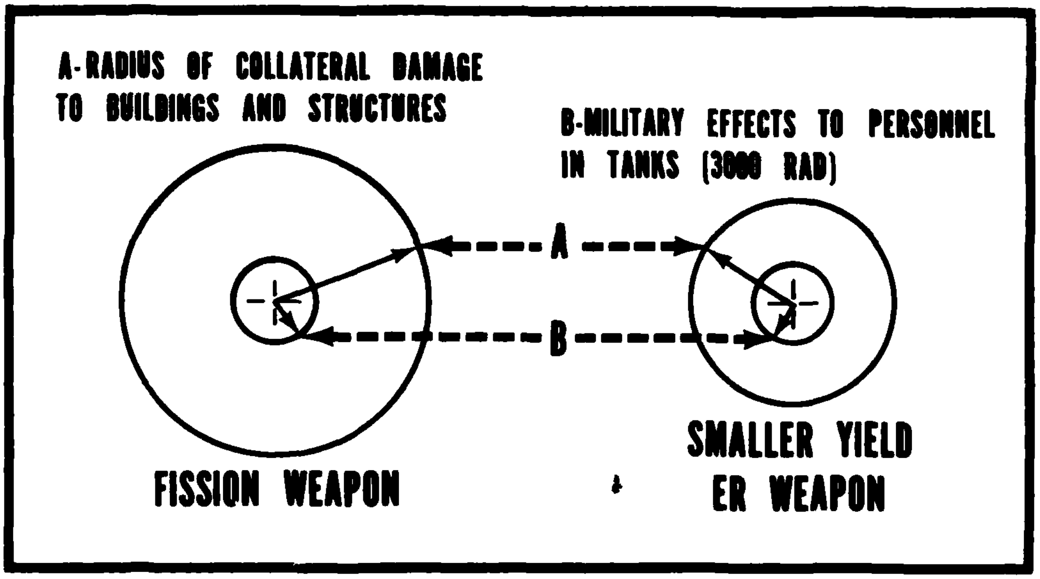


Figure 3. Military Effectiveness/Collateral Damage.

On the other hand, warheads can be tailored to reduce the residual nuclear radiation effects. This type of warhead offers advantages when a commander wants to damage a target by a surface burst. By reducing the residual radiation effect, a higher yield can be used if necessary to achieve the level of blast damage or crater size desired.

Inaccurate systems combined with errors in target location force the commander to increase the yield to insure damage desired to a point target or to decrease a yield to meet constraints. By improving the accuracy of our delivery systems, we can reduce the yield required to attack point targets or increase the yield used in a constrained area to achieve a greater military effect.

IV HOW WERE COLLATERAL DAMAGE AVOIDANCE TABLES DEVELOPED?

To assist the commander and his staff, the new (1977) FM 101-31 series of manuals contains collateral damage avoidance tables and procedures to use the tables to incorporate collateral damage considerations into target analysis. A collateral damage avoidance table has been developed for each weapon system and yield. Figure 4 is a typical table. These tables were developed by selecting a degree of injury or damage and then determining the associated level of effect. Consistent with current US and NATO safety criteria, a five percent incidence of potentially hospitalizing injuries and a five percent incidence of moderate structural damage at the leading edge of a populated area were selected as the collateral damage guidelines. The five percent levels are applied at the leading edge of a town to insure extremely low levels of damage and injuries in the town as a whole. This is illustrated in Figure 5. The arcs shown represent distances from the burst to which several predicted probabilities of damage or injury extend. With the five percent level at the leading edge of the town, the 1 percent level extends only an additional 10% in range and most of the town receives little, if any, damage. These collateral damage guidelines accomplish the following objectives:

Conscionable. The degree of structural damage caused by allowing no more than a five percent incidence of moderate damage at the leading edge of town, while discernible, is far from devastating. The amount and severity of injuries imposed on noncombatants by this philosophy are the same as for troops exposed at the emergency risk level.

Understandable. The amount and severity of injuries and damages are clearly stated.

Practicable. The nuclear weapons effects levels associated with the injury and damage levels are determinable. These effects levels can be translated into avoidance radii in a manner similar to that used to obtain radii of troop safety.

V <u>WHAT CATEGORIES OF INFORMATION ARE AVAILABLE?</u>

The avoidance radii were developed for weapon employment parameters (i.e., weapon systems, yields, heights of burst) for a spectrum of structures and the shielding available to the populace. The tables are divided into three categories: personnel injury, moderate damage to facilities, and thermal ignition.

Governing Personnel Injury Radii. The radii listed for personnel injuries represent a five percent incidence of injuries requiring hospitalization. In addition to the five percent incidence of hospitalizing injuries, there will be an unspecified number of lesser injuries which do not require hospitalization. Civilians are assumed to be in one of the three environments discussed below:

Urban Environment. Civilians in this environment are assumed to be in the basements of one-story masonry buildings whether in a built-up or farm area. Injuries to these civilians can occur because of either radiation or blast. The larger of the two radii (blast or radiation) is tabulated. Thermal effects are not considered for personnel injuries inside of buildings.

Rural Environment. Civilians in this environment are assumed to be in one-story wood-frame houses without basements whether in a built-up or farm area. As discussed in the preceding paragraph, the larger radius associated with blast or radiation is tabulated. Again, thermal effects were not considered for civilians inside of buildings.

Personnel in Open. The radii listed for this category equate to emergency risk to unwarned, exposed troops. Thermal, blast and radiation effects are all considered, and the largest of the three radii is tabulated.

Moderate Damage to Facilities Radii. Radii listed are for five percent incidence of moderate damage due to blast.

Thermal Ignition Radii. Radii listed are the distances at which ignition, not necessarily sustained burning, is achieved. A probability of building damage cannot be associated with these radii.

VI <u>HOW IS COLLATERAL DAMAGE DISTANCE (CDD) CALCULATED?</u>

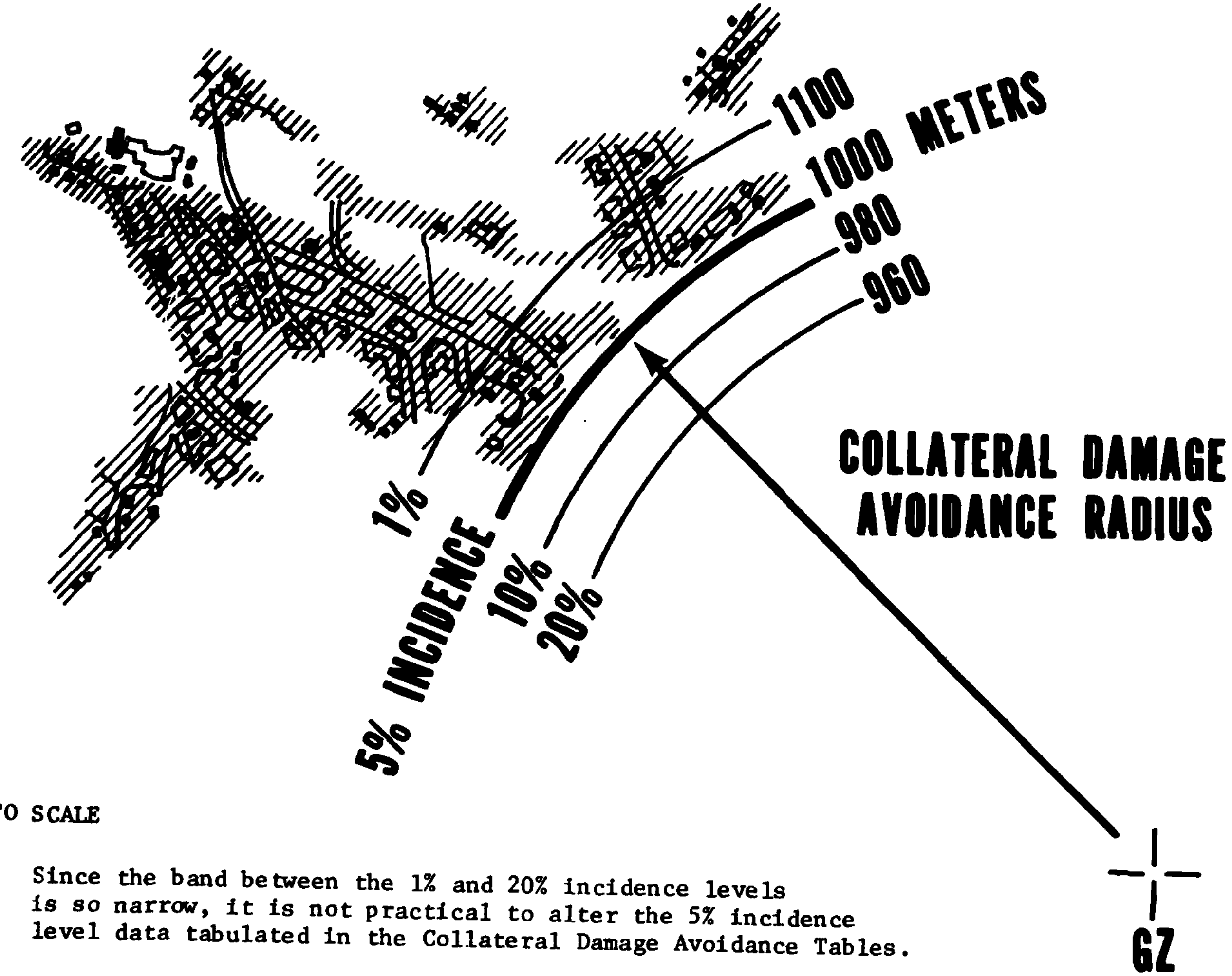
The CDD has two components: the radius of collateral damage (RCD), which is obtained by entering the appropriate collateral damage avoidance table (Figure 4) at the selected HOB (typically the asterisked HOB), and the appropriate horizontal delivery error buffer distance (a certain number of CEP corresponding to the level of assurance specified). The procedure for determining the CDD is as follows:

1 KT (5–24)	SHORT RANGE CANNON			COLLATERAL DAMAGE AVOIDANCE TABLES (Distances in meters)							SHORT RANGE CANNON		1 KT (5–24)
	PERSONNEL INJURY (5% incidence)			MODERATE DAMAGE TO FACILITIES (5% incidence)					THERMAL IGNITION (threshold level)				
HOB	URBAN	RURAL	IN OPEN	SINGLE STORY FRAME BUILDING	SINGLE STORY MASONRY BUILDING	LT STEEL FRAME INDUST BLDG	FIXED BRIDGES	RAIL ROAD EQUIP	WOOD SHINGLES	DRAPES	NEWSPAPERS & DEBRIS		HOB
600	650	850	1150	1480	700	110	0	0	500	900	990		600
570	680	870	1170	1520	730	210	0	0	530	920	1000		570
540	700	890	1180	1680	810	270	0	0	560	940	1020		540
510	720	900	1200	1910	840	320	110	0	590	960	1030		510
480	740	920	1210	1930	870	360	190	0	610	970	1050		480
450	760	930	1220	1940	900	400	240	0	630	990	1060		450
420	780	950	1230	1930	940	460	290	0	650	1000	1070		420
390	800	1140	1240	1910	1150	530	330	0	670	1010	1080		390
360	810	1160	1250	1880	1160	720	390	0	690	1020	1090		360
330	820	1170	1260	1840	1170	740	590	0	700	1030	1100		330
300	860	1160	1260	1790	1170	730	610	0	710	1040	1110		300
270	840	1140	1270	1740	1140	710	610	280	720	1050	1120		270
240	840	1100	1280	1680	1110	690	580	420	730	1050	1130		240
210	850	1060	1280	1610	1070	670	550	450	740	1060	1130		210
180	850	1020	1280	1540	1030	640	530	450	750	1070	1140		180
160	850	1010	1290	1460	980	610	510	460	760	1070	1140		150
120	850	1010	1290	1380	940	590	490	460	760	1070	1140		120
90*	850	1000	1290	1300	880	560	470	450	770	1080	1150		90*
60	830	990	1300	1220	830	530	440	430	770	1080	1150		60
30	810	960	1150	1140	770	490	420	410	680	960	1020		30
1	760	910	1000	1060	720	460	390	370	580	820	880		1

NOTE: PERSONNEL INJURY NORMALLY GOVERNS COLLATERAL DAMAGE CONSTRAINTS.

*** Typical HOB**

Figure 4. Collateral Damage Avoidance Table.



NOT TO SCALE

NOTE: Since the band between the 1% and 20% incidence levels is so narrow, it is not practical to alter the 5% incidence level data tabulated in the Collateral Damage Avoidance Tables.

Figure 5. Predicted Probabilities of Damage and Injury.

Determine the radius of collateral damage. The analyst enters the appropriate collateral damage avoidance table at the proper HOB and extracts the RCD under the appropriate column. If the analyst must consider more than one column category, then he extracts the largest RCD.

Obtain the horizontal buffer distance. The coverage tables are used to obtain the CEP. The analyst enters that coverage table corresponding to the weapon system and yield he is considering with the gun-to-target range and extracts the CEP. (If the range is unknown, then he enters the table at 2/3 maximum range). This CEP is then multiplied by the appropriate factor extracted from Table 1 below, corresponding to the level of assurance specified.

Table 1. Assurance Versus CEP

Assurance (%)	CEP Multiplication Factor
50	1.00
90	1.83
99	2.58

Sum the two. The collateral damage distance is equal to the sum of the RCD and the horizontal buffer distance as determined in the two paragraphs above.

VII WHAT ARE SOME EXAMPLE CALCULATIONS?

Example 1.

Given: Short Range Cannon (SRC)
Yield: 1 KT
CEP: 45m
Find: CDD for civilians in an urban environment with 50% assurance of not exceeding 5% incidence of casualties in a multi-directional environment.

Solution: Enter the Collateral Damage Avoidance Table for the SRC, 1 KT (Figure 4), at the asterisked HOB of 90m and extract 850m as the RCD under the urban personnel column. To account for delivery error, add 1 CEP (45 meters) to this value to obtain 895m as the Collateral Damage Distance with an associated 50% assurance.

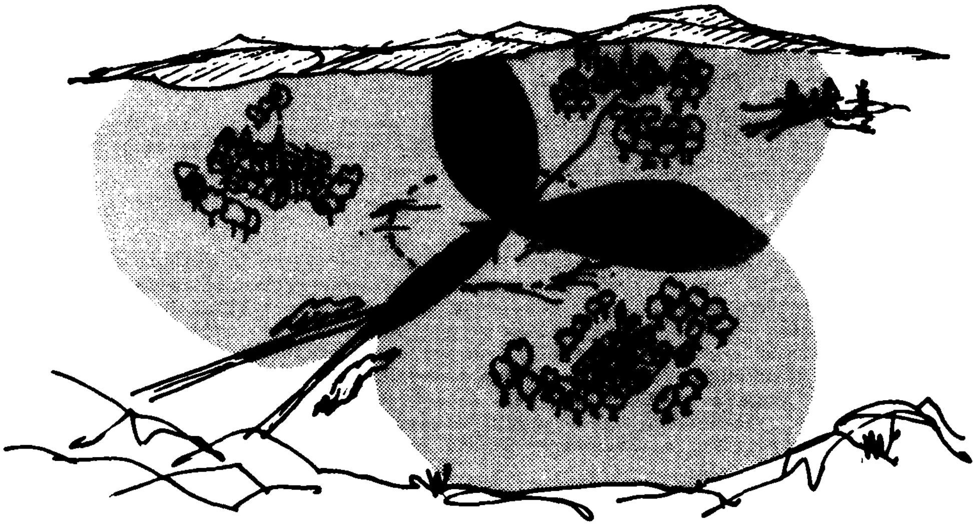
Example 2.

Given: Short Range Cannon (SRC)
Yield: 1 KT
CEP: 45m
Find: The governing CDD, considering all listed categories, with a 90% assurance of not exceeding 5% incidence of casualties in a multi-directional environment.

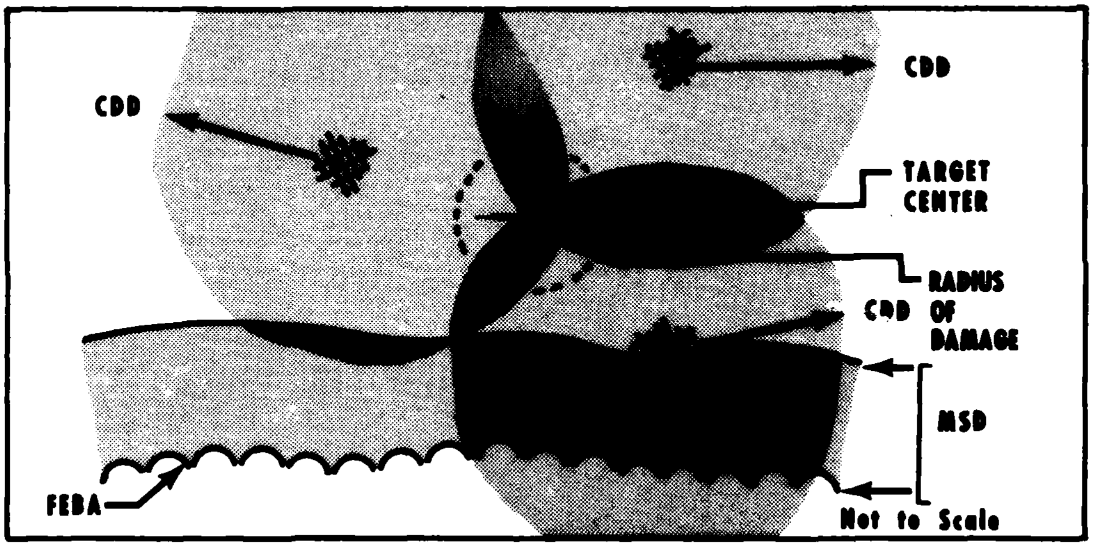
Solution: Enter the Collateral Damage Avoidance Table for the SRC, 1 KT (Figure 4), at the asterisked HOB of 90m and extract 1300m (under the single story frame building column) as the largest RCD. To account for delivery error, extract a value of 1.83 from Table 1, and add (1.83) x (CEP) = 82m to 1300m to obtain 1382m as the Collateral Damage Distance (CDD) with a 90% assurance.

VIII HOW ARE COLLATERAL DAMAGE DISTANCES USED?

After the target analyst calculates the CDD, he graphically applies the distance to the area of proposed employment, measuring from the leading edge of populated areas. Thus suitable and unsuitable areas for DGZ selection for each weapon system and yield combination are portrayed. For instance, the analyst may determine the appropriate distances illustrated in Figures 6 through 8. Figure 6 shows the 10 KT Free Flight Rocket limiting requirements drawn on the proposed area of employment. Based on the limiting requirements, this clearly illustrates that, within the area of the suspected target, there are no suitable areas for possible DGZ selection.



Ground View (Target and Populated Areas)



Map View

Note: Shading represents nuclear no-fire areas.

Figure 6. 10 KT Free Flight Rocket.

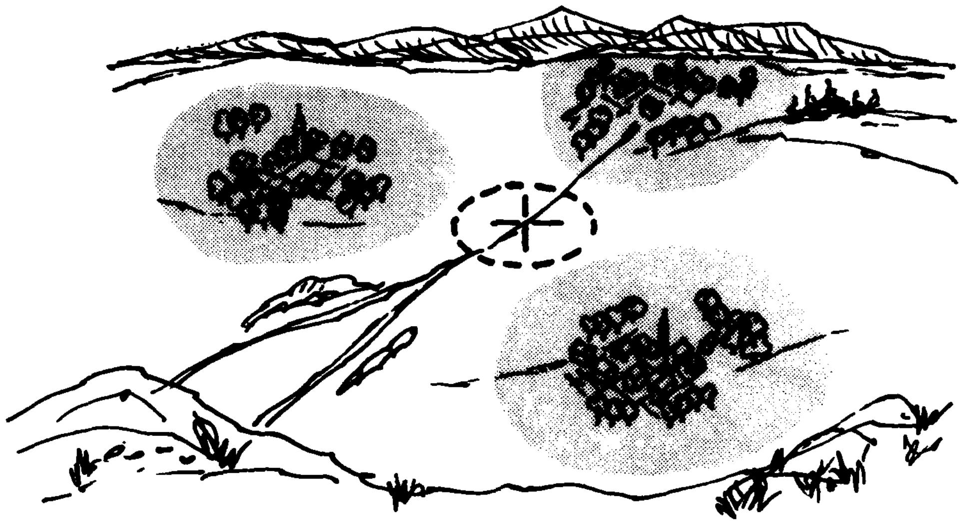
Figure 7, a 5 KT Short Range Cannon (SRC), and Figure 8, a 2 KT SRC, illustrate the limiting requirements for two other weapon systems and yield combinations applied to the same area. However, in these cases, suitable DGZ selection areas are available.

If only one weapon were available in each yield (2 KT or 5 KT), the analyst would select the 5 KT as shown in Figure 7, because the radius of damage associated with this yield weapon gives the most target coverage.

The final selection of weapon system and yield combination to be employed is based on those available combinations which will give the best coverage in the area of the suspected threat without exceeding collateral damage and troop safety constraints.

IX CONCLUSION.

A key element in the ability of the United States and its allies to execute a policy of "flexible response" is the manner in which we handle the consideration of collateral damage. Once hostilities begin, collateral damage considerations will have a broad ranging impact. Besides the humanitarian aspects, the reduction of collateral damage could assist in lowering the risk of escalation by signaling limitations on our use of tactical nuclear weapons. The current doctrine and procedures for incorporating the collateral damage considerations in the employment of nuclear weapons on the battlefield enhance the credibility of our national policy of "flexible response." The new FM 101-31 series of manuals further amplifies the vast importance of properly considering collateral damage in target analysis and provides commanders and staffs the tools to do so.



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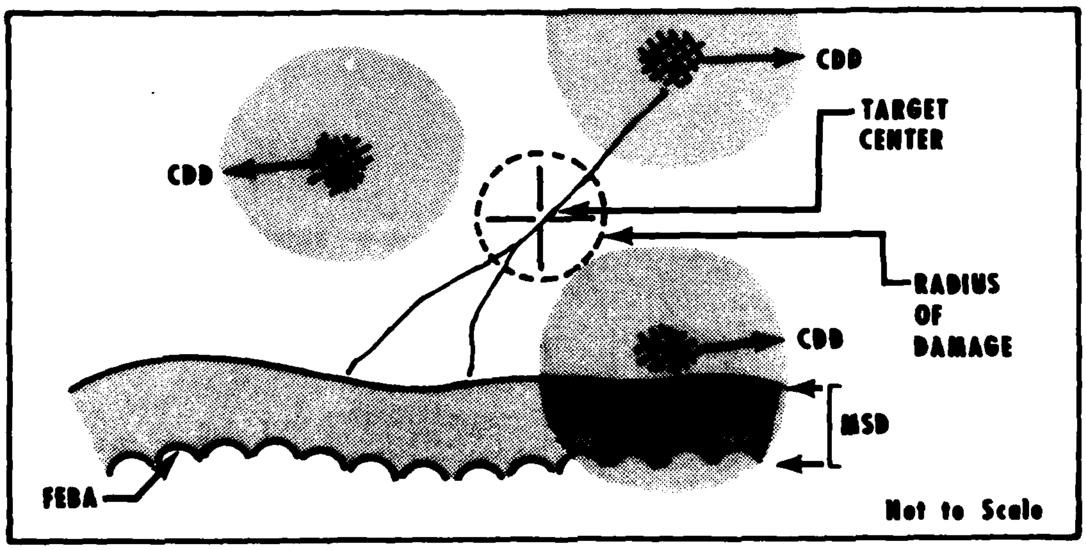
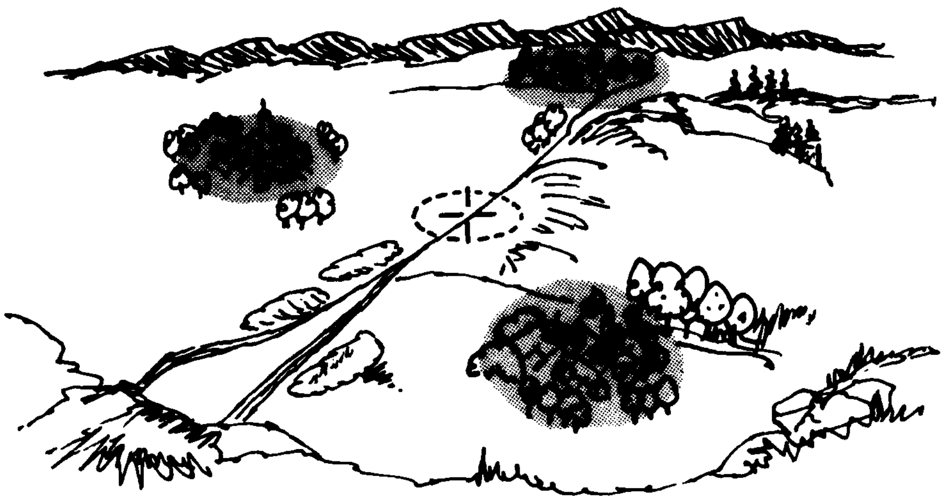


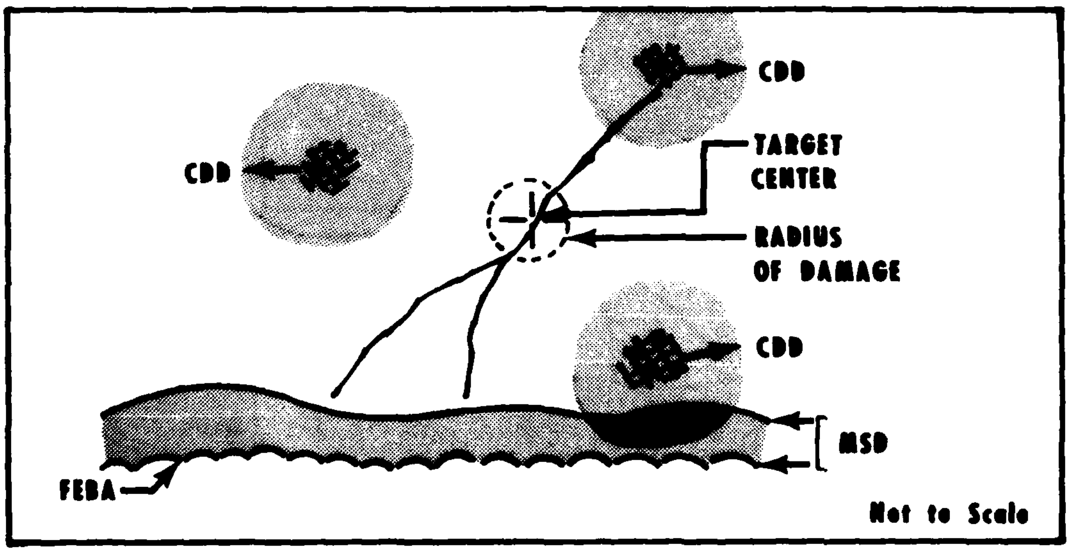
Map View

Note: Shading represents nuclear no-fire areas.

Figure 7. 5 KT Short Range Cannon.



Ground View (Target and Populated Areas)



Map View

Note: Shading represents nuclear no-fire areas.

Figure 8. 2 KT Short Range Cannon.

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