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Collateral Damage Implications of Employing Nuclear Weapons in an Air Defense Role over Central Europe

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ABSTRACT

The purpose of this study is to explore the ramifications associated with possible employment by NATO of nuclear weapons in an air defense role over Central Europe. A reasonably realistic hypothetical situation is developed to facilitate discussion concerning the air threat; acceptable collateral damage; nuclear weapon employment constraints; nuclear weapon effectiveness, considering these constraints; and the trade-off between collateral damage and weapon effectiveness. It is concluded that limited NATO employment of tactical nuclear weapons in the defense of NATO airspace is a viable concept from a collateral damage standpoint. A credible flexible response strategy must incorporate defensive nuclear weapon response packages when there is a possibility that NATO cannot defend the airspace using conventional weapons.

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COLLATERAL DAMAGE IMPLICATIONS OF EMPLOYING NUCLEAR WEAPONS IN AN AIR DEFENSE ROLE OVER CENTRAL EUROPE

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INTRODUCTION

The purpose of this study is to explore the ramifications associated with possible employment by NATO of nuclear weapons in an air defense role over central Europe. Some basic constraints have been established for planning purposes. Those affecting this paper are: employment will be defensive in nature with weapons detonated only over NATO territory; both air and ground assets will be employed so as to achieve maximum effective use of resources; the lowest available yield is to be used which will accomplish desired damage.

Other criteria must also be met for this concept to be considered a viable option by NATO. There must be positive control over escalation; there should be high assurance as to the predictable response from the enemy; and collateral damage must be kept to acceptable levels.

This chapter will explore the constraints that might be placed upon NATO planners with respect to limiting collateral damage. Collateral damage can be broadly defined as damage to militarily unimportant property and/or casualties to other than enemy military forces caused by a nuclear detonation.[1] For purposes of this discussion, however, collateral damage will be defined as damage to friendly forces, property and non-combatants.

This chapter will develop a reasonably realistic hypothetical situation to facilitate discussion concerning the following questions. What might be considered acceptable collateral damage? What collateral damage limitations might be established prior to authorizing employment of nuclear weapons in an air defense role? Will the employment of air defense weapons be effective, considering these employment constraints? Is there an acceptable trade-off between the relative effectiveness and the collateral damage experienced on the ground? Finally, some conclusions will be offered for consideration.

METHODOLOGY

The methodology employed throughout the Chapter will be to establish assumptions upon which to base further discussion and analysis. The justification for these assumptions will be stated and supported whenever possible. Every attempt will be made to test the assumptions with respect to logic, realism and reasonableness. However, due to the lack of factual data in some areas, certain of the assumptions will be of a subjective nature.

Basic assumptions will be stated concerning the Warsaw Pact air threat against which NATO must plan an effective air defense. The effects of nuclear weapons will be discussed in some detail to support establishing hypothetical collateral damage criteria under conditions perhaps best described as 'emergency'. For further discussion purposes, this criteria will be assumed to be the maximum damage acceptable to NATO and/or the NATO member nation directly concerned. These assumptions will be used as a basis for discussing constraints governing nuclear weapon employment in the air defense role over friendly NATO territory. Certain conclusions will be drawn concerning the use of nuclear weapons in the air defense role based upon the assumed threat, assumed collateral damage limitations and resultant employment constraints.

The overall methodology has been designed to facilitate further analysis of a classified nature by permitting substitution of actual data regarding delivery systems, nuclear warheads available to the NATO commander, and collateral damage limitation criteria. Actual minimum burst altitudes can then be determined based upon actual collateral damage constraints. Conclusions may then be drawn as to whether NATO employment of nuclear weapons in an air defense role is a viable concept with respect to collateral damage limitations and the probable air threat.

BACKGROUND

Policies established by a country are those that facilitate the accomplishment of national goals and objectives. Stated in another way, self-interest determines the policies established at the national level. Alternative courses of action are analyzed, and a decision is made based upon the course of action which provides the greatest benefit, or results in the least cost, with respect to attaining national goals and objectives. One goal or objective that certainly each country has is that of maintaining identity as a nation. Policies are established, therefore, that are in that nation's self-interest with respect to maintaining its integrity and identity as a nation. One of these policies is to defend its territory against aggression. This policy is the main reason NATO exists tody. Nations remain members of NATO simply because it is in their self-interest to do so.

NATO's objectives, which incidentally coincide with the security objectives of the United States, can be stated as, "... deterring attack, either conventional or nuclear, on member nations; to present any potential aggressor contemplating attack with unacceptable risks; and should deterrence fail, to respond to the attack in such a way that the outcome is favorable..."[2] To attain these objectives, NATO has adopted the strategy of 'flexible response', which means that should deterrance fail, the mission of NATO forces will be to "...conduct an initial conventional defense as far forward as possible; preserve or restore the integrity and security of the NATO area; and conduct deliberate escalation of the conflict to the extent required to turn back the aggression if it cannot be contained."[3]

With respect to Warsaw Pact nations initiating aggressive action in the central European region, the Federal Republic of Germany would be most affected. Germany fully supports the NATO strategy of flexible response and has publicly stated that resolute and adequate political countermeasures must be launched at the very onset of an aggressive action to insure integrity of NATO territory. German authorities have included as an integral part of these countermeasures authority to employ defensive type nuclear weapons.[4] The necessity for possibly using nuclear weapons early in any conflict is widely accepted throughout the Federal Republic of Germany.[5]

One question often raised by those discussing the NATO strategy of flexible response is, "At what point should tactical nuclear weapons be utilized as an integral part of the overall defensive effort?" Where there are essentially two opposing conventional forces, and one force considerable outnumbers or has a definite advantage over the other, the relatively weaker conventional force may be required to use tactical nuclear weapons to maintain a favorable balance of power or a credible flexible response escalation capability. This would appear to be especially apparent when the defensive objective is to meet and defeat the enemy as rapidly and as far forward on the battlefield as possible.

The above scenario generally describes the situation facing NATO today in central Europe.[6] The Supreme Allied Commander, Europe, (SACEUR) has been tasked by NATO to develop flexible response packages designed to meet various levels of Warsaw Pact aggression and escalation. SACEUR must plan for the possible first use of tactical nuclear weapons to be employed in the event conventional escalation fails to successfully defend against the numerically superior conventional forces which the Soviet and non-Soviet Warsaw Pact nations are capable of deploying against NATO.[7]

One of the problems facing NATO planners is defense of the airspace over central Europe. Loss of air superiority to the aggressor may well be the factor that tips the scales in his favor. Since the Warsaw Pact air threat consists of tactical aircraft that considerably outnumber those immediately available to NATO, reason alone dictates that serious consideration must be given to using tactical nuclear weapons in order to maintain a credible flexible response capability.[8] It is well worth remembering, however, that a flexible response strategy is viable only as long as there remains, should deterrance fail, the capability for effective controlled escalation. A viable NATO air defense flexible response strategy pre-supposes that a credible deterrant capability exists. The premise that a conventional and nuclear air defense capability exists within NATO will be a basis for follow-on discussion as well.

As outlined in the introduction, constraints are placed on employment of nuclear weapons for both political and humanitarian reasons. One of these constraints concerns the collateral damage that may result from the effects of a nuclear detonation. Another of the basic constraints is that nuclear weapons may be employed only over NATO territory. Therefore, the collateral damage from the detonation must be politically as well as militarily acceptable to the NATO member nation over which the weapon is to be employed. The Nuclear Planning Group, subordinate to the NATO Nuclear Defence Affairs Committee, establishes policy guidance for SACEUR regarding the initial use of nuclear weapons.[9] It would appear reasonable to assume that this guidance would include the maximum acceptable collateral damage under emergency conditions.

Having established collateral damage limitations and nuclear weapon employment constraints, how effective will be the employment of nuclear weapons in an air defense role against the Warsaw Pact air threat? Is the trade-off acceptable? This will be explored in some detail later.

THE AIR THREAT

The Warsaw Pact has a numerical superiority in fighter, reconnaisance, and bomber tactical aircraft deployed along the NATO Central and lower Northern Regions, as well as along the Southern flank.[10] In the Central Region, Warsaw Pact tactical fighter aircraft outnumber those of NATO by a factor of two to one.[11] Surface-to-air missile systems, combined with NATO qualitative superiority in aircraft and pilot capability, undoubtedly close this gap somewhat. However, whether conventional air defense weapons will be able to defeat or contain the Warsaw Pact air threat during the early days of any conflict is subject to serious question. If conventional flexible response packages do not succeed in denying air superiority to the Warsaw Pact enemy forces, employment of nuclear weapons to maintain a viable defensive capability must be seriously considered.

Weather over central Europe may well be the determining factor with respect to tactics employed by Warsaw Pact forces at the onset of any aggression. Weather is especially significant with respect to the Warsaw Pact air threat. The weather over central Europe is often poor, with conditions of less than 1500 feet cloud base and three nautical mile visibility greater than 50% of the time.[12]

For follow-on discussion purposes, two air attack profiles will be considered. The first is a high altitude profile involving an air attack by groups of two or four aircraft flying in formation. The second profile is a low altitude attack by groups of two or four aircraft. It would appear that a low altitude attack profile might be favored by the Warsaw Pact due to the cloud base restrictions, limited all-weather capability of Warsaw Pact aircraft and pilots, and the relatively limited detection capability of low level attack due to radar masking and earth curvature.[13] A low level attack profile will be defined as entry into NATO airspace below 1500 feet. There are other factors that certainly would influence Soviet and non-Soviet Warsaw Pact tactics, and there are differing positions even within the NATO community supporting high altitude, low altitude and mixed attack profiles. The most convincing arguments, however, appear to favor low altitude entry into NATO airspace.[14] Proponents of the latter position recognize that when the aggressor aircraft approach the target area, a pop-up maneuver will be employed to more effectively attack the target.

Attack profiles are significant with respect to employment of nuclear weapons in an air defense role in that, generally speaking, the higher the detonation, the less collateral damage at or near ground zero. Attack profiles are also important because NATO's objective is to engage these aircraft as far forward as possible, i.e. upon entering NATO airspace. As will be developed, the effects from detonating a nuclear weapon against a threat coming in at 30,000 feet are quite different, from a collateral damage standpoint, than detonating that same weapon against a threat at or below 1500 feet.

This section has established two possible attack profiles for comparative purposes. Although the altitude selected separating low versus high altitude attack profiles is subjective, the weather considerations and limited low level detection capability offers some degree of support for selecting the 1500 foot differentiation. These factors also provide some support for the position that a low altitude attack profile is more probable that a high altitude attack. Selecting a different altitude would in no way invalidate the overall methodology employed in the subsequent discussion.

NUCLEAR WEAPON EFFECTS

A brief discussion of the effects of a nuclear detonation is appropriate to appreciate fully the possible ramifications of a decision to utilize nuclear weapons against either a low or high altitude attack profile. The effects of nuclear weapons are so devastating that, no matter what the threat, certain employment constraints must be established limiting the employment of these weapons over friendly territory.

There are three distinct effects from a nuclear explosion. These are characterized as blast (shock effect), thermal radiation (heat and light), and nuclear radiation (the ionizing effect when radiation is absorbed).[15] For purposes of this discussion, damage resulting from a nuclear explosion will be characterized as either personnel casualties or 'other damage'. Personnel casualties are normally used as a basis for target analysis when considering the impact upon friendly force dispositions.[16] The reasoning is that if constraints are imposed to limit friendly casualties, other damage will be acceptable if caused by the same detonation. Therefore, personnel casualties will govern the remaining discussion of collateral damage limitations.

In an air defense role, the nuclear weapon will be detonated above the earth, ground zero being that point on the ground directly below the burst. There are two categories of airburst. A low airburst is defined as a detonation below 100,000 feet and at a height such that the fireball does not touch the ground. It will be assumed that whatever height of burst is selected, fallout effects will be negligible. A high airburst is characterized as being 100,000 feet or above.[17] The difference between the effects from a low airburst and a high airburst due to the atmosphere is inconsequential with respect to collateral damage as it is examined in this chapter. However, an airburst results in the most effective coverage of damage to ground targets, especially personnel.[18] As a result, when employed in an air defense role, nuclear weapon effects on the ground will be maximized. This is an important consideration when evaluating casualties to unwarned exposed personnel. Unwarned exposed personnel will be defined as those individuals who are directly exposed to the burst and have not taken action to protect themselves by covering their eyes and exposed skin, falling prone on the ground, seeking cover, etc. The category of unwarned exposed personnel will be used to establish maximum acceptable friendly casualties.

Blast is the shock effect produced by a high pressure impulse (wave) as it travels outward from the burst. Approximately 50% of the energy released by the nuclear explosion is blast, and considerable damage may result.[19] Exposed personnel would be quite vulnerable to flying debris at a great distance from the burst. However, for lower yield weapons, blast probably would not be the governing factor with respect to limiting unwarned exposed personnel casualties. This statement will be supported and expanded upon later when selected warhead yields and total effects are analyzed.

Thermal radiation is essentially heat and light produced by the nuclear explosion. When a nuclear weapon detonates in the atmosphere, thermal energy is emitted in two pulses.[20] The first pulse consists of x-rays and ultra-violet light that is normally insignificant, since other weapon effects predominate. The second pulse, visible light and infra-red radiation, accounts for almost all the thermal damage. It travels in straight lines at the speed of light, but it can be easily attenuated or absorbed. As a result, it is extremely dificult to predict accurately casualties from thermal effects. It is generally accepated, however, that maximum thermal effect is produced by a low airburst. The thermal radiation is immediately turned into heat and light to which exposed personnel are extremely vulnerable. Normally, second degree burns are considered sufficient to cause combat ineffectiveness.[21] Also, the energy released as intense light will cause temporary blindness to those even indirectly exposed. Again, this level of injury will be used to establish maximum acceptable friendly casualties.

Radiation is the third effect category. This category is broken down into two sub-categories, initial radiation and residual radiation.[22] Residual radiation is that which is emitted one minute after burst. For purposes of this discussion, residual radiation will be considered insignificant. However, the initial radiation (that emitted during the first minute after detonation) is very important and in some instances will be the governing factor. This is true even though initial radiation comprises only five per cent of the total energy released by the nuclear detonation.

Initial radiation consists of alpha, beta, gamma and neutron emissions. Due to the limited range of alpha and beta particles, only gamma and neutron emissions are significant for purposes of follow-on discussion. Gamma rays and neutrons have high penetrating power, generally travel in a straight line, and essentially travel at the speed of light. However, significant protection is difficult because the particles scatter in the target area when colliding with nuclei of objects that they come into contact with.[23] Initial radiation may produce effects that blast and thermal do not, especially with respect to smaller yields, and personnel are extremely vulnerable to initial radiation.[24]

Having briefly discussed the effects of a nuclear explosion, it would appear appropriate to establish some criteria of measurement to facilitate estimating casualties. For thermal radiation, it has been established that second degree burns are considered sufficient to cause combat ineffectiveness and temporary blindness to those exposed to the explosion. However, no criteria was stated for blast or initial nuclear radiation. With respect to blast, thermal radiation and/or initial nuclear radiation will be the governing factor due to the relatively small yields selected for analysis and the fact that unwarned exposed personnel are being used to compute damage limiting constraints.[25] However, there may be considerable blast casualties due to flying debris (secondary effects) depending upon the circumstances.

The effects of radiation on people have been studied in some detail. Based upon scientific experimentation, it has been concluded that total exposure to 200 REMS or less over a 24 hour period will cause some nausea and discomfort to exposed personnel, but this dosage should cause no casualties or deaths.[26] Scientists have testified before the United States Senate that approximately 50% of those individuals exposed to 450-500 REMS will become casualties and die.[27] For military target analysis purposes, a total dosage of 650 RADS is required for assuring 50% casualties to unwarned exposed personnel.[28] These figures are not necessarily inconsistent, in that a REM (Roentgen Equivalent Mammal) is a biologically significant dosage and is used to express radiation absorption as a dose unit of biological effect, whereas a RAD is simply a unit of absorbed radiation. The REM is calculated by multiplying the number of RADS by an RBE (Relative Biological Effectiveness) factor. An RBE factor of 1.0 signifies 100% gamma radiation. A mixture of other types of radiation will raise or most often lower this factor.[29] Therefore, the REM dose rate need not equal the RAD dose rate to be equivalent.

In the foregoing discussion of effects, it was stated that blast, thermal radiation, and nuclear radiation are the three categories of nuclear weapon effects that may affect unwarned exposed personnel. Thermal radiation and initial radiation effects will probably be the governing effects to consider with respect to limiting casualties from relatively small yield nuclear detonations. However, blast effects must be considered for the larger yields and, in fact, may be the predominate effect.

COLLATERAL DAMAGE CONSTRAINTS

The strategy of flexible response essentially precludes the use of nuclear weapons in an air defense role unless the NATO conventional defensive capability is insufficient to limit the Warsaw Pact from attaining air superiority. Whether the situation justifying the employment of nuclear weapons is described as critical or an emergency is inconsequential. The point to be made is that the NATO commander, within the strategy of flexible response, will not request authority to employ nuclear weapons unless it becomes necessary in order to defeat the enemy. This position would appear to be especially valid when considering that NATO would be employing the initial tactical nuclear weapon, thus risking escalation of the conflict into a nuclear confrontation. In any event, it is assumed that collateral damage constraints would be set at emergency levels due to the criticality of the military situation.

Emergency levels for the purpose of discussion will be thermal radiation causing temporary blindness and no more than second degree burns to exposed skin, nuclear radiation resulting in a total dose rate of no more than 300 REMS per 24 hour period to unwarned exposed personnel, and associated blast damage. This level of injury is assumed to be the maximum acceptable from both a political and military standpoint.

Based upon these hypothetical collateral damage limitations, what constraints would be placed upon NATO forces employing nuclear weapons? First, second degree burns will result from nuclear explosions at heights of burst shown below in Table I. Temporary blindness would also result from exposure at these distances. Note that two sources are shown and compared. Since both reflect approximate slant range distances, an average has been taken for purposes of summarizing total effects.

TABLE I

Heights of Burst Causing Temporary Blindness and Second Degree Burns to Exposed Skin

Yield (KT)	Slant Range[30] Source 1	Slant Range[31] Source 2	Slant Range Average
1	Not Given	2600 feet	2600 feet
2	3800 feet	3800 feet	3800 feet
5	5300 feet	4800 feet	5100 feet
10	7400 feet	7900 feet	7700 feet
20	10500 feet	10000 feet	10300 feet

The data shown in Table II below pertains to total dose rates of 300 REMS, which appears to be a reasonably acceptable total dose rate under the emergency conditions previously described. Again, distances are approximate, and, as in Table I, reflect those casualties at or near ground zero.

TABLE II

Heights of Burst Causing Nuclear Radiation Dose Rates of 300 REMS[32]

Yield (KT)	Slant Range Distance
1	2900 feet
2	3300 feet
5	3800 feet
10	4500 feet
20	5100 feet

Blast or shock effect can be associated with the slant ranges shown for thermal radiation. However, for larger yields, blast may become the governing effect.[33]

Although the slant ranges shown above are approximations, they do serve to provide a vehicle for making some general observations. After comparing the two tables, certain minimum burst altitudes (MBA's) can be established for the various selected yields. A probable vertical weapon system delivery error of 100 feet will be added to each height of burst.[34] Horizontal error is insignificant for collateral damage considerations at ground zero. Table III reflects minimum burst altitudes for the selected yields based upon total weapon effects and the hypothetical collateral damage limitations.

TABLE III

Minimum Burst Altitudes

Yield (KT)	Slant Range Distance
1	3000 feet
2	3900 feet
5	5200 feet
10	7800 feet
20	10400 feet

Nuclear weapons employed in an air defense role cannot be detonated below the minimum burst altitudes shown above without causing unacceptable damage to friendly troops and civilian non-combatants. Considering the above limitations, how effective will employment of these nuclear weapons be against the Warsaw Pact air threat and the probable attack profile?

EFFECTIVENESS AGAINST THE AIR THREAT

The Warsaw Pact air threat discussed earlier in the Chapter was categorized into two possible attack profiles. A high altitude attack profile was characterized as entry into NATO airspace at or above 1500 feet in altitude. Taking into consideration the minimum burst altitudes shown in Table III, there is a high probability that employment of air defense nuclear weapons will be extremely effective when detonated at the closest point to a formation of two or four aircraft attacking at or above 1500 feet. Two factors should be considered in support of this statement. Initial radiation effects can be increased by a factor of 1.5 when comparing damage to an aircraft and pilot at the same slant ranges shown in the previous tables.[35] This means that aircraft flying at extremely low level (on the deck) will be exposed to no less than 450 REMS when passing over ground zero. The temporary blindness and heating effects will also significantly affect the pilot, even though he is somewhat protected inside the aircraft. Blast will affect his capability to control the aircraft, especially at lower levels, due to shock wave reinforcement as it bounces off the ground.

The low altitude attack profile would be somewhat less vulnerable to total nuclear effects from a burst at the minimum burst altitude. However, for the reasons outlined above, the combination of all three effects may well result in most enemy pilots being unable to control their aircraft and accomplish their mission. Due to the subjective nature of the above statement, the probable effectiveness of nuclear weapons against low altitude attack profiles certainly can be argued. However, assume that the employment of a weapon at or above the minimum burst altitude is, in fact, effective against a low altitude attack. One important point that has not been brought out up to this point is that each minimum burst altitude was established based upon the detonation of one nuclear weapon. The nuclear radiation effects, for example, of a second detonation at or near the same point in space within a 24 hour period would be additive. Therefore, the established minimum burst altitudes are valid only for detonation of one weapon at or near the same point in space.

An option may be to raise the height of burst to an altitude permitting multiple detonations. This option certainly merits consideration. However, as the minimum burst altitude is raised, aircraft entering NATO airspace in a low altitude attack profile, which has been concluded to be the most probable attack profile, would be less vulnerable to the effects of a single nuclear weapon. As a result, the trade-off between nuclear weapon effectiveness and the collateral damage associated with a burst at or near the minimum burst altitude may be less than acceptable.

CONCLUSION

An effort has been made to establish a realistic, yet hypothetical, political and military environment facing NATO policy makers concerning the Warsaw Pact air threat to central Europe and the viability of the NATO strategy of flexible response. The German government, regardless its publicly stated support of NATO strategy, will greatly influence constraints governing employment and the ultimate decision to use nuclear weapons over German territory.

As indicated at the beginning of the Chapter, the methodology employed would be to develop reasonable assumptions regarding the air threat, acceptable collateral damage, associated nuclear weapon employment constraints, and effectiveness of these weapons against the Warsaw Pact air threat. The basis for authorizing use of nuclear weapons was characterized as NATO's inability to successfully defend NATO airspace using conventional weapons. In this situation, NATO's conventional flexible response strategy could no longer be considered viable. It was also inferred that the German government supported the NATO flexible response strategy, to include use of defensive nuclear weapons should they be required to defeat the enemy.

However, is employment of nuclear weapons to defeat the enemy air threat justified when considering the criteria heretofore established? Certainly, if the attack profile is at an altitude whereby employment of multiple nuclear weapons results in acceptable collateral damage and effective air defense, employment is justified, other factors not withstanding. However, the probable air threat was established as low altitude entry into NATO airspace in formations of two or four aircraft. Effectiveness of a single weapon at the hypothetical minimum burst altitude against this threat may be staisfactory from a collateral damage standpoint. A 'show of force' to establish without a doubt NATO's willingness to escalate into the nuclear arena might also be justified from a collateral damage standpoint. However, multiple detonations at or near the same point in space at these hypothetical altitudes would be unacceptable.

For reasons described below, it appears doubtful that more than one nuclear weapon would need to be detonated at or near the same point in space in order to maintain a viable flexible response policy. It is necessary to recall a few of the basic constraints of the overall study. First, NATO would have high assurance of the predictable response of the enemy. Secondly, every effort would have been made to insure that the Warsaw Pact had been advised of the conditions under which NATO would, in fact, employ nuclear defensive weapons. The Warsaw Pact might decide to test the resolve of NATO to escalate the conflict into the nuclear arena. However, once nuclear weapons were employed by NATO against the air threat, there is every reason to believe that the enemy would negotiate for a peaceful settlement of the conflict. The alternative facing the Warsaw Pact would be escalation into a general nuclear war.

In summary, NATO employment of tactical nuclear weapons in the defense of NATO airspace is a viable concept from a collateral damage point of view. A credible flexible response strategy must incorporate defensive nuclear weapon response packages when there is a possibility that NATO cannot defend the airspace using conventional weapons. However, the assumption is made that more than one nuclear detonation at or near the same point in space would not be required to deter further aggression.

FOOTNOTES

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19. U.S. Department of the Air Force, Extension Course Institute, Air University, Nuclear Weapons: Effects and Criteria for Selection, (Washington: Atomic Energy Commission, 1967), p. 21.

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