STRATEGIC DETERRENCE IN THE POST START ERA

THESIS

David C. McCormick
Captain, USAF

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

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COMMITTEE:	NAME/DEPARTMENT	SIGNATURE
Advisor	Major Bruce W. Morlan/ENC	B. W. Morlan
Reader	Lt Col James T. Moore/ENS	James T. Moore

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David C. McCormick, B.S.
Captain, USAF

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Preface

Since the fall of our former adversary, the Soviet Union, there have been numerous calls for drastic reductions in the United States' strategic nuclear arsenal. These calls have been from all corners and frequently were based on emotional appeals that often lacked a sound military basis. Although the Soviet threat has disappeared, new military and economic challenges that threaten the United States' international stature appear daily. Thanks to the thousands of men and women who served in the SAC Alert Force over its forty year existence, the cold war ended without a shot being fired!

The purpose of this study was to investigate the deterrent value of various strategic force configurations within a target valuation framework. Unclassified notional weapon and target data were used in this thesis to demonstrate the deterrent effect of various nuclear and conventional force structures. A glossary of technical terms is contained in Appendix A.

Many thanks to my advisor, Major Morlan, who patiently and kindly guided me through the complicated and often mystical world of strategic force analysis. Lt Col Moore, my reader, offered excellent insight into the utility various strategic force structures might offer and provided direction on those frequent days when I'd confronted another seemingly insurmountable obstacle. Special thanks to my wife Linda who provided immense support and displayed unwavering confidence in me during many, many long weeks and months.

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Abstract

With the Soviet Union's fall there have been widespread calls for drastic reductions in the United States military's strategic nuclear forces. Although a major threat to the United States has been greatly reduced, the number of strategic targets will not decrease as rapidly as the number of available weapons. This research considers how the United States should think about strategic forces in the rapidly changing world order of the 1990s. An extensive literature review of deterrence concepts and conventional weapons capabilities is conducted with special attention paid to the role that precision guided munitions played in the 1991 Persian Gulf War air campaign. Using a methodology that considers both target hardness and target value, three test cases representative of possible international deterrence scenarios the United States might face during the 1990s are tested against proposed strategic force structures in a reduced arms environment. The Arsenal Exchange Model, a linear programming allocation tool, is used to demonstrate the methodology. Soviet compliance with previous arms control agreements is also reviewed. Recommendations are made concerning the utility of including certain precision guided conventional weapons into the United States strategic force arsenal.

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I. Introduction

Overview

Recent announcements by both President Bush of the United States and Boris Yeltsin of the Russian Commonwealth appear to indicate that drastic cuts in strategic nuclear weapons may soon be forthcoming (1:54). Should these cuts actually take place, nuclear weapons levels will be lower than at anytime in the last 30 years. While many spectators are quick to praise this unprecedented level of superpower cooperation in "making the world a safer place", serious questions concerning United States Defense community capabilities and bipolar stability are being raised. Furthermore, an increasing number of third world countries are actively pursuing the purchase of ballistic missile systems in an obvious attempt to develop long range offensive forces.

Although large nuclear weapon arsenals appear dangerous to the casual observer, fewer weapons may actually increase the likelihood of their use. Proponents of the "few weapons, high instability" argument believe that incentives for striking first occur when one side perceives that an advantage may be obtained from attacking first. This might occur in an attempt to preemptively disarm the opposing country or to simply launch first in the face of an inevitable first strike by the other side. A recent observation by Professor Joseph Nye sums up this view nicely. "The paradox is that at very low numbers you might have instabilities in periods of great political crisis" (1:54).

Any arms reduction proposal presents important verification challenges. Large inventories tend to greatly reduce the value of a few additional weapons. However, with fewer weapons on each side, there is greater marginal advantage to be gained from cheating because a few hidden weapons would represent a much larger percentage increase with respect to a reduced arsenal. Some past examples of cheating include failing to destroy weapons as agreed, deploying mobile systems when not permitted, and using anti-ballistic missile defense systems in prohibited areas are commonly cited cases.

The Soviet Union had a blemished record with respect to past arms control agreements - there is no reason to believe that their successors, the Commonwealth of Independent States under Boris Yeltsin, intend to fully honor any previous arms control agreement (19). Some specific violations are addressed in Appendix B. This reluctance may be compounded by some member state's strong desire to develop a powerful military. For many emerging countries, nuclear weapons hold a special appeal because they publicly attest to a country's inclusion in the elite nuclear club of major world powers. Beyond the obvious military implications, this membership may convey to them expectations of better trade and improved political relations with the United States.

Background

The concept of strategic nuclear deterrence has been in existence nearly as long as nuclear weapons themselves. Strategic nuclear deterrence, as used here, describes a long standing United States policy of massive retaliation against aggressors using long range weapon systems such as bombers, land based missiles, and submarine launched ballistic missiles. As a component of United States Defense policy, deterrence was used almost exclusively to describe the focus of relations between the United States and the former Union of Soviet Socialist Republics.

In recent years however, increasing numbers of political and military leaders argue that:

> ... deterrence - in the sense of pure retaliation - does not always constitute defense. And this is the beginning of the trouble. Deterrence always contains a good measure of bluff and pretense, and even self-delusion. It seems cheaper to manipulate an enemy's perceptions than to prepare to defeat him on the ground. The aura of deterrence, once created, seems to be infinitely extensible, at no marginal cost; the nuclear umbrella seems to cover any and all, by an exercise of will or commitment. (26:162-163)

A classic case of deterrence was the Cuban Missile Crisis when the United States threatened nuclear retaliation against the Soviet Union for its involvement in transporting nuclear capable missiles to Cuba. That early international standoff literally paralyzed the world and demonstrated the powerful political leverage that nuclear armed nations could bring to bear in certain negotiating situations.

American nuclear strategy evolved significantly over the thirty years that followed that confrontation with the Soviet Union. While "deterrence" used to be the ultimate goal of statesmen, American leaders, both military and civilian, have only recently recognized that "stability" is an equally useful concept in the arms control process. Some specific types of stability will be discussed in Chapter Two.

Deterrence and stability are very different and distinct concepts. Briefly, the composition of past force structures tended to concentrate on the consequences of use rather than the incentives for use. That is to say that, with large arsenals, leaders viewed the threat of a preemptive disarming strike as virtually nonexistent. As a result, little attention was paid to a concept known as "first strike" stability. First strike stability is high when neither side perceives any advantage in striking first. In some circles stability and deterrence have been considered equally important issues to consider in force structure analysis.

However, nuclear deterrence, not stability, became the central tenant of United States defense policy. As Lt Col Drew points out in his work Nuclear Winter and National Security, United States' deterrence policy evolved through the years from a threat of punishment to a promise of denial. When nuclear weapons were still relatively new, politicians saw them as a magical tool that could prevent any foreign power from acting contrary to United States wishes. Any act of aggression would be immediately met with a massive nuclear strike as punishment. Clearly this was not a very flexible policy.

Recognizing the serious limitations inherent in a policy of punishment through massive retailation, more recent United States leaders have sought a national defense policy that denied a potential adversary his military and political objectives short of destroying his entire country (10:42). This "deterrence by denial" policy continues to the present and requires that each party have an understanding of the other's motives.

A serious limitation of the deterrence concept is a highly questionable assumption that international adversaries are able to communicate "complex and finely calibrated strategies of coercion" in such a fashion as to avoid being misunderstood (20:132).

For deterrence to work, both parties must understand what their opponent values most. By publicly holding these objects at risk of destruction, potential adversaries can be deterred. For example, if the Soviets valued leadership highly, then a demonstrated United States' capability and firm resolve to include leadership targets in the United States nuclear strike plan would enhance deterrence. Similarly, enemy targeting of major United States cities places the civilian population at risk and provides a strong incentive for United States leadership to avoid war. This thesis proposes that conventional weapons can fill many of the roles previously held by nuclear weapons. Furthermore, due to their lower political "cost" of usage, they may be more effective instruments of national defense policy.

Problem Statement

In the past, deterrence was usually synonymous with massive nuclear punishment of an aggressor, even if the exchange resulted in mutual destruction. In practice, forty years of deterrence proved effective in preventing escalation of superpower conflicts.

However, with severely reduced nuclear weapons levels the United States may no longer credibly threaten massive retaliation against a potential adversary. Instead of assured destruction, military planners must now carefully select targets that realistically raise the cost of aggression to unacceptable levels. What constitutes unacceptable levels of damage is not often obvious since target values are essentially "in the eyes of the beholder". Additionally, extremely accurate long range precision guided conventional weapons have recently come of age and must be integrated into any future United States strategic force structure.

The specific question to be addressed in this thesis is the following. How should the United States think about the size and composition of strategic forces in a rapidly changing world?

In an attempt to gain insight into the research question, a number of computer model analysis runs will be conducted. In each computer run various force structures are tested against three likely deterrence scenarios the United States may face in the 1990s. Specific items of interest for the analysis include:

1. Can analysis demonstrate the successful incorporation of highly accurate conventional weapons into a deterrent strategy?

2. Given a particular force structure, how can this force structure be evaluated against various United States strategic objectives in light of two-sided deterrence?

3. How might the employment of highly accurate, high yield conventional weapons in a combined nuclear/conventional strategic arsenal affect deterrence and United States warfighting abilities?

Scope and Limitation

Both the United States and Commonwealth of Independent States justifiably fear that the proliferation of nuclear, chemical, and biological weapons to third world powers will likely threaten world peace. Recognizing the seriousness of this issue, former Soviet leaders were openly critical of their country's arms control negotiators for seemingly ignoring the problem of nuclear proliferation among would be newcomers:

> The Foreign Ministry authors also criticize Arbatov and his colleagues for not taking into account third countries' systems. They differ from them in their attitude to total nuclear disarmament (which they do not consider ultimately desirable). They do not assume that third-power arsenals can be eliminated by arms control. (5:46)

While nuclear proliferation is truly a serious threat to world order, this thesis makes no attempt to directly examine the issue of global multipolar stability. Instead it focuses on the more narrow questions of United States strategic force capabilities in a bipolar scenario with the newly formed Commonwealth of Independent States or a single third world country.

Many factors potentially affect international relations between the United States and the newly formed Commonwealth of Independent States. In an attempt to explore and understand key political and military factors and interactions, various analysis models have been constructed in an attempt to quantify deterrence and stability. Unfortunately, some of these factors (e.g., national sentiment, leadership preferences, etc...) are extremely difficult, or even impossible to model while other factors such as yield, number of targets and weapons, accuracy, and reliability are easily quantified. Therefore, a particular model's outcome is highly dependent upon which factors are included for consideration. This thesis uses target valuation in a damage expectancy model as a primary measure of effectiveness.

Additionally, there is no extensive wartime data from which to predict weapon performance so uncertainty exists concerning the accuracy of any model's embedded weapons effect algorithms. Therefore, analysis models will necessarily be incomplete at best:

> The lack of historical experience with nuclear battle dynamics tends to focus modeling on the basic processes of targeting (i.e., allocation), damage assessment, and flight dynamics; consequently, the principal discriminants in modeling have this same flavor.(3:245)

Assumptions

This thesis assumes that damage expectancy alone is insufficient as a measure of effectiveness when assessing a particular warplan's adequacy. When simple damage expectancy techniques are used, they only calculate the level of physical damage achieved. Dynamic target valuation weightings, an important consideration in a tense political situation, are not considered when a damage expectancy measure of effectiveness is used. An explicit assumption in this thesis is that target valuation is an acceptable measure of effectiveness for a weapon to target allocation scheme. Therefore the measure of effectiveness used will be value damage expectancy.

The model used in this thesis considers only prompt nuclear effects such as blast overpressure and dynamic pressure. No attempt is made to quantify secondary effects such as thermal radiation, delayed radiation from fallout, and electromagnetic pulse. Furthermore, issues of enroute aircraft refueling, fratricide, and communications connectivity are not directly modeled. However, the skilled analyst can deal effectively with these issues when constructing the problem by adjusting probabilities of arrival, reliability, and connectivity.

Summary

This chapter provided key background information and a specific problem statement. Chapter Two will review some of the large body of literature which examines deterrence, stability, Page

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and arms control from the United States viewpoint. A discussion of precision guided conventional weapon capabilities and employment follows a review of U.S. nuclear force roles. Additionally, a key force allocation model, the Arsenal Exchange Model, is described in detail. Lastly, the Soviet perspective on deterrence and arms control compliance will be examined. Chapter Three describes the methodology that will be used to evaluate six proposed force structures against three cases. The Arsenal Exchange Model, a linear programming allocation tool, is used to conduct the evaluations. Chapter Four details important assumptions imbedded in this analysis, describes the chosen measure of effectiveness, and lists the specific forces and targets used. Chapter Five discusses the results obtained from the various computer model runs. Conclusions and recommendations are contained in Chapter Six.

II. Literature Review

Introduction

This chapter reviews literature on national defense policy, deterrence, stability, nuclear forces, strategic targeting issues, and conventional weapons capabilities. Several specific precision guided conventional weapons are reviewed. Additionally, the strategic targeting process and a frequently used force allocation model are examined. Lastly, the Soviet perspective is considered in an attempt to determine what strategic force decisions the newly formed Commonwealth of Independent States might make.

National Defense policy

With the Soviet "threat" having all but disappeared and the Persian Gulf War victory fresh in the American mind, there has been indifference in some quarters about national security and geographically distant third world adversaries. However, the recent discovery by United Nations inspectors of significant Iraqi nuclear technology has jolted many Americans back to the reality that sound military strategy and preparedness is not simply a wartime requirement. Daily, new long range threats appear around the globe:

> The continuing proliferation of nuclear capabilities shapes the future strategic environment for several reasons. Nuclear weapons pose the one clear threat to the physical security of the United States. (4:56)

Additionally, the failed coup attempt against former Soviet President Gorbachev raised the distinct possibility that nuclear weapons could fall into the control of small states struggling for independence. Presumably these states, having little or no experience with nuclear weapons, might not have the necessary restraint to forgo their use in a crisis. What begins as a regional war could quickly escalate to world conflict and embroil the United States in a major international war. Fortunately, nuclear weapons from the former Soviet Union which are now maintained by the newly formed Commonwealth of Independent States are under central control, thereby reducing this possibility.

Because nuclear proliferation is a serious and ongoing world problem, it is important that the United States develop a national and military strategy to deal with potential adversaries who may possess strategic weapons of mass destruction. It is far from clear that third world powers and the emerging post-Soviet states are deterrable in the traditional sense. Rather, a fresh look is necessary in order to determine how best to structure military power in the framework of national security strategy in the 1990's. According to Osgood, as quoted by Lider,:

> Military strategy must now be understood as nothing less than the overall plan for utilizing the capacity of armed coercion - in conjunction with the economic, diplomatic, and psychological instruments of power - to support foreign policy most effectively by overt, covert, and tacit means. (25:194)

National security policy is instrumental in the development of specific areas of military and political strategy. As Lider notes, these two key areas of strategy are intertwined and should generally be considered simultaneously. He believes that military force, whether actually used or not, is necessary in the conduct of all state business. According to Lider, strategy should be considered in the following fashion:

1. As the dimensions of strategy, where 'dimensions' have meant the various fields of activity - political, social, operational, logistical - which should be taken into account to make strategy effective.

2. As the kinds of means used to attain the aims of strategy - military, economic, diplomatic, ideological and other means; these have been reflected in the partial strategies - military, economic, etc., which are included in the overall - i.e. state-strategy in military affairs, especially in war.

3. As the kinds of methods used; open (war) and covert (in peacetime).

4. As a variant of the latter in the form of strategy functions corresponding to the main functions of armed forces.

5. As missions assigned to strategy in military planning. (25:195)

Deterrence. Many experts view deterrence as an interactive process between two opposing parties. Often these two parties are world superpower leaders who are busy trying to test each other's limits. By publicly proclaiming both purpose and commitment, a defender builds credibility with both an adversary and the world community. This forces potential challengers to make regular assessments of both capability and commitment. Kelleher notes that while certain international problems sometimes threaten successful implementation:

> the repetitive cycle of test and challenge is expected to provide both sides with an increasingly sophisticated understanding of each other's interests, propensity for risk taking, threshold of provocation, and style of foreign policy behavior. (20:140-1)

As mentioned in Chapter One, deterrence relies heavily on the far from perfect assumption that opposing leaders can clearly and succinctly state their position. With their large staffs and complex communications systems, this would not seem to be a problem. However according to Jarvis, as quoted by Morgan, a number of "common errors of perception" can occur on a frequent basis in superpower relations. These communications difficulties are listed in Table 2.1.

According to Lider, deterrence can be subdivided by the "main types of military challenges by the conceivable adversary" into four types (25:236). As mentioned earlier, the original concept of deterrence was synonymous with massive retaliation for direct Soviet aggression against the United States. This became known as Type I deterrence, or passive deterrence, since the response resulted <u>after</u> attack.

With the formation of NATO and the United States' extension of the nuclear umbrella over Europe, Type II deterrence was born. Its promise was to deliver a crushing nuclear blow against the Soviet Union for an attack, either conventional or nuclear, against Western Europe. This concept became known as active deterrence because the threatened action of a nuclear strike came <u>before</u> enemy attack on the United States.

Table 2.1

Selected Common Errors of Perception

1. Decision-makers tend to fit incoming information into their theories and images

2. Scholars and decision-makers are apt to err by being too wedded to the established view and too closed to new information, as opposed to being too willing to alter their theories

3. Actors can more easily assimilate into their established image of another actor's information contradicting that image if the information is transmitted and considered bit by bit rather than if it comes all at once

4. When messages are sent from a different background of concerns and information than is possessed by the receiver, misunderstanding is likely

6. When people spend a great deal of time drawing up a plan or making a decision, they tend to think that the message about it they wish to convey will be clear to the receiver

8. There is an overall tendency for decision-makers to see other states as more hostile than they are

11. Actors tend to overestimate the degree to which others are acting in response to what they themselves do when the others behave in accordance with the actor's desires; but when the behavior of the other is undesired, it is usually seen as derived from internal forces.

12. When actors have intentions that they do not try to conceal from others, they tend to assume that others accurately perceive these intentions

13. It is hard for an actor to believe that the other can see him as a menace, it is even harder for him to see that issues important to him are not important to others.

adapted from (30:55)

With the spread of communism and increased military might of third world countries (largely financed by the Soviet Union and China) Type III deterrence developed. It became known as limited deterrence because it threatened an attack, either conventional or nuclear, against an instigator of aggression even if their military forces were not directly involved.

Increased hostilities in virtually every corner of the world became the genesis for Type IV deterrence. This type of deterrence threatened a subnuclear response for revolutionary and guerilla wars that somehow threatened United States interests. Lider has summarized these four types of deterrence and identified probable military courses of action that are implicitly and explicitly threatened in each. Table 2.2 contains this information.

Stability. Stability is a broad term that seeks to describe the situation in which one side perceives an advantage in striking their opponent first. According to Bluth, stability has long been considered in light of preemptive strikes:

> The fundamental criterion of stability was the possibility of carrying out a completely or partially disarming first strike, with stability decreasing as one side increased its first-strike potential. (5:43)

Other perspectives of stability exist. Deterrence stability describes a form of stability in which neither side perceives an advantage in launching a surprise attack due to fear of reprisal. Crisis stability describes the situation where preemptive strikes may become increasingly likely during heated political exchanges between international adversaries.

Table 2.2

Lider's Four Deterrence Types

Type I Deterrence (against the danger of direct attack on United States' territory)

1. First pre-emptive thermonuclear attack on the enemy's territory
   1.1 countercity (countervalue)
   1.2 counterforce
   1.3 mixed

2. Second 'retaliatory' attack on the enemy's territory
   2.1 countercity (countervalue)
   2.2 counterforce
   2.3 mixed

3. Limited strategic war
   3.1 selected mixed objects attacked
   3.2 military objects attacked

Type II Deterrence (against the danger of a direct attack on Western Europe)

4. Thermonuclear attack on the enemy's territory

5. 'Graduated action'(military operations gradually escalating)

6. 'Triggering' nuclear attack by a third partner (the French concept)

7. Automatic escalation (the West German variant)

Type III Deterrence (against local aggression, mainly in the Third World)

8. Tactical nuclear war

9. Local conventional war

Type IV Deterrence (against internal uprisings, called insurrections)

10. Counter-guerilla (counter-insurgency) war

extracted from (21:242)

According to Kent, stability can be summarized into the simple view that if neither side sees an advantage in striking first, then stability has been achieved (21:2).

Certain weapons systems are perceived to be more stabilizing than others. For example, a multiple independently targetable reentry vehicle (MIRV) equipped Peacekeeper intercontinental ballistic missile is viewed by many as destabilizing because, for the relatively small expense of perhaps two or three warheads, an enemy could destroy 10 United States warheads. Similarly, ballistic missile submarines, with their load of 100 - 300 warheads, make very tempting targets for an enemy who is weighing the cost of attack. Conversely, a mobile single warhead missile system such as the recently cancelled United States Air Force Small ICBM can be considered highly stable because of their location uncertainty. An enemy would have to expend anywhere from 5-15 warheads in order to achieve a high probability of eliminating just one warhead. This exchange is deemed highly improbable (33:79).

In his book Dynamically Stable Deterrence, Lt Col Reule of Air University argues that single warhead mobile missile systems would be the most stabilizing strategic nuclear weapons in the United States inventory. Their mobility poses an effective dilemma for the enemy target planner - he must employ multiple weapons against a single warhead. In a post-START era with reduced weapons on both sides, mobile single warhead systems would, according to Reule's theory, appear highly desirable.

Lt Col Reule believes that the use of deception and mobility will create a new class of land-based missiles that cannot be effectively targeted by the Soviet Union. He postulates that this would force a radically new view of the concept of deterrence and increase first strike stability tremendously. Reule's formula for Dynamically Stable Deterrence (DSD) follows:

> DSD is achieved by developing and deploying weapon systems that use combinations of passive defensive measures such as deception, mobility, and hardening to make them unattackable. If such weapon systems can be deployed, then they should be essentially unattackable because no enemy can know with enough confidence where they will be when his attack arrives, or even how many exist [i.e. ideal for cheating on arms control agreements]. If such basing modes characterized the forces of both sides, dynamically stable deterrence would exist. (33:2)

Reule sees single warhead mobile missile systems as highly stabilizing nuclear weapons. (Because of the strong incentives for a first strike attack, he does not feel that ballistic missile submarines and bombers constitute desirable weapon systems.) The biggest advantage, striking first during a crisis, would be eliminated because of the difficulty in determining enemy target location. Recognizing this fact, he postulates superpowers would see no advantage to large arsenals and would actually be motivated to build down (33:2-3).

According to Reule, DSD would require a significant departure from the current basing policies for strategic systems. No longer would the locations of land based systems be public knowledge - concealment becomes the essential ingredient for survivability. That requirement would appear to limit the implementation of his recommended basing scheme because the United States public does not feel comfortable about the movement of nuclear weapons off military installations.

However, political difficulties with verification, the well known American public's resistance to the movement of nuclear weapons on public land, and continued Soviet cheating on related arms control issues are no doubt chief reasons why President Bush recently canceled both the rail mobile Peacekeeper missile and road mobile Small missile programs. Because of the canceling of our mobile missile programs, United States arms control negotiators will be in a much better position to insist that the Commonwealth of Independent States abandon their mobile systems. It is not likely that United States strategic forces will include land based mobile missile systems in the foreseeable future.

Role of US Nuclear Forces

The advent of significant numbers of nuclear weapons 40 years ago created serious difficulties in conducting accurate assessments of necessary military force strengths. More than any other weapon ever developed, strategic nuclear weapons have had an especially profound impact on United States defense policy. No longer could tanks, aircraft, and troops simply be counted and compared against those of a potential adversary. Instead, detailed analysis needed to be conducted to ascertain, as best possible, enemy strength. Factors such as weapon system reliability, penetrability, and survivability took on greatly increased significance. Often, it becomes too difficult to assess an enemy's "real" strength because of large uncertainties in certain areas such as actual weapon accuracy, reliability, and ability to penetrate terminal defenses. Therefore, U.S. planners tended to be more interested in "perceived" strength. However, as General Maxwell Taylor describes, there are critical differences between "real" and "perceived" strength.

Taylor defines real strength as "an ability to destroy major Soviet targets, military and civil, with nuclear weapons at intercontinental ranges" (26:157). Conversely, perceived strength, Taylor believes, is "the net impression of strength which the appearance of our strategic forces creates in the national minds of the Soviet Union, the US, and perhaps other countries" (26:158). To be most effective, deterrence requires a credible force structure controlled by a believable government. This means "perceived" strength. Snow adds his views concerning the absolute necessity of creating the "right" perception in an enemy's mind:

> It is generally agreed that deterrence rests on two primary factors: the physical capability to inflict awful penalties on a state doing something we have said is impermissible; and the belief by the person whom one seeks to deter that one will in fact do things one has threatened to [do]. (26:159)

Perfect deterrence then, would suggest that strategic military forces need never be used in a combat role. Brodie suggests that the presence of nuclear weapons in a nation's arsenal requires a fundamental change of mission for her strategic military forces:

> Thus far the chief purpose of our military establishment has been to win wars. From now on its chief purpose must be to avert them. It can have no other useful purpose. (33:29)

This preventative role falls largely upon those strategic nuclear forces composing the United States nuclear TRIAD.

TRIAD Concept. The American nuclear forces have long been split among three legs of a strategic triad in order to enhance survivability and flexibility. The TRIAD may be conceptually thought of as a triangle with each leg representing a strategic nuclear delivery system; bombers, missiles, and submarines. Each leg has its strengths and weaknesses with the combination of all three producing a synergistic effect. Figure 2.1 shows a conceptual image of the United States strategic TRIAD. The "DE" abbreviations stand for damage expectancy and their relative size and position denote the amount of damage expectancy that could be achieved using one, two, or all three legs of the TRIAD.

Many see the need for continued presence of a nuclear triad as the United States reduces the size of its nuclear arsenal:

> The search for a stable strategic nuclear deterrent at reduced but modernized force levels should continue to receive emphasis, both through arms programs and negotiations. No events foreseen in the surprise-free strategic environment would cause the United States to depart from its present emphasis on a balanced triad of offensive central nuclear forces and the maintenance of theater nuclear capabilities comparable to those of the adversary. (4:179)

The virtues of a TRIAD style strategic force structure have long been the subject of discussion among members of the defense community. While each TRIAD leg's various weapon systems may justifiably be criticized in its own right, collectively

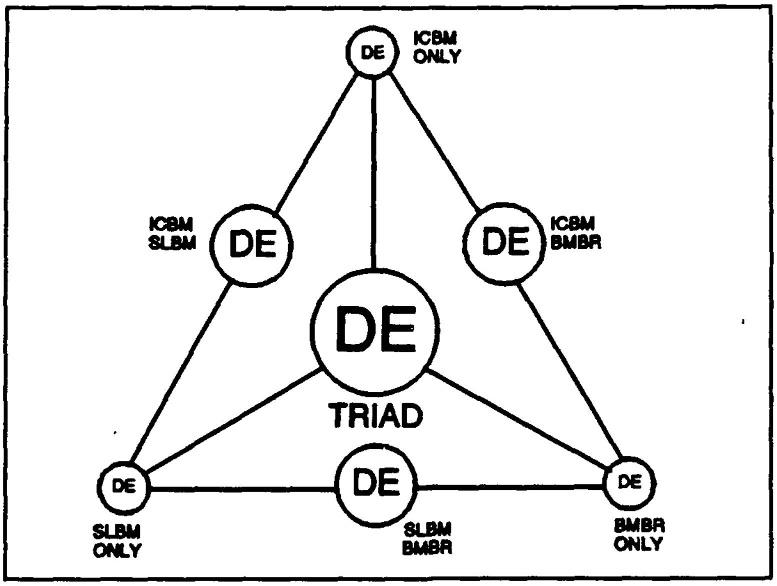


Figure 2.1. **TRIAD** adapted from (35:51)

they possess unusually high levels of synergy. Weakness in any one leg is more than offset by its contribution to the <u>entire</u> TRIAD. For example, fixed silo ICBMs are viewed as a vulnerable, "use or lose" asset, especially when equipped with multiple warheads. Critics of ICBMs frequently note that this "use or lose" feature makes ICBMs highly destabilizing. However, ICBMs are the best prompt, hard target killing weapon U.S. forces possess.

Manned bombers are the slowest U.S. strategic weapon. However, this lack of speed can be viewed as contributing to stability because superpower negotiations could conceivably continue during the entire bomber flight time. In theory at least, recall would be possible until moments before weapon release. One of the chief enemy threats against United States bombers are SLBMs. Many critics of a heavy reliance on manned bombers caution that SLBM warning times may be so slight as to prevent bombers from clearing their base's airspace before the attack begins to destroy those bases (23:2).

Ballistic missile submarines carrying SLBMs are both prompt and mobile, and these qualities have encouraged many strategic analysts to label them the most survivable of any strategic nuclear weapon. However, communication connectivity concerns and SLBM attractiveness as potential targets highlight the chief reservations of critics. Leary properly views these issues of strength and weakness in a collective sense and states that it is a "balance of forces" that optimize the TRIAD's benefits. His conclusion is that any future United States strategic force structure should continue to follow the proven TRIAD concept because the strengths and weaknesses will tend to offset each other (23:65).

Table 2.3 contains a summary of weapon's characteristics for those strategic nuclear systems found in each of the three TRIAD legs. At this time the United States does not have any mobile ICBM systems; however, they have been considered for adoption numerous times during the last decade. Most recently, a single warhead, road mobile intercontinental ballistic missile system, the Small ICBM, was designed, prototyped, and field tested. However, the system was cancelled by the Bush Administration (1:54).

Table 2.3

Summary of TRIAD Weapon Characteristics

Issue	Bomber	ICBM (fixed)	ICBM (mobile)	SLBM
Survivability	moderate	low	high	high
Connectivity	good	good	moderate	poor
Speed	slow	prompt	prompt	prompt
Alert Rate	low (30%)	high (90%)	high (90%)	medium (50%)
Penetrability	moderate	high	high	high
Stability	high	low	high	medium
Accuracy	good	excellent	good	moderate
Reliability	medium	high	high	medium

(31), (35)

Arms Reductions. The current (1991) and recently proposed (late 1990s) American and Soviet force structures are depicted in Table 2.4. As can readily be seen, each side's TRIAD remains intact in the post-START era.

Table 2.4

Shrinking Nuclear Arsenals

	Current Warheads		Post-START Warheads	
System	**U.S.**	**Soviet**	**U.S.**	**Soviet**
ICBM	2450	6694	1444	3028
SLBM	5440	2804	3456	1872
Bombs/SRAMs	2336	252	2720	80
ALCMs	1600	852	1860	1450
SLCMs	399	100	880	880
TOTAL	12225	10702	10360	7310

Adapted from (1:54)

Arms reduction talks have been a superpower activity for almost forty years. For many years, the balance of strategic forces rested quantitatively with the Soviet Union and qualitatively with the United States. However, during the early 1980s, Soviet forces were significantly modernized. Bluth identifies the following areas where the greatest progress took place:

1. increased progress in the mastery of complex fuel and guidance technologies;

2. reduced ICBM vulnerability through mobility;

3. the emergence of a genuine triad with the development of an intercontinental range bomber, air launched cruise missiles, and a modern long-range submarine launched ballistic missile force. (5:40)

While arms control negotiations during the 1980s may have appeared reassuring to the general public, Gray maintains that they were in fact little more than an exercise in dialogue between the Soviet Union and the United States. He feels that many people confuse the arms control process with peace. Because communications are taking place between superpowers during arms control negotiations, the public develops the mistaken belief that common values are shared (16:34).

Gray says that history is our best judge on arms control effectiveness. He cites the climate between the two world wars:

> The experiences of the 1920s and 1930s demonstrated that formal arms limitation agreements: are negotiable and sustainable only when the political context is unusually friendly (i.e., when war is nowhere near in sight); cannot achieve their objectives (help prevent war, promote stability, and so forth); are so thoroughly political that their terms typically make no strategic sense; lead to the development and deployment

> of treaty-compatible, treaty evasive or treaty-avoiding weapon systems which make sense primarily with reference to arms control and not to prospective military utility for national geostrategic need.(16:41)

It was Soviet President Gorbachev who first offered serious arms levels reductions. This thesis will not examine the complex and often contradictory area of arms control agreements. Rather, the assumption will be made that future superpower nuclear arsenals will likely never be the size of those possessed by the United States and Soviet Union in 1990.

Large segments of the general population have applauded nuclear arms reductions because they believe such action "makes the world a safer place". However, the very process of reducing nuclear weapons levels may be creating dangerous levels of instability. Difficulties arise because of how remaining weapons might be employed:

> The paradox of stability arises from the fact that nuclear strategies (and targeting doctrines, in particular) wobble between countervalue (hitting cities, industry, populations) and counterforce (striking military forces, in particular the silos where the enemy's nuclear missiles are housed-one hopes before he has a chance to fire them). The paradox is this: Counterforce reinforces deterrent stability because it increases the credibility of use; but it sacrifices crisis stability, almost precisely for the same reason. Countervalue, on the other hand, creates greater crisis stability; but it may lack deterrent stability, precisely because its use is not credible. (26:165)

<u>Conventional Weapons</u>

If Viet Nam was the television war, quite likely the Persian Gulf War will be remembered as the precision guided munitions (PGM) war. Although representing only a small portion of the total munitions dropped, "gun sight" camera footage of laser guided munitions going down building airshafts and through aircraft shelter doors dramatically demonstrated how truly effective these weapons can be against hardened point targets (40). This is a significant departure from the tactics of dropping large volumes of "dumb" iron bombs against area targets.

In recent years, conventional weapons delivery systems have matured significantly and, given the proper combination of airframe and guidance set, can now be considered suitable for attacking strategic targets. The term strategic targets here is taken to mean those targets located significant distances from the battle area and vital to the long term enemy order of battle. Examples of such targets are munitions storage areas, hardened command centers, hardened communications sites, and power production facilities.

Table 2.5 details characteristics of three precision guided munitions. Laser glide bombs (LGB) are two thousand pound weapons equipped with a television seeker for daytime use or an infrared seeker for nighttime use. Any aircraft can drop an LGB; however, special guidance equipment is required in the controlling aircraft. Cruise missiles are long range, self propelled, subsonic weapons equipped with a terrain matching radar which allows them to fly at low altitude and avoid detection by enemy defenses. Because cruise missiles have significant range once launched and are carried by air refuelable bombers, they are essentially intercontinental range weapons.

Table 2.5

Precision Guided Munitions

Weapon Designation	Carrier	Range (miles)	CEP (meters)
GBU-15 LGB (Laser Glide Bomb)	F-4 F-15 F-16 F-111 F-117	1-40	<30
ACM-86 ALCM (Air Launched Cruise Missile)	B-52G B-52H	1500	<30
AGM-129 ACM (Advanced Cruise Missile)	B-52G B-52H B-1B B-2	1800	<30

(17)

Table 2.6 clearly illustrates how improved accuracies have dramatically reduced the number of weapons necessary to achieve a 90% probability of severe damage against a hardened target. Severe damage occurs with 90% probability when a 2000 pound bomb lands anywhere within a 20 foot circle centered on the target. Accuracy is commonly referred to as circular error probable (CEP), which is defined as the radial distance from an aim point in which 50% of the bombs will land. Severe damage is defined as the level of damage that precludes further military use without complete reconstruction. Since complete reconstruction capability would not normally be available at base level, equipment receiving severe damage usually requires lengthy depot level repairs.

Table 2.6

Effect of CEP on Quantity Necessary to Place One Weapon on Target

Conflict	Delivery System	CEP (feet)	Quantity Required
WW II	B-17	3300	9070
Korea/SEA	F-84/F-105	400	176
Desert Storm	F-16	200	30
Desert Storm	F-117	<10	1

(40)

Not all conventional weapons need be delivered to the immediate target area by aircraft. For example, air launched cruise missiles and the more recent advanced cruise missiles can be employed as long-range stand off weapons when carried aboard heavy bombers such as the B-52, B-1, and B-2. Additionally, the US Navy has the Tomahawk cruise missile which can be launched from various vessels. Because of their low radar cross section, low infra-red signature, and terrain following capability, cruise missiles have an excellent probability of arrival on target. Combined with high accuracy, these features hold all but the most hardened enemy targets at significant risk.

Experiences from the Gulf War. As reported by Defense Department spokesman Pete Williams on Jan 16, 1992, the first air strikes against Iraq were flown by Barksdale AFB, LA based B-52 bombers. Reportedly, seven aircraft flew nearly 14,000 miles to launch a payload of conventional cruise missiles against high priority targets deep inside Iraq. While the details are classified, it may be reasonably assumed that due to the weapon's 1500 mile range, they were fired while the B-52 was in a stand off role well outside coastal defenses (24:17).

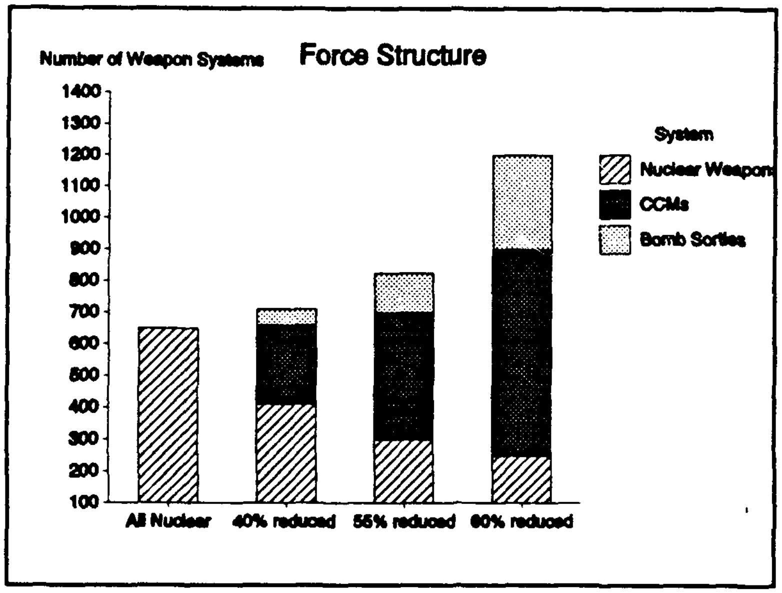
According to an unnamed Air Force intelligence officer, the allied strategic air war effectively shut down all militarily significant transfers of oil, electricity, and supplies. Allegedly, weapons could be delivered so accurately that electric power plants were struck in such a fashion that repair time would be minimized in the post war period. This source concluded with the claim that "There are a significant number of people in uniform that don't understand there has been a revolution in warfare" (12:65).

An unintended consequence of the precision bombing is that Iraqi officials may have misunderstood United States' intentions. The Iraqi interior minister is quoted by a Greenpeace International analyst as saying "We would have understood carpet bombing, but we didn't understand this other, [i.e., precision bombing of very select targets]" (12:63). This situation illustrates the difficulty that can be encountered when sending political signals across the globe using military power.

<u>Conventional Target Evaluation Methodology</u>. In a recent article, Gallagher and Kelly describe a methodology they developed to assist in the previously time consuming task of operational planning of conventional weapons against fixed targets. Difficulties had been encountered in the past because of the huge number of variables involved and the lack of suitable

databases. Because no force allocation models existed for large scale conventional weapons allocations, they modified the Arsenal Exchange Model (until then, a purely nuclear model) so that it was suitable for conventional and combined conventional/nuclear weapon allocations against large databases of enemy targets.

The result of their work was a successful hybrid model that allows for the combined allocation of both nuclear and conventional weapons in accordance with standard constraints and objectives. Of interest are the simulation runs they conducted in which the objective was to neutralize an enemy target set with a minimum number of weapons. Holding the required damage level constant, they studied the effects of nuclear arms reductions upon total weapons required. Figure 2.2 clearly shows that the stated objectives were accomplished, albeit with significantly more conventional weapons, even with a reduced nuclear arsenal.



(14:885)

Figure 2.2. Effect of Nuclear Arms Reduction on Combined Nuclear and Conventional Force Structures

Strategic Targeting Process

Strategic targeting is one of the final steps taken during the military's formulation of national security objectives. If presidential guidance is to emphasize strikes against enemy warfighting capability, then the analyst prepared target base contains a high percentage of counterforce targets. During the strategic targeting process, what begin as broad objectives are refined into specific weapon to target assignments.

It is the Joint Strategic Target Planning Staff's (JSTPS) job to transform these objectives into a viable nuclear weapons employment plan. That plan is known as the Single Integrated Operations Plan (SIOP) and describes the method in which United States strategic weapons would be employed in wartime.

Allocation is the process of determining which United States weapons are assigned against an enemy target base. Battilega says "Allocation, very simply, means the assignment of weapons to targets" (3:259). During the strategic targeting process, he says the following questions must be answered:

1. How many weapons are there?
2. How many targets are there?
3. How effective is each weapon against each target?
4. What is the priority for assignment of weapons to targets?
5. What are the overall objectives of the allocation?
6. What operational considerations must be treated as a part of the assignment process?
7. What uncertainties must be explicitly treated as a part of the assignment process?
8. What potential countermeasure could the opponent invoke to deny the allocation objectives?" (3:259)

When constructing an enemy target list, it is also important to know which targets are most important, why they are important, and what particular value they hold to the enemy. As Snyder notes, it may well be the case that perceived values, as seen by the U.S. target planner, are quite different than actual values ascribed by the enemy (36). In such a case, the United States might not be holding the enemy's most precious (as seen in their own eyes) objects at risk. If this were true, deterrence could be highly ineffective.

Leary notes that "targeting is a complex task with numerous options intended to maximize flexibility" (23:17). During the initial assessment, potential Soviet targets are normally grouped into four separate and distinct classes as shown in Figure 2.3.

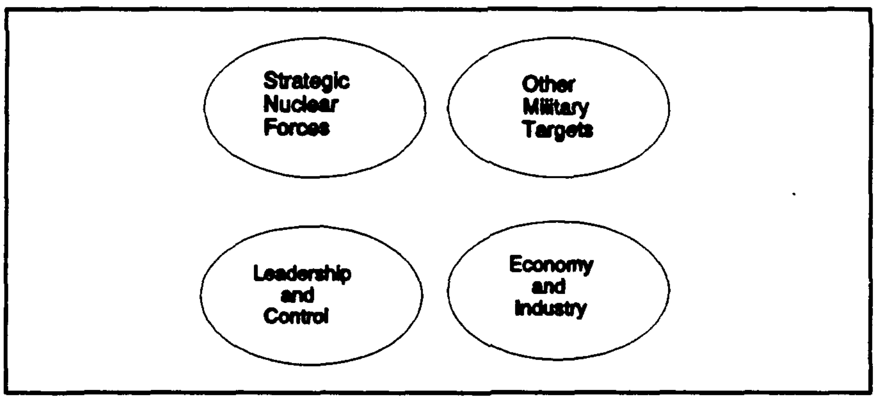


Figure 2.3. Target Classes

Within each class, individual targets are identified and assigned to the national target list for possible inclusion into the current year's SIOP. Because of the extensive computational requirements involved, the JSTPS uses large computer algorithms to assist in the mating of weapons and targets; this process requires many months to complete. Presently, only nuclear weapons are included in this allocation process.

Modeling

A number of different models have been constructed which purport to examine force structures and potential superpower nuclear exchanges. While the various models differ in their particular approach to strategic targeting, Batteliga notes that the following generally accepted analytic scenarios are common ingredients in all (3:243):

> **Assured Destruction Scenario:** In this scenario an assumed maximum counterforce attack is followed by an attack against the non-military assets of the aggressors. This is intended to be a sufficiency test of strategic deterrence.
>
> **Damage-Limiting Scenario:** This scenario is the inverse of the Assured Destruction scenario. It is used to test the maximum degree to which offensive action could be employed to limit nuclear damage from a potential aggressor.
>
> **General Exchange Scenario:** In this scenario, one opponent executes a hypothetical nuclear warplan, followed by a hypothetical retaliatory warplan. Several dimensions (e.g. relative urban/industrial damage) can be measured.
>
> **Counterforce Exchange Scenario:** In this scenario, an initiator launches all or part of his force against the vulnerable nuclear delivery systems of the opponent. All or part of the survivors are then launched in retaliation against the vulnerable reserve of the initiator. This scenario tests the potential advantage to be gained from a preemptive attack, and hence is used to study stability and balance questions.

Each of these scenarios can be viewed as a possible nuclear confrontation encounter between the superpowers. Effective strategic nuclear exchange models which carefully abstract all these scenarios have developed great credibility among members of the defense community. Indeed models sometimes develop a personality of their own and there is frequently a danger of giving model output undue credibility. As one author has noted:

> The models in a certain sense become the oracle to which strategic planners turn to assist them in decision making, force structuring, and war plan generation. (3:237)

Measures of Effectiveness. Measures of Effectiveness (MOEs) are important tools that essentially serve as yardsticks for use in assessing the attainment of stated objectives. One of the most important elements of any analysis is the selection of an appropriate measure of effectiveness. The chosen measure of effectiveness must be easily understood, capture the problem's essence, and be agreed upon by the various agencies who will view model output. While it would be useful to measure deterrence or stability directly, that is generally not possible (36:2-16). As a consequence, a number of calculated and dynamic measures of effectiveness have been constructed which attempt to satisfy user requirements. Normally the study's purpose will dictate which MOE is appropriate. However, in some instances it may be necessary to use multiple MOEs so that desired allocations and goals can be achieved.

Several common static measures of effectiveness are listed below in equations (1) through (3). Embedded in these static measures of effectiveness are certain weapon and weapon system characteristics such as yield, warhead numbers, accuracy, and target hardness (36:2-16).

$$EMT = yield^{2/3} = (MT)^{2/3} \qquad (1)$$

$$CMP = \frac{EMT}{CEP^2} = \frac{(MT)^{2/3}}{(NM)^2} \qquad (2)$$

$$ECMP = \frac{\ln(1 - PA + PA * (.5^{(CMP * LR * LR)}))}{\ln(0.5) * LR^2} \qquad (3)$$

where

EMT = Equivalent Megatonnage

CMP = Counter Military Potential

ECMP = Effective Counter Military Potential

yield = explosive output (megatons)

NM = nautical miles

CEP = circular error probable (nm)

PA = probability of arrival

LR = lethal radius (feet)

The value of static measures of effectiveness is their ease of use in nuclear force targeting and allocation model codes. In the models, static MOEs are the building blocks for dynamic MOEs.

Dynamic MOEs are calculated during the weapon to target allocation process. Snyder identifies the following dynamic MOEs as being particularly useful for a decision maker (36:2-15):

1. target value destroyed
2. residual weapons
3. goal satisfaction

4. minimum cost
5. optimal force structure
6. surviving ICBMs
7. warheads on target

Measures of effectiveness may be clear to an analyst who must recommend between alternate courses of action. However, to be truly useful, the measure of effectiveness must be easily understood by a nontechnical reader. As former Secretary of State Dr Henry Kissinger noted:

> One of the key problems of contemporary national security policy is the ever-widening gap that has opened up between the sophistication of technical studies and the capacity of an already overworked leadership group to absorb their intricacy. (32:v)

Damage expectancy, a cumulative probability of damage figure which is computed by summing all individual probability of arrivals multiplied by their respective single shot probability of kill, is one such easily understood measure of effectiveness. Allocation models using a damage expectancy measure of effectiveness optimize total damage to the target base by assigning weapons toward the most easily destroyed targets. A major shortcoming of damage expectancy as a measure of effectiveness, however, is that it fails to consider any subjective value that foreign leaders may place on their national assets.

Soviet Perspective

Deterrence and stability are concepts that require similar perceptions among two opposing parties if they are to work. This means that bipolar stability between the United States and

Soviet Union were directly affected by each country's perceptions of the others intentions, capabilities, and values. While there has been substantial dialogue between representatives of each side, unfortunately the Soviets do not share American views on the relative stability various weapon systems offer. Nowhere is this profound difference of opinion better illustrated than with Intercontinental Ballistic Missile systems:

> The [Soviet] preference for ICBMs as leading to a more stable strategic environment is in stark contrast to the American view, which has seen ballistic missiles as the central factor of instability. US arms control efforts (particularly in the post-Reykjavik phase of START) have been directed at reducing or even eliminating ICBM forces. (5:44)

There have been numerous proposals by both sides to reduce nuclear stockpiles from current levels. Soviet scientists are also interested in the effects that arms reductions might have on stability between the superpowers. In the words of one Soviet scientist:

> Since 1984...[we] have been engaged in studies of various modes of drastic strategic arms reductions. The central concept is that of strategic stability. The scholars engaged in this research prepared assessments of various configurations of force postures based on extensive computer modelling. The fundamental criterion of stability was the possibility of carrying out a completely or partially disarming first strike, with stability decreasing as one side increased its first-strike potential. (5:43)

Soviet leaders advanced a number of arguments concerning what they perceived as the stabilizing nature of unMIRVed ICBMs. Those comments, as reported by Bluth, are contained in Table 2.7.

The Soviets also felt that conventional weapon systems were an area where great strides could be made in strategic capability. According to Goure, the Soviets further felt that certain missions previously filled by nuclear assets could be assigned to long range precision guided conventional weapons (15:43).

Table 2.7

Soviet Thoughts on Stability

1. Command and control of ICBMs is much more reliable. Two-way communication with submarines may at times be disrupted and therefore requires that submarines must technically be able to fire missiles without authorization.

2. The trajectories of ICBMs are relatively predictable after launch and therefore facilitate early warning. SLBMs and particularly SLCMs are much more suitable for attempts to bypass early warning systems.

3. Although ICBMs have come to be considered the most effective counterforce weapons, the accuracy of SLBMs has now improved considerably. By restricting the force to mobile single-warhead ICBMs both the vulnerability and the first-strike potential problem can be overcome since it takes more than one warhead targeted per enemy missile to be assured of a successful first strike, and this in any event becomes virtually impossible if the missiles are mobile.

4. As a delivery vehicle for nuclear weapons, bombers are not considered conducive to a stable strategic environment because of their nuclear/conventional capability.

adapted from (5:44-45)

<u>Summary</u>

This chapter reviewed relevant literature concerning national defense policy, deterrence, and stability. Different types of deterrence were discussed as well as the difficulties encountered with multicultural communications during periods of international tension. The characteristics of various nuclear weapons, the strategic triad, and conventional weapons were examined. Detailed consideration to mobile systems was given since these were the weapon of choice for the former Soviet Union. Experiences from the Persian Gulf War were reviewed in order to ascertain the emerging strategic role of conventional weapons. The next chapter develops a methodology for examining various force structures and target valuation schemes using a combined nuclear/conventional strategic force structure.

III. Methodology

Introduction

The previous chapter discussed national defense policy, deterrence, stability, and the role that nuclear weapons have played in the past. Additionally, strategic targeting issues, measures of effectiveness, and the utility of target valuation were discussed. Lastly, conventional weapon capabilities were discussed in light of their performance during the recent Persian Gulf War. This chapter will develop a methodology for evaluating a combined nuclear and conventional weapon force structure within a value damage expectancy measure of effectiveness framework.

Disclaimer

All weapons and target data have been drawn from unclassified sources such as Janes, Air Force Magazine, and the Snyder thesis (17),(11),(36). While the data may be considered realistic enough to demonstrate this proposed methodology, any analyst using this decision framework in a real world setting would first need to obtain classified databases from an office such as the Joint Strategic Target Planning Staff at Offutt AFB, Nebraska.

Modeling Limitations

Not all aspects of reality can be modeled. Often, the most crucial parts of a volatile international crisis situation: intentions, motivations, and values, cannot be easily quantified.

Therefore, any force structure analyst using models and simulation to examine potential international behavior must recognize the limitations of their tools:

> Modelers and users alike must be cognizant of the fact that no model can fully replicate combat; the best that should be expected is that the model may provide visibility to the relationships between some key parameters. (3:233)

Normally these parameters are items such as numbers and types of targets, weapons and delivery vehicles available, and probabilities of arrival and damage. Distinctions are typically made between prompt and slow arriving weapons, single warhead and MIRV systems, and warhead yield. Additional characteristics that are important to include in the model are weapon system reliability, availability, accuracy, and terminal defense penetration capability. This thesis proposes that an important parameter to consider is target value. Target value is not static; rather, the changing priorities of an opponent's leadership require a dynamic target value consideration by United States' planners.

Strategic Nuclear Modeling

Although modeling of strategic nuclear forces is not an exact science, it does offer the best insight possible concerning the potential outcome of a nuclear exchange. Consequently, military planners often use computer models and simulations to assist in difficult strategic force exchange analyses. Battilega asserts that:

> The modeling of strategic conflict has, in fact, assumed a high degree of importance. As strategic systems have become perhaps the cornerstone of national defense, the importance of understanding the risks and benefits of utilizing such systems without resorting to actual trials becomes paramount. (3:237)

In the United States defense community, one popular analysis tool is the Arsenal Exchange Model (AEM), a linear goal programming model that is designed for use as a means of analyzing strategic force structure issues. Currently the AEM is in daily use by personnel at the Air Force Center for Studies and Analysis, Washington, D.C. and at the Joint Strategic Target Planning Staff at Offutt AFB, Nebraska. As mentioned previously, a variety of MOEs can be applied to the AEM. By selecting a suitable measure of effectiveness, the decision maker can make informed decisions about issues such as force structure, force posture, and cost/capability tradeoffs. For years, the MOE of choice among analysts at the Joint Strategic Target Planning Staff was damage expectancy. It continues to be popular today.

Arsenal Exchange Model. Battilega and Grange review the Arsenal Exchange Model at length. They observe that:

> The Arsenal Exchange Model (AEM) is conceptually formulated around a mapping of the strategic resources of two world powers into three components: retaliatory nuclear forces (e.g., ICBMs), non-retaliatory military targets (e.g., nuclear storage sites), and non-military resources (e.g., urban/industrial complexes). (3:283)

The AEM utilizes a linear goal programming allocation process for user input weapon and target data. In practice, the AEM serves as an interface device between analyst supplied data sets and a powerful linear programming algorithm. Embedded in this algorithm is nuclear weapon effects code that permits automatic calculations for such shock wave and blast effects as peak overpressure and peak dynamic pressure. The resulting data is then used in MOE calculations to "optimally allocate weapons to targets so that maximum value is achieved" (3:284). The editors note that:

> The basic purpose of the AEM is to assign weapons to targets in a way that maximizes the utilization of weapons toward the achievement of a user-specified set of objectives without violating user-specified constraints. (3:285)

The Arsenal Exchange Model's flexibility allows an analyst to construct a variety of different exchange scenarios. AEM, Inc, the model's current maintainer, believes that the following four scenarios, as summarized by Batteliga, cover all probable variations of a nuclear conflict between the superpowers.

Batteliga summarizes the four scenarios (3:283-284):

> 1. A **one-strike scenario** allocates the initiator's arsenal against his opponent's value targets and nonretaliatory military targets (called other military targets (OMT) in the illustration). There is no assumed retaliation. This scenario determines the maximum non-force target damage the initiator can achieve.
>
> 2. The **two-strike scenario** is composed of a CF/CV [counterforce/countervalue] strike by the initiator with a retaliatory strike against the initiator's OMT and value targets. This scenario allows the initiator to maximize his value returned relative to that of the opponent since he has the option of attacking his opponent's forces or targeting the value targets, in an approximate mix.
>
> 3. A **three-strike, optimum force scenario** consists of a CF first strike, a CF/CV retaliation, with the initiator's CV strike last. This scenario is sensitive

to the survivability of the various weapon types and attempts to simulate a damage-limiting first strike, with a reserve force holding the retaliator at risk. Such a plan could possibly preclude the second and third strike in a real war if the retaliator's price is sufficiently high. OMT are targeted in the CF first strike.

4. A **three-strike, optimum reserve target scenario** consists of a CF/CV first strike, a CF/CV retaliation, and a CV strike by the initiator's specified reserve force against those value targets not previously attacked. Survivability is important in choosing the proper list of targets for each strike. This scenario is most useful if total arsenal simultaneous launching is not possible, or in other circumstances where forces will be targeted during retaliation.

Conversation with current and former analysts indicates that these scenarios are indeed studied frequently. Almost without exception the only strategic weapons considered for use by United States forces have been nuclear (18),(31).

Hedges. The Arsenal Exchange Model offers the analyst options that allow the specification of certain restrictions in the weapon to target allocation process. For example, it might be desired that no bombers attack ICBM sites. Or certain minimum quantities of weapons may need to be reserved for use in a second strike. Hedging is the process of specifying certain constraints or conditions that the AEM must satisfy as it seeks to maximize its objective function. Often, hedges that specify the maximum amounts of any weapon type to be used against a class of targets are used to guard against a failure in any one triad leg. For example, an analyst may specify that no more than fifty percent of the weapons allocated against military targets may be ICBMs. The editors describe hedging in precise linear programming terms:

> An alternative optimization criterion is offered by use of **hedging allocations**. Such allocations are obtainable within AEM by use of analyst-specified auxiliary goals, side conditions, or extra requirements that must be met by the allocation while, at the same time, attempting to maximize the basic objective function. (3:284)

Multiple hedges can be prioritized in ways that allow the AEM to satisfy important user specified conditions first before moving on to lower priority conditions. For example, an analyst might feel that the allocation process should cover ninety percent of all military targets before covering any economic targets, regardless of target value. Without this particular hedge, the AEM would seek to maximize its objective function by allocating weapons against high value targets regardless of category.

Measures of Effectiveness. This thesis uses a dynamic measure of effectiveness referred to as value damage expectancy. When this measure of effectiveness is used, the Arsenal Exchange Model considers analyst supplied target values and target vulnerabilities to determine weapon allocation. The precise means of calculation for this measure will be explained in detail in Chapter Four.

Measuring Stability with AEM. Currently the AEM has no ability to quantify the level of stability a particular force structure possesses. While stability is indeed an important concept, no effort to quantify or measure it is made in this thesis. Instead it is discussed in qualitative terms.

Problem Formulation

Specific deterrence cases will be tested in this thesis to see if potential adversaries are deterred by various United States strategic force structures. For the purposes of this thesis, successful deterrence is defined as the threat of destroying 80% of the enemy's target value for the particular scenario. The three deterrence cases are described below:

Case 1. A counterforce/countervalue exchange appears likely between the United States and entire Commonwealth of Independent States. Can United States forces inflict enough damage on the enemy to deter them?

Case 2. NCA orders a counterforce preemptive strike against a third world power. NCA wishes to stay below the nuclear threshold - can conventional weapons satisfy the objectives?

Case 3. NCA orders an escalation control counterforce strike against one commonwealth state. NCA desires to use conventional weapons only. Unfortunately, the situation escalates into a full scale counterforce/countervalue exchange involving all commonwealth states.

Although preliminary weapon to target allocation work has been done by Gallagher and Kelly using the AEM, currently no widely available capability to directly handle a mixed nuclear and conventional weapon set exists (14). Through model accommodation however, an analyst can manually input the damage expectancy values for specific conventional weapons against specific point and area targets. This capability allows the direct input of damage expectancy for various conventional weapon and target combinations. Embedded in these damage expectancy values are

various factors such as CEP, probability of launch survival, weapon system reliability, and probability to penetrate.
In the AEM version used for this thesis effort, an off line calculation of DE achieved by conventional weapons was required. The following figure details the damage expectancy calculation as accomplished both internally in AEM for the nuclear weapon to target matchups and externally for the conventional weapon to target matchups.

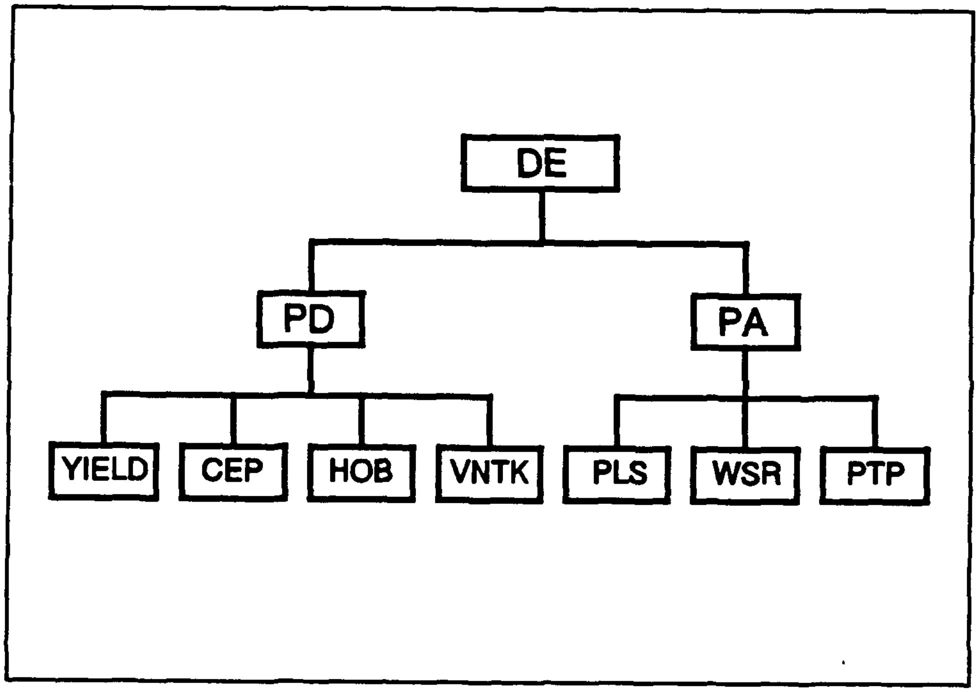


Figure 3.1. Damage Expectancy extracted from (35:24)

DE = Damage Expectancy
PD = Probability of Damage
PA = Probability of Arrival
Yield = Explosive Power
PLS = Probability of Launch Survival
CEP = Circular Error Probable
WSR = Weapon System Reliability
HOB = Height of Burst
PTP = Probability to Penetrate
VNTK = Vulnerability Index

In the most recent version of AEM (which was not available for this thesis effort) a new conventional weapon damage input format is available. This format will allow analysts to avoid offline damage expectancy calculations and instead let the AEM algorithms accomplish the complete computation process. This enhancement will also make sensitivity analysis much easier and faster.

Target Valuation

The essence of using a value damage expectancy measure of effectiveness is the assignment of relative weights to each target class. Then, based on the number of targets in the particular class, each individual target receives a point value.

The total number of points used when evaluating any particular scenario is arbitrary - what matters is their division among the various target classes. These weightings would vary according to leadership perceptions of what an enemy perceived to be important at the time. As Snyder explains in great detail in her thesis and effectively demonstrates in two test cases, weapons necessary to achieve a predetermined set of results can vary significantly depending on target value. Snyder cautions against blindly using these figures for force structure decisions without first considering other qualitative factors such as military judgement and historical evidence (36:4-20).

Effect on Weapon Allocation. Snyder concludes that target values can greatly affect weapon allocation. Her allocation results for two test cases are listed in Table 3.1.

Table 3.1

Weapons Required by Type

	Unconstrained Cases		Constrained Cases	
Weapon	Case 1	Case 2	Case 1A	Case 2A
MM2	450	450	450	312
MM3	600	600	600	0
MM3A	900	900	900	0
PKPR	500	500	500	0
POSIEDON	0	215	763	3
TRIDENT	1627	548	0	0
B-52G	1128	1128	1128	0
B-52/ALCM	600	1464	1464	545
B1B	192	192	19	0

adapted from (36:4-21)

The second and third column headings refer to Snyder's cases where no maximum damage level was specified, thereby permitting the allocation of virtually all weapons. In these instances large numbers of additional weapons were expended beyond those necessary to achieve 80% value damage expectancy. The allocation of remaining weapons by the Arsenal Exchange Model produced only small marginal results. The last two columns show far fewer weapons being allocated against the enemy target base because maximum value damage levels have been preset at an 80% level. That constraint forces the AEM to use **only** the weapons necessary to achieve an 80% value damage expectancy requirement.

Target Classes

Following the method used in Snyder's thesis, targets are grouped into three general classes and further divided into subsets. Table 3.2 shows the target base used by Snyder.

Table 3.2

Items considered for inclusion in a Target Base

Military	Weapons	Non Time Sensitive Time Sensitive	Silo SLBM
	C3	Soft Control Centers Hard Control Centers Communications	Time Sensitive NonTime Sensitive
	Ops	Space Assets Ports Bases	
	Support	Defense Industry Resources Supply	
SOC/ECON	Economic	Non-defense Industry Power facilities Food	
	Social	Transportation Population	
Govt LDR		Hard Control Centers Soft Control Centers	

extracted from (36:3-17)

Summary

This chapter presented a data disclaimer, reviewed general modeling limitations, examined strategic nuclear modeling considerations and discussed target valuation as a measure of effectiveness. Three specific deterrence cases were presented against which certain nuclear and conventional strategic force structures are to be evaluated. The next chapter presents the results of this methodology applied to the three specific deterrence cases.

IV. Demonstration of Methodology

Introduction

This chapter applies the methodology developed in Chapter Three to three specific deterrence cases representative of probable world scenarios the United States may face during the coming decade. After stating assumptions and explaining the chosen measure of effectiveness, three specific test cases and six force structures are examined. The proposed methodology permits an evaluation of various force structures using specific goals and differing decision maker preferences under a target valuation framework. Six different United States' strategic force structures, ranging from exclusively nuclear to almost fully conventional, are tested against several hypothesized deterrence scenarios using the Arsenal Exchange Model.

Assumptions

Forces on each side are assumed to be fully generated to alert status, thereby allowing all strategic weapons in the respective arsenals to be used. Similiar analysis could easily be conducted for the nongenerated case in which only certain United States strategic forces are available for immediate launch. As of late 1991, that "day-to-day" force does not contain bombers so their contribution in this scenario would be limited. Furthermore, in this thesis it will be assumed that United States forces will be launched on receipt of tactical warning. Tactical warning is defined as evidence that a large scale attack against the United States is underway. In the tactical warning situation, enemy weapons may not have impacted yet.

Additionally, only prompt nuclear weapons effects such as dynamic and drag overpressure are considered. (Thermal effects, electromagnetic pulse, and fallout radiation are ignored.) Lastly, total communications connectivity failures are assumed to be negligible during the prelaunch time frame. This simplifying assumption is realistic since United States forces receive their launch orders over a variety of redundant communications systems, some of which can operate in a nuclear environment.

Calculating Value Damage Expectancy

Damage expectancy is a commonly used measure of effectiveness in strategic force analysis situations. It is also one of two factors imbedded in the measure of effectiveness this thesis uses, value damage expectancy. The other factor is individual target value as perceived by the analyst and decision maker. It is important to note that target value and hardness are often not directly correlated.

Calculation of individual value damage expectancies are performed by multiplying damage expectancy by respective target values. Equation (4) describes the calculation for an individual target:

$$\textbf{Value Damage Expectancy} = \textbf{Target Value} \times \textbf{Damage Expectancy} \quad (4)$$

Aggregrate value damage expectancy numbers for each of the test cases are obtained by summing all individual results. As a measure of deterrence, analysts typically calculate the ratio of value damage expectancy achieved to aggregate target value in the enemy target base. For example, if a particular enemy target base had been assigned an arbitrary aggregate point value of 20,000 points and 15,000 points were deemed destroyed during the scenario model run, then value damage expectancy achieved would be 75%.

Table 4.1 contains conventional weapon damage expectancy values for the various weapon/target combinations considered in this thesis. The precision guided munitions such as LGBs, air launched conventional cruise missiles (CCM) and sea launched conventional cruise missiles (Tomahawks) are highly accurate and therefore extremely effective against point targets such as communications centers, aircraft shelters, and hardened leadership centers. These so called "smart weapons" have destructive capabilities which approach those of nuclear weapons against a wide range of point targets. Laser glide bombs would likely be carried by long range F-117/F-111 aircraft, cruise missiles by B-52s, and Tomahawks by Naval surface ships and submarines. Because cruise missiles can be launched from significant stand off ranges (1000-1500 miles), an attacker can achieve both surprise and near zero attrition on the carriers.

In contrast to precision guided munitions, iron bombs must be released almost directly over the target area, thereby subjecting the carrier aircraft to target defenses. Additionally, even under the best of circumstances, delivery accuracy is substantially worse than that of precision guided munitions. Therefore, only softer area targets can be considered suitable for attack with iron bombs. The values in Table 4.1 could be easily changed by any analyst doing follow-on work.

Table 4.1

Target Vulnerability to Various Conventional Weapons

	LGB	B-52 CCM	Tomahawk	Iron
Silo	0.25	0.25	0.40	0.01
Sub Pen	0.50	0.60	0.65	0.05
N-Time Wpn	0.90	0.90	0.80	0.40
T Comm	0.80	0.80	0.80	0.11
N-T Comm	0.90	0.90	0.90	0.80
Hd Cmd/Ctl	0.85	0.85	0.88	0.05
Sf Cmd/Ctl	0.90	0.90	0.92	0.11
Airbase	0.80	0.85	0.85	0.25
Naval Port	0.90	0.90	0.90	0.40
Space Port	0.90	0.95	0.95	0.50
Supplies	0.90	0.90	0.90	0.50
Resources	0.90	0.90	0.90	0.80
Def Indus	0.90	0.90	0.90	0.50
Food	0.95	0.95	0.95	0.80
Elec Pwr	0.90	0.90	0.90	0.11
Nat Def	0.90	0.90	0.90	0.50
Civ Popul	0.95	0.95	0.95	0.80
Trans	0.90	0.90	0.90	0.80
Hd Ldrshp	0.85	0.80	0.80	0.11
Sf Ldrshp	0.90	0.90	0.92	0.11

Cases Tested

A recent nuclear weapons policy study by the Strategic Air Command has recommended that U.S. forces be prepared to execute five new strike options rather than the present Single Integrated Operational Plan which pitted all U.S. forces against the Soviet Union. These proposed strike options were considered when building the cases used in this thesis.

The new strike options include:

- All out attack against the new Commonwealth of Independent States (CIS).
- Limited strikes on military targets within the CIS.
- Multiple exchanges with the CIS.
- Strikes against Third World countries.
- Strikes against C^3 and leadership targets using precision guided conventional weapons. (2:38)

A total of three different deterrence cases are examined in this thesis. The cases are quite different in terms of conflict size and examine various forms of deterrence in light of Lider's four deterrence types. Six different United States strategic force structures are tested against target sets developed for the three cases. Case 3, a multiple exchange scenario, demonstrates how dynamic target valuation can be used to reflect changing leadership priorities during wartime.

Case 1. Case 1 is a test of Lider's Type I Deterrence against the danger of direct attack on United States' terrority. A description of Case 1 is restated below:

Case 1. A counterforce/countervalue exchange appears likely between the United States and entire Commonwealth of Independent States. Can United States forces inflict enough damage on the enemy to deter them?

This case seeks to demonstrate a United States ability and will to use nuclear forces against assets the Commonwealth of Independent States values highly. As Snyder notes, the Soviets have always valued leadership highly and placing this entity at significant risk of destruction would be of great deterrent value for the United States (36:3-4). Cimbala refers to this as "counterpolitical" targeting (9:39). Because the highest levels of leaderhip would be located in hardened underground command bunkers, these targets receive a very high individual target value. Figure 4.1 contains the entire target base for Case 1. For ease of calculation, 20,000 total value points have been chosen for Case 1.

Two hedges are used as allocation controls in Case 1. The first hedge specifies that 50% or more of the enemy missile silos must be attacked by United States "missile type" forces. Missile type forces are defined as either land based ICBMs or sea based SLBMs. This hedge forces the AEM to allocate prompt arriving weapons against vital enemy ICBM targets before they can be launched. The second hedge requires that AEM cover time urgent targets such as communications centers and enemy leadership positions with prompt arriving weapons at a level of 80% or greater. This hedge forces the AEM to allocate prompt weapons against targets that have decreasing values with respect to time. For example, destroying a communications center <u>before</u> it could send launch orders to its subordinate missile units is an example of destruction of a time urgent target.

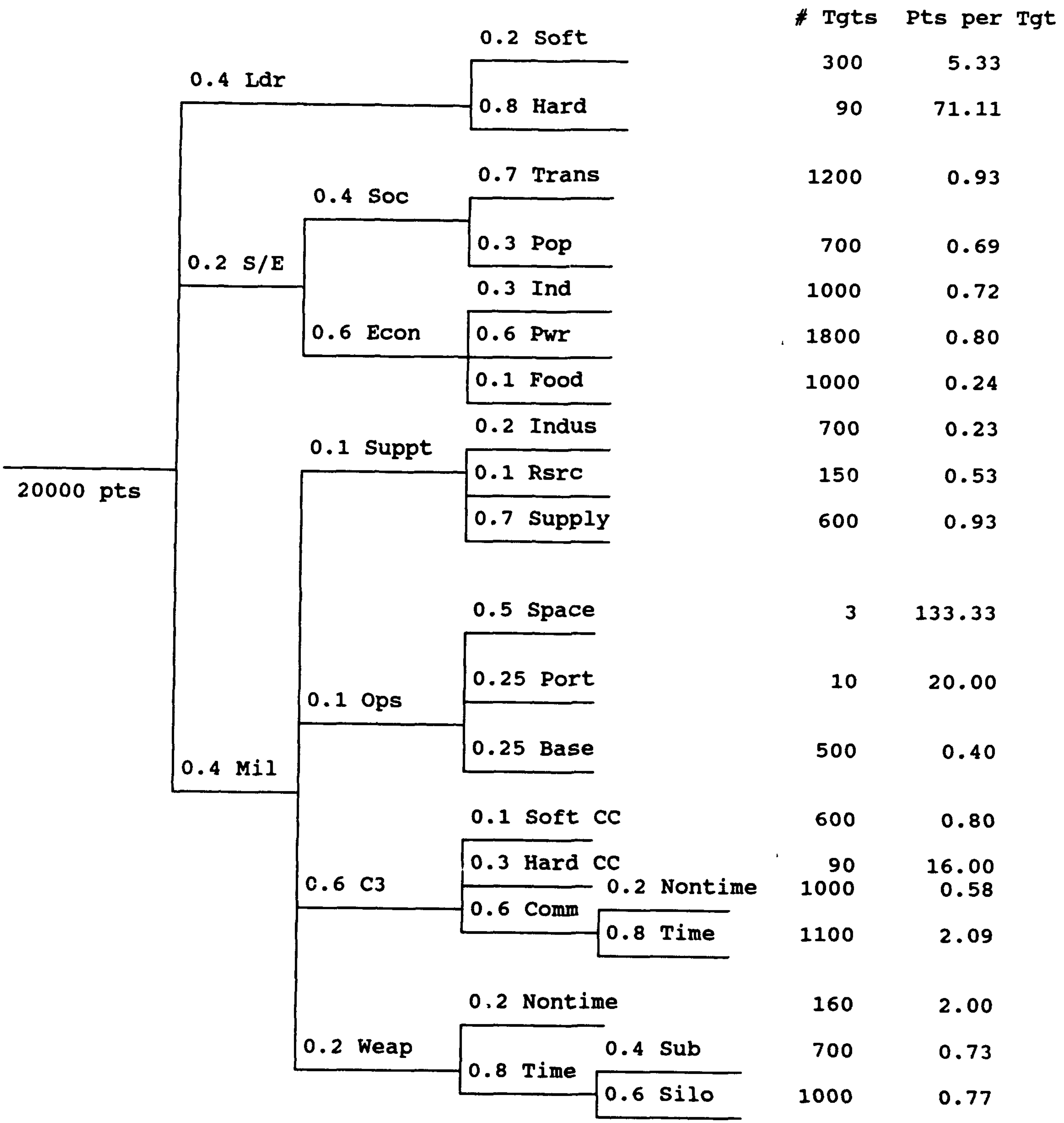


Figure 4.1. Target Base for Case 1

Case 2. Case 2 examines Lider's Type III deterrence, which is local aggression in the Third World. Case 2 is a scenario where a Third World country develops a small nuclear capability and then threatens to use it against one of its regional neighbors. Equally plausible is a scenario where a country acquires nuclear technology and delivery systems with the intent of exporting them to nations predisposed to supporting terrorist activity. Efforts to control the spread of ballistic missiles that could deliver chemical, biological, or nuclear weapons have met with only limited success to date (19:45),(29:12-14,15-16). This scenario is not implausible; Iraq reportedly has a top-secret uranium mining complex in its northern area that is capable of producing weapons grade uranium (6:63). Case 2 is restated below:

> **Case 2.** National Command Authorities (NCA) order a counterforce preemptive strike against a third world power. NCA wishes to stay below the nuclear threshhold - available strategic conventional weapons will be used. Can they satisfy the objectives?

For political reasons, both internally and internationally, the United States does not wish to be the first to use nuclear weapons in this scenario. Therefore, the National Command Authority (NCA) desires to launch a single devastating strike against the enemy's uranium enrichment plants, nuclear weapon production facilities, and missile assembly buildings using conventional weapons only. Additionally, the NCA desires the destruction of a large number of the enemy's command centers and leadership bunkers so as to disable the enemy government.

The strike package selected must be small, yet highly effective so that mission objectives can be achieved in a single combined attack wave of fighter bombers, heavy bombers, and naval cruise missiles. Additionally, the NCA would like a weapon's package that can be delivered to the target area with maximum surprise within 24 hours. Stealth and forward basing are both factors that can help achieve this goal.

All potential targets have been judged vulnerable to the strategic conventional weapons available. The nuclear weapon production facility and aircraft storage shelters can be reliabily penetrated by 2000 pound laser glide bombs or conventional cruise missiles. Leadership facilities, radar sites, and communications centers are vulnerable to any of the conventional weapons available. Figure 4.2 contains the enemy target base and associated target values for Case 2. For ease of calculation, 20,000 total value points have been chosen.

Two hedges are used as allocation controls in Case 2. The first hedge specifies that at least 95% of the enemy "nuclear" targets (i.e. uranium refinery, nuclear weapon production facility, booster assembly plant) be destroyed. The second hedge specifies that no more than 80% of the enemy leadership be destroyed so that personnel exist for the formation of a new government. Because the attack is to be coordinated with all weapons arriving simultaneously in a single wave, there are no hedges concerning time sensitive targets.

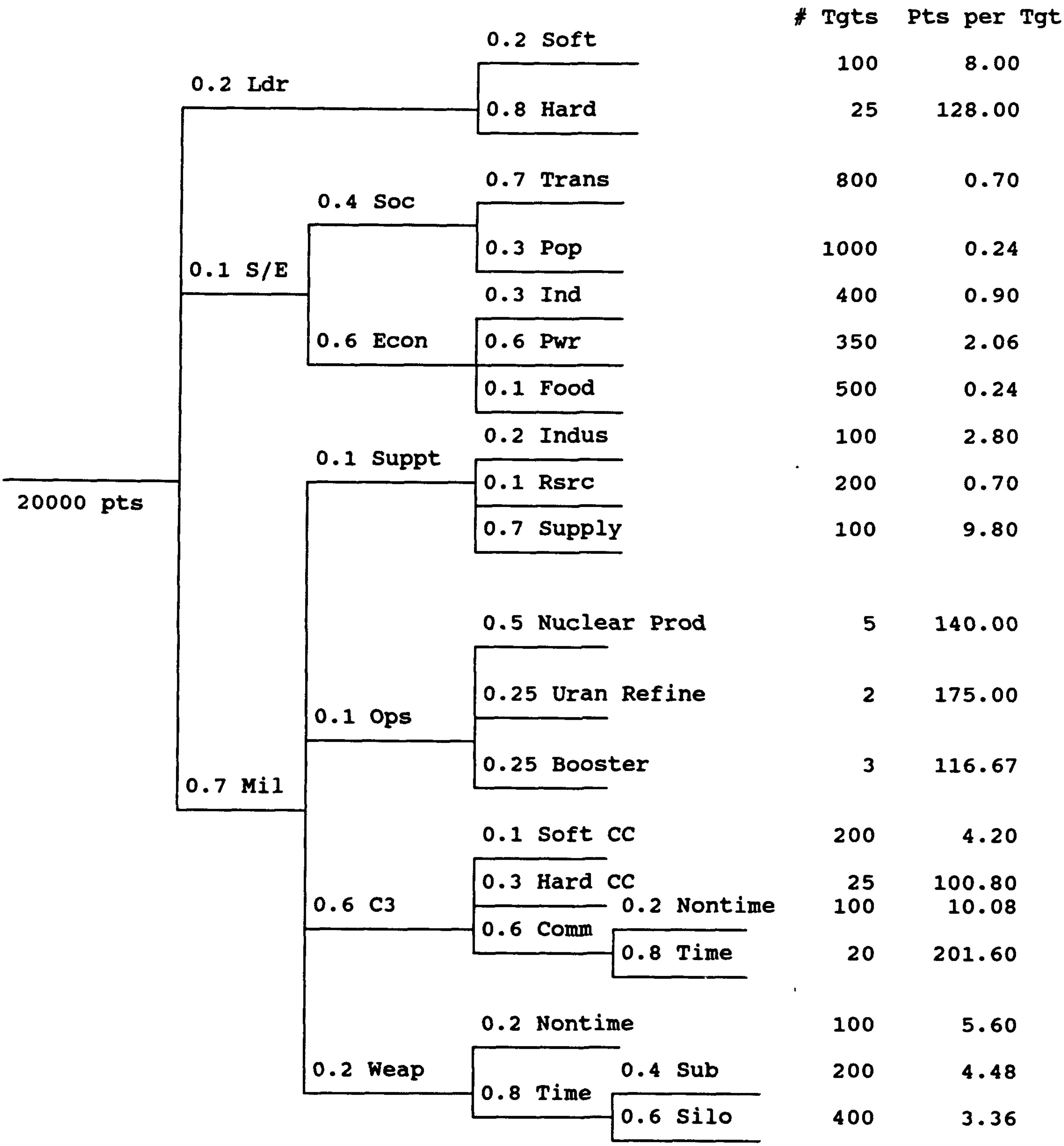


Figure 4.2. Target Base for Case 2

Case 3. Case 3 again examines Lider's Type I deterrence, this time in a multiple exchange scenario where escalation controls have failed. Case 3 is restated below.

> **Case 3.** NCA orders an escalation control counterforce strike against one Commonwealth State, using conventional weapons, if available. Unfortunately, the situation escalates into a full scale counterforce/countervalue exchange involving all Commonwealth States.

This case seeks to demonstrate a United States ability to use offensive strategic forces against one adversary and then respond appropriately to a larger enemy alliance which threatens to strike the United States in retailiation for the preemptive strike.

Case 3 is split into two phases. Phase I, Case 3a, models United States forces in a preemptive counterforce strike against one commonwealth state. This is a war which the United States wages in hopes of limiting the scope of conflict. As in Case 2, the National Command Authority desires to avoid the first use of nuclear weapons and will use an exclusively conventional weapon set, if available. Figure 4.3 contains the single Commonwealth States' target base for Case 3a. 20,000 total value points are used for the target set in Case 3a. Because the strike is counterforce in nature, 80% of the target weighting is placed against military targets.

After the United States' preemptive strike the entire Commonwealth allies together and threatens a retailiatory attack. Phase II, Case 3b, models residual United States forces in a counterforce/countervalue strike against the entire Commonwealth target base. Figure 4.4 contains data on the other two Commonwealth States' (i.e. targets not considered in Phase I) target base for Case 3b. There are no target values in Figure 4.4 since the figure does not represent the complete target base for Case 3b. Surviving targets from Case 3a are added to this Case 3b target base prior to Phase II execution. This new target base also contains 20,000 total value points, so after the surviving targets from the one Commonwealth State have been added to those of the other two Commonwealth States, individual target values can be computed. Since Case 3b is now a combined counterforce/countervalue strike, target weightings for the military category have been reduced to 60% while leadership has now assumed increased importance and is doubled to a 30% weighting.

Essentially, target values have changed to reflect the United States shift from a damage limiting deterrence stance to a warfighting stance. This is a war the United States cannot afford to lose. Therefore, great emphasis is placed on destroying targets the enemy would use in controlling its strategic offensive and defensive forces. For example, very high value is given to destroying the enemy space capability so that his intelligence gathering capability is limited. Without reliable intelligence, the enemy is denied critical battle information and will not have attack warnings or know the success or failure of his attacks. Additionally, disrupting vital communications systems, especially early in the war, can prevent launch orders from reaching enemy forces, thereby negating their value without destroying them directly.

A number of hedges are used as allocation controls in Case 3a. Because the National Command Authority desires to remove the immediate threat that this single Commonwealth poses without unduly aggravating the other two, damage levels for enemy ICBMs have been set at 80% while total damage against military targets and all targets combined is to be held at 50% or less. A higher damage level for ICBMs has been set due to their promptness, difficulty in intercepting, and destabilizing nature. Additionally, damage tc leadership is to be held at 80% or less so that Commonwealth government personnel remain who can negotiate a peace settlement with the United States.

When escalation occurs and a Phase II exchange between the United States and entire Commonwealth appears likely, hedges and target values are modified to reflect a counterforce/countervalue exchange. The first hedge forces the AEM to allocate United States prompt arriving weapons against Commonwealth time sensitive targets such as communications centers and leadership positions. Other hedges specify that at least 90% damage must be done to the enemy's military capability and that electric power production facilities must be at least 50% destroyed. Lastly, for reasons identical to those in Phase I, no more than 80% of the leadership targets are to be destroyed.

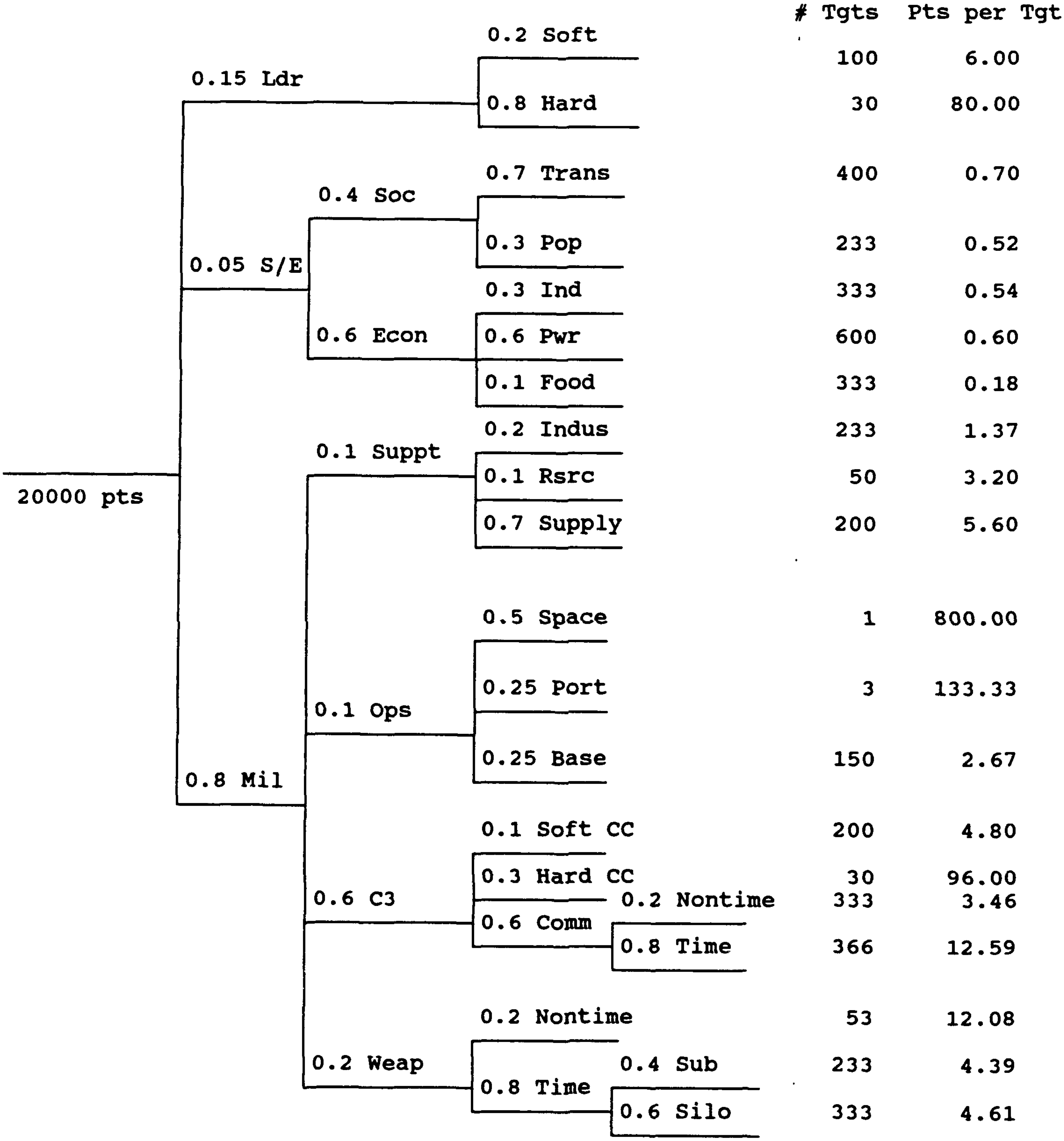


Figure 4.3. Target Base for Case 3a

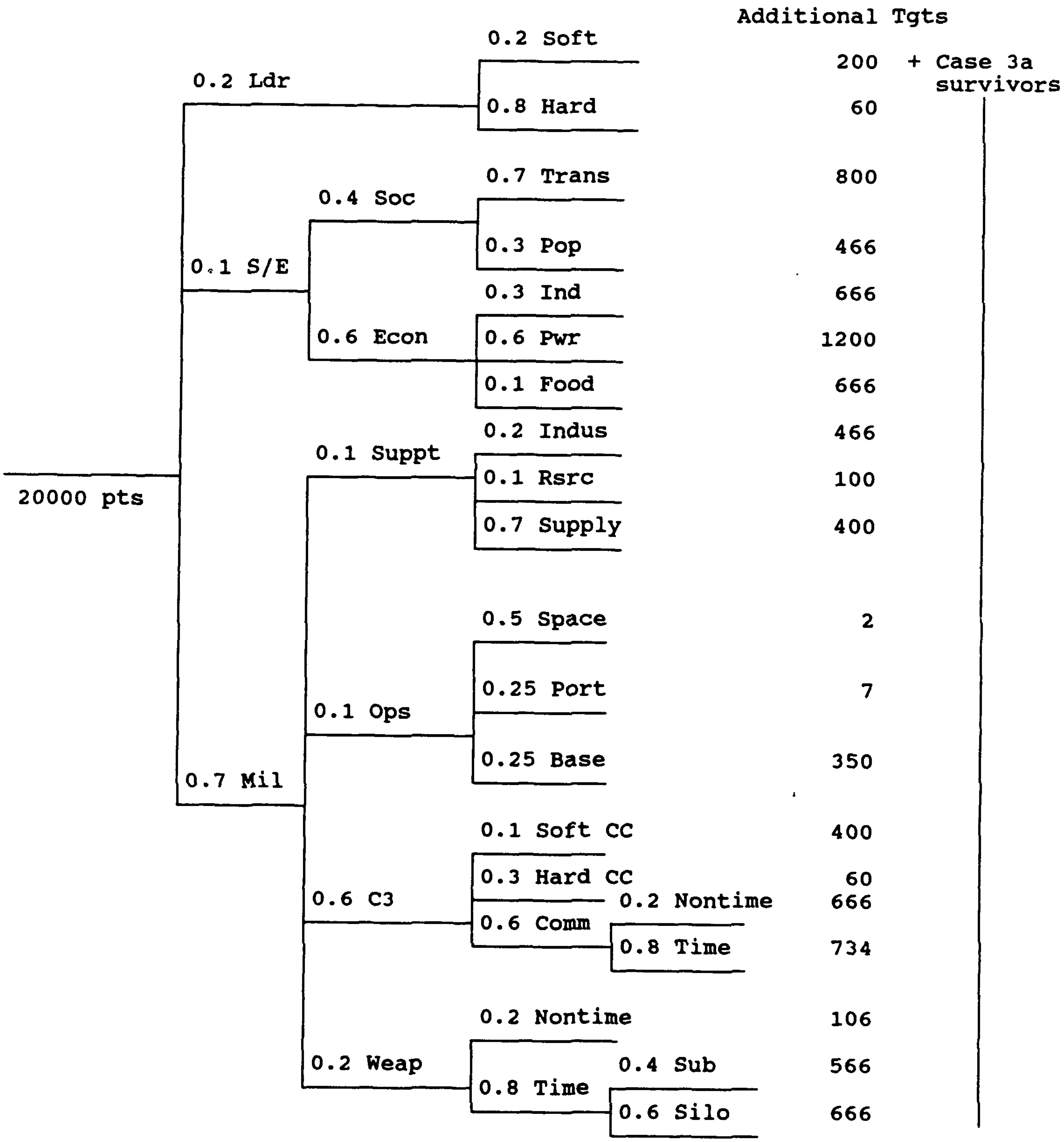


Figure 4.4. Target Base for Case 3b

Force Structures Used

Six different strategic force structures have been constructed for use in this thesis. They range from all nuclear (Force I and Force II) to nearly all conventional (Force VI) in composition and are designed to measure the effects of various force structure decisions such as downloading, ICBM retirement, and bomber retirement.

The various forces have been postulated based on reports that the United States may reduce the number of nuclear warheads below the 9000 level allowed by the Strategic Arms Reduction Treaty (START). Additionally, precision guided conventional weapons may be included in the United States strategic force structure (2:38).

In situations where a combined conventional and nuclear force is used (Forces III - VI), conventional weapons are executed first, immediately followed by nuclear weapons. Although accomplished primarily for ease of analysis since the 1989 version of AEM used for this thesis cannot simultaneously allocate both conventional and nuclear weapons, a leading conventional attack is highly realistic for important reasons. Most conventional weapons are not prompt arriving, therefore using them after a nuclear attack would decrease their utility against time sensitive targets. Furthermore, executing conventional weapons after a nuclear exchange could result in severely degraded weapon accuracies due to dust clouds, electromagnetic pulse, and changed terrain features.

Table 4.2 contains various nuclear weapon characteristics and damage expectancy factors such as reliability, penetration probability, availability, prelaunch survivability, and communications connectivity. Jtype refers to a categorization technique AEM uses to track which leg of the TRIAD weapons are from; "1" is ICBMs, "2" is SLBMs, and "3" is bomber. As stated in the Chapter Four assumptions section, prelaunch survivability and communications connectivity are assumed to be perfect.

Table 4.2

Nuclear Weapon AEM Input Parameters

	Jtype	rel	ptp	av	pls	C^3
MM2	1	0.80	0.90	0.85	1.00	1.00
MM3	1	0.85	0.95	0.90	1.00	1.00
MM3A	1	0.90	0.95	0.90	1.00	1.00
PKPR	1	0.90	1.00	0.90	1.00	1.00
Poseidon	2	0.80	0.95	0.80	1.00	1.00
Trident	2	0.90	0.95	0.80	1.00	1.00
B-52Grav	3	0.75	0.60	0.80	1.00	1.00
B-52ALCM	3	0.90	0.90	0.90	1.00	1.00
B-1BALCM	[illegible]	0.90	0.90	0.90	1.00	1.00
Tomahawk	2	0.90	0.90	0.90	1.00	1.00
B-1BGrav	3	0.80	0.80	0.80	1.00	1.00

Force I. Force I contains those weapons agreed to under the Strategic Arms Reduction Treaty. This force is a true TRIAD with ICBMs, bombers, and submarines all represented in large numbers. The three TRIAD legs each contain several different systems which help guard against a failure or breakthrough fully disabling that leg.

Because each leg is robust, great flexibility is available to a decision maker considering various attack options. With the large number of weapons available, a decision maker could conceivably "ride out" an enemy attack and still have sufficient forces to inflict severe retailiatory damage on an aggressor.

Table 4.3 contains the specific weapons systems and payloads comprising Force I.

Table 4.3

Weapons Available for Force I (START Levels)

NAME	Number	Warheads Carrier	CEP (FT)	YIELD (MT)
MM2	450	1	2000	1.2
MM3	200	3	700	.17
MM3A	300	3	600	.335
PKPR	50	10	300	.3
Poseidon	256	10	1500	.04
Trident	384	8	400	.1
B-52 Grav	141	8	350	1.08
B-52 ALCM	122	12	200	.2
B-1B Grav	96	12	300	.75

(36)

Force II. Force II assumes that the United States has downloaded its multiple warhead land based systems and retired the Minuteman II ICBMs and Posiedon SLBMs. Downloading describes the process where the number of warheads on a missile is reduced. Examples of this concept are the proposed transformations of Minuteman 3 missiles from three warhead systems to one warhead systems and Peacekeeper missiles from ten warhead systems to three warhead systems. Downloading is widely seen as a stabilizing move because it reduces the value an enemy can achieve by attacking first. Specifically, it makes little sense to expend two or three warheads against a one warhead system in a hardened silo. Therefore, downloading creates a situation where little or no incentive exists "to strike first in a crisis or to launch one's vulnerable forces when warning is received that an attack is under way" (27:22),(39:53).

Force II is still a TRIAD force but much greater emphasis has now been given to the air breathing bomber leg. Arms control advocates would likely applaud such an action because bombers are slow arriving weapons perceived to pose little threat to first strike stability. This is because an opponent would have ample warning, possibly even hours, of an impending attack by bombers. Furthermore, their recall feature lends credence to the argument that negotiations could continue for many hours and the aircraft could still be recalled before they reach their targets.

Table 4.4 contains the specific systems and payloads included in Force II.

Table 4.4

Weapons Available for Force II (Reduced/Downloaded START)

NAME	Number	Warheads Carrier	CEP (FT)	YIELD (MT)
MM3	200	1	700	.17
MM3A	300	1	600	.335
PKPR	50	3	300	.3
Trident	384	8	400	.1
B-52 Grav	141	8	350	1.08
B-52 ALCM	122	12	200	.2
B-1B Grav	96	12	300	.75

Force III. Force III is a bomber/submarine DYAD which has had a significant number of conventional weapons incorporated into it. Arms controllers might consider this particular force structure more survivable and stabilizing than a TRIAD structure because the "use or lose" multiple and single warhead ICBMs have been removed. However, the removal of ICBMs would result in a significant loss of prompt arriving, hard target kill weapons.

Since this force has two different legs (bomber/SLBM) in it, a technological breakthrough against one leg would not nullify the entire U.S. nuclear arsenal. This force assumes that an additional 100, conventional only, B-1Bs have been purchased. Additionally, this force contains another system (B-52) that can be converted to conventional only missions.

Table 4.5 shows the weapon systems and payloads for Force III.

Table 4.5

Weapons Available for Force III (Bomber/Sub DYAD with conventional)

NAME	Number	Warheads Carrier	CEP (FT)	YIELD (MT)
Poseidon	256	10	1500	.04
Trident	384	8	400	.1
B-52 Grav	141	8	350	1.08
B-52 ALCM	122	12	200	.2
B-1B Grav	96	12	300	.75
LGB	100	1	<30	n/a
B-1B CCM	100	8	<30	n/a
Tomahawk	350	1	<30	n/a
Iron	1000	1	300	n/a

Force IV. Force IV contains those nuclear forces agreed to under START and also includes a significant number of strategic conventional weapons. This force assumes that an additional 100, conventional only, B-1Bs have been purchased.

The inclusion of conventional weapons in a strategic force structure, while maintaining a full nuclear TRIAD, makes this the most robust weapon set tested. Such a force structure might be seen by some arms control observers as destabilizing due to the substantial net increase in total strategic weapons. However, nearly all the added conventional weapons are slow arriving and therefore contribute towards increased stability. Because this particular force provides substantial precision guided conventional weapons capability while maintaining significant nuclear forces, it would offer great flexibility to a decision maker.

Table 4.6 contains the weapon systems and payloads for Force IV.

Table 4.6

Weapons Available for Force IV (START with conventional)

NAME	Number	Warheads Carrier	CEP (FT)	YIELD (MT)
MM2	450	1	2000	1.2
MM3	200	3	700	.17
MM3A	300	3	600	.335
PKPR	50	10	300	.3
Poseidon	256	10	1500	.04
Trident	384	8	400	.1
B-52 Grav	141	8	350	1.08
B-52 ALCM	122	12	200	.2
B-1B Grav	96	12	300	.75
LGB	100	1	<30	n/a
B-1B CCM	100	8	<30	n/a
Tomahawk	350	1	<30	n/a
Iron	1000	1	300	n/a

Force V. Force V contains a downloaded nuclear TRIAD and also incorporates strategic conventional weapons. Both prompt weapon TRIAD legs have been significantly reduced by the retirement of Minuteman II land based missiles and sea based Poseidons. Downloading landbased Minuteman IIIs to one warhead and Peacekeepers to three warheads would be seen by many arms control analysts to enhance stability. Furthermore, retiring the Poseidon and Minuteman II systems would allow the United States to reduce its nuclear arsenal to below START levels while maintaining the most capable systems. This force assumes that an additional 100, conventional only, B-1Bs have been purchased.

Table 4.7 contains the weapon and payload data for Force V.

Table 4.7

Weapons Available for Force V
(Reduced/Downloaded START with conventional)

NAME	Number	Warheads Carrier	CEP (FT)	YIELD (MT)
MM3	200	1	700	.17
MM3A	300	1	600	.335
PKPR	50	3	300	.3
Trident	384	8	400	.1
B-52 Grav	141	8	350	1.08
B-52 ALCM	122	12	200	.2
B-1B Grav	96	12	300	.75
LGB	100	1	<30	n/a
B-1B CCM	100	8	<30	n/a
Tomahawk	100	1	<30	n/a
Iron	1000	1	300	n/a

Force VI. Force VI is a downloaded, submarine only, nuclear MONAD with a significantly enhanced strategic conventional weapon capability. All land based ICBMs have been retired while remaining B-52 and B-1B bombers have been modified to carry conventional cruise missiles only.

Arms controllers might consider this force the best obtainable in a severely reduced weapons environment. The downloaded sea based SLBMs are considered stabilizing due to their location uncertainty and reduced warhead load. However, this force would be highly susceptible to an enemy breakthrough in antisubmarine warfare (ASW) technology and tactics. If such a breakthrough occurred, the United States might find itself suddenly without a viable strategic nuclear weapon force.

Another problem with this force structure is that it possesses minimal prompt hard target kill capability and there are some important targets beyond SLBM range in the Soviet land mass. Should an opponent place a large number of his own weapons out of SLBM range, then stability might well be decreased. Furthermore, potential communications connectivity breaks may cause the submarines to be far less responsive than a land based ICBM force.

Table 4.8 contains the weapons and payloads available for Force VI. Arsenal Exhange Model input code for Case 1, Force VI, has been included in Appendix C and is representative of the 24 different computer runs performed for this thesis.

Table 4.8

Weapons Available for Force VI (Downloaded/Sub only MONAD with conventional)

NAME	Number	Warheads Carrier	CEP (FT)	YIELD (MT)
Poseidon	200	1	1500	.04
Trident	240	1	400	.1
LGB	100	1	<30	n/a
B-52 CCM	250	8	<30	n/a
B-1B CCM	96	8	<30	n/a
Tomahawk	350	1	<30	n/a
Iron	1000	1	300	n/a

<u>Force and Case Matrix</u>

Table 4.9 summarizes the forces and deterrence cases tested in this thesis. Forces I and II are not tested against deterrence Case 2 because they do not contain the required strategic conventional weapons.

Table 4.9

Review of Cases Tested

	Strategic Force Structures					
	I	II	III	IV	V	VI
Case 1	x	x	x	x	x	x
Case 2	n/a	n/a	x	x	x	x
Case 3	x	x	x	x	x	x

Summary

This chapter begins by stating assumptions used in the AEM analysis, then discusses value damage expectancy calculations and concludes by describing the three test cases and six forces used to analyze United States' deterrence issues. Specific survivability, connectivity, and promptness characteristics of each force were reviewed. In the next chapter, the results of the six forces applied to the three cases are presented.

V. Results and Discussion of Results

Introduction

This chapter presents and discusses the results obtained from using six different force structures against the three deterrence test cases. Specific weapon allocation results for each force/case combination are reviewed and surviving targets from each model run are examined. Various aspects of target valuation and user input constraints, as they affected weapon allocation, are also discussed. Lastly, conventional weapon performance against the target base is reviewed.

Arsenal Exchange Model Results

Value damage expectancy results are summarized in Table 5.1. As noted previously, Forces I and II were not executed against Case 2 since that case specified that only nonnuclear munitions be used.

Table 5.1

Value Damage Expectancy Achieved

Deterrence Scenario	Force used					
	I	II	III	IV	V	VI
Case 1 (Entire Commonwealth)	82%	68%	84%	92%	82%	54%
Case 2 (Conv only against Third World power)	n/a	n/a	81%	81%	81%	89%
Case 3 (Multiple exchange)	66%	42%	77%	82%	73%	25%

Deterrence Sufficiency. Figure 5.1 shows a plot of value damage expectancy results for the six forces tested against the three deterrence scenarios.

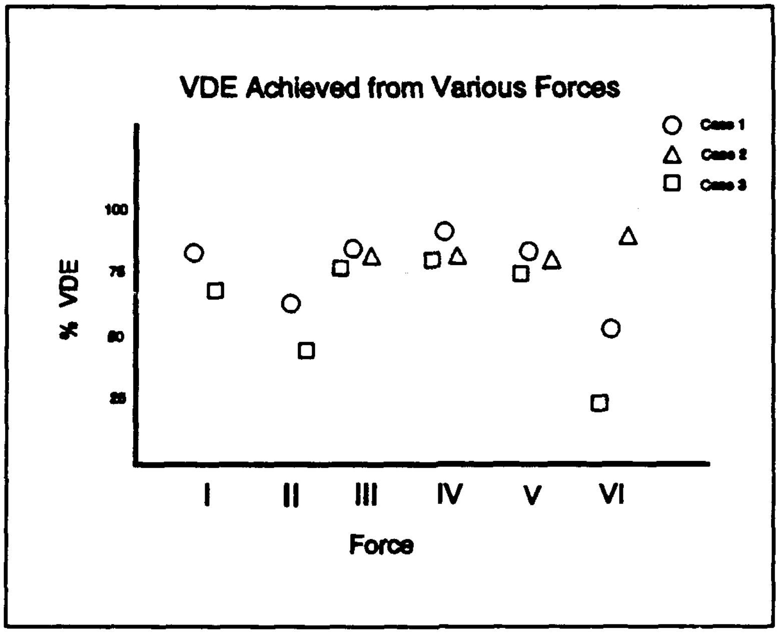


Figure 5.1. Deterrence Sufficiency Plot

It appears that the MONAD of Force VI would not be capable of achieving likely national command authority objectives in either Case 1 or Case 3. Since it is plausible to assume that our adversaries perform analysis similar to our own, an enemy might reasonably perceive that a successful attack could be launched against the United States if this particular force structure was adopted. Should an enemy reach this conclusion, then deterrence would have in fact failed no matter what military options a leader could threaten to employ. This is because a key component of deterrence is based largely on the perception created in an opponent's mind about military capability.

Conversely, Forces III, IV, and V all promise high levels of damage against an enemy in the three deterrence cases tested. Analytic results like this should suggest to the national command authority that they could feel confident U.S. military forces were capable of inflicting substantial damage against an aggressor. That capability, coupled with a demonstrated and strongly pronounced resolve to use force if necessary, means that these force structures would be deterring. These forces all contain at least a nuclear DYAD and several hypothesized forces have downloaded ICBMs. Force V might have special appeal to arms controllers who want to download the multiple warhead land based missile systems due to their perceived destabilizing nature. Specific results for each Case/Force combination are presented in the following section.

General Comments. Certain general comments about weapon allocations can be made which apply to all Case/Force combinations. First, the use of hedges to meet decision maker requirements results in an allocation where less than optimal value damage expectancy is achieved. Secondly, although a particular target type (ex. silos) may have high value as a class, large numbers of targets in that category result in individual targets being assigned low values. As a consequence of this, fewer weapons are allocated by value driven models such as AEM against these low value targets.

Results for individual runs reveal how many of each weapon type are allocated against particular targets. Low value targets consistently receive few or no weapons (unless forced by user input hedges) while high value targets are often allocated multiple weapons. This allocation of multiple weapons produces damage expectancy levels near unity. An example of this situation is shown in Table 5.2 where two cruise missiles are allocated against each of the three space targets.

Specific weapon allocation results for each Case/Force combination are contained in Appendix D. Table 5.2 contains allocation results from Case 1, Force III. An analyst reviewing this data could determine the marginal utility of one additional weapon against time sensitive communications (TCOM) targets.

Table 5.2

Weapon Allocation for Case 1, Force III

Target	**Number Atkd**	**DE**	**Number of Weapons Used**			
			LGB	**CCM**	**T-hawk**	**Iron**
NTW	160	0.90		1		
TCOM	634	0.80		1		
TCOM	260	0.80			1	
TCOM	176	0.67				5
TCOM	30	0.59				4
HDCC	90	0.88			1	
Port	10	0.90	1			
Space	3	1.00		2		
Hd Ldr	90	0.85	1			

Case 1. Table 5.3 shows which targets survived destruction when the various Forces were applied to the Case 1 target set. This is information an analyst might review when determing whether allocation objectives had been met. For example, it may be determined that defense industries (Defin) should be damaged in this scenario. Should this be desired, then an analyst would either increase the appropriate target values or use an allocation control (hedge) to force the allocation. Target types which received less than 60% physical damage are highlighted and may require a "second look" by an analyst assiging target values.

Case 2. Table 5.4 shows which targets survived destruction during the Case 2 model runs. Results are identical for Forces III, IV, and V since the same conventional weapon mix is used in each Force. Interestingly, no weapons are allocated against hardened silos when Forces III, IV, and V are used. This may be explained by examining the individual target characteristics such as hardness and value. Because silos have a much higher hardness than submarines, and consequently a lower probability of kill, weapon allocations against submarines were far more effective.

Case 3. Table 5.5 shows which targets survived destruction during the Case 3 model runs. Forces III and VI are both relatively "weapon poor" which largely explains the significant number of surviving targets. An analyst might be particularly interested in reviewing the allocation results for Forces II and VI since the majority of military targets escaped destruction in these runs.

Table 5.3

Surviving Targets in Case 1

	Target Type	# of Tgts	Force used					
			I	II	III	IV	V	VI
Mil	Silo	1000	280	495	235	191	326	386
	Sub	700	112	349	390	196	550	534
	NTW	160	21	39	2	2	2	16
	TCOMM	1100	176	209	36	29	36	220
	NTCOM	1000	624	1000	1000	545	1000	1000
	HDCC	90	0	1	1	1	1	2
	SFTCC	600	114	600	144	144	562	600
	Base	500	500	500	72	72	73	454
	Port	10	0	0	0	0	0	0
	Space	3	0	0	0	0	0	0
	Supp	600	114	114	150	87	114	600
	Rsrc	150	150	150	150	125	150	150
	Defin	700	700	700	700	700	700	700
Soc/ Econ	Food	1000	1000	1000	1000	1000	1000	1000
	Power	1800	416	543	478	379	560	1800
	NDef	1000	299	1000	884	256	1000	1000
	People	700	254	700	700	252	700	700
	Trans	1200	190	190	193	177	190	1000
Ldr	Hd Ldr	90	0	0	0	0	0	5
	SftLdr	300	7	16	11	30	37	300

Table 5.4

Surviving Targets in Case 2

	Target Type	# of Tgts	Force used					
			I	II	III	IV	V	VI
Mil	Silo	400	Not Tested		400	400	400	168
	Sub	200			70	70	70	32
	NTW	100			10	10	10	1
	TCOMM	20			0	0	0	0
	NTCOM	100			10	10	10	1
	HDCC	25			3	3	3	0
	SFTCC	200			18	18	18	20
	Boost	3			0	0	0	0
	Refin	2			0	0	0	0
	NucPr	5			0	0	0	0
	Supp	100			10	10	10	1
	Assbly	200			149	149	149	40
	Defin	100			20	20	20	10
Soc/ Econ	Food	500			500	500	500	500
	Power	350			35	35	35	35
	NDef	400			400	400	400	40
	People	1000			1000	1000	1000	1000
	Trans	800			160	160	160	160
Ldr	HdLdr	25			1	1	1	1
	SftLdr	100			91	91	91	91

Table 5.5

Surviving Targets in Case 3b

	Target Type	# of Tgts	Force used					
			I	II	III	IV	V	VI
Mil	Silo	1000	107	107	83	104	89	872
	Sub	700	125	700	85	69	85	455
	NTW	160	23	160	6	3	3	38
	TCOMM	1100	155	950	127	41	139	958
	NTCOM	1000	1000	864	240	173	960	1000
	HDCC	90	1	9	0	0	1	60
	SFTCC	600	294	600	144	87	124	600
	Base	500	500	500	460	120	500	500
	Port	10	0	1	0	0	0	7
	Space	3	0	0	0	0	0	0
Soc/ Econ	Supp	600	528	529	74	72	87	600
	Rsrc	150	150	150	36	36	150	150
	Defin	700	700	700	700	700	700	700
	Food	1000	1000	1000	1000	1000	1000	1000
	Power	1800	900	1007	900	900	900	1800
	NDef	1000	1000	1000	1000	1000	1000	1000
	People	700	700	700	700	700	700	700
	Trans	1200	1200	1200	1200	366	1200	1200
Ldr	HdLdr	90	1	8	1	1	1	9
	SftLdr	300	300	300	271	275	275	300

Utility of Conventional Weapons

Precision conventional weapons played a significant role in the various scenarios. Using Forces III, IV, and V, the conventional weapons accounted for 47% of the value damage expectancy against the Case 1 target set. With the enhanced conventional weapon set of Force VI, 50% value damage expectancy was achieved. Upon preliminary examination, it appeared that the additional weapons had caused a significant increase in value expectancy damage levels. However, in light of the uncertainties inherent in damage expectancy factors such as probability to penetrate, weapon system reliability, etc..., this small difference (3%) between value damage expectancies cannot be considered meaningful.

The high amount of damage achieved from conventional weapons alone in each of the model runs can be attributed to the following obvious observation. When a weapon set consists of both nuclear and precision conventional munitions, whatever is available in abundance will account for the greatest amount of damage. Furthermore, weapons will be employed against targets that offer the highest probability of kill. As mentioned previously, accuracy and explosive yield greatly influence probability of kill. Within the conventional weapons, iron bombs were most effective against soft area targets such as troop concentrations, transportation targets (rail yards, transshipment points, etc...) and soft communications complexes.

Table 5.6 presents a breakdown of value damage by weapon type for Case 1. Note that Force VI's downloaded submarines were only able to achieve a small (4%) value damage level against the combined Commonwealth. This may be explained by reviewing the specific weapon allocations. As noted previously, the same allocation controls were specified for both the conventional and nuclear strikes in Cases 3a and 3b. In the Case 1, Force VI combination, it appears that these allocation controls forced a significantly larger percentage of available weapons against relatively low value targets such as military sites and power generating stations, leaving few available weapons for use against higher value targets. In weapon poor/target rich scenarios such as this, allocation controls may produce suboptimal results. Also, relatively poor submarine launched weapon accuracies lowered SLBM effectiveness againt the many point targets.

Table 5.6

Value Damage Expectancy (VDE) Contributed by Conventional and Nuclear Forces-Case 1

Case 1 VDE due to:	**Force Used**					
	I	**II**	**III**	**IV**	**V**	**VI**
Conventional	n/a	n/a	47%	47%	47%	50%
Nuclear	82%	68%	37%	45%	35%	4%
TOTAL VDE	82%	68%	84%	92%	82%	54%

Table 5.7 shows the value damage achieved by conventional forces in Case 2. Forces III, IV, V all contain an identical mixture of conventional weapons which explains the common result of 81%.

Table 5.7

Value Damage Expectancy (VDE) Contributed by Conventional Forces-Case 2

Case 2 VDE due to:	**Force Used**					
	I	**II**	**III**	**IV**	**V**	**VI**
Conventional	n/a	n/a	81%	81%	81%	89%
TOTAL VDE	n/a	n/a	81%	81%	81%	89%

Table 5.8 shows the results obtained during the multiple exchange scenario of Case 3. Table entries in the row for Case 3a refer to value damage against a single Commonwealth State. Entries in the row for Case 3b refer to value damage against a target set which consists of surviving targets from Case 3a and those targets deemed part of the other two Commonwealth states. These values are **not** additive; instead they should be considered only in light of the particular application (i.e. Case 3a <u>or</u> Case 3b). Also there is little difference (9%) between Forces III, IV, and V. The next section discusses how an analyst might view value damage already achieved in an initial exchange should escalation occur and a second exchange appear imminent. This information would be of interest to an analyst using a value damage expectancy methodology to study multiple exchange scenarios.

Table 5.8

Value Damage Expectancy (VDE) Contributed by Conventional and Nuclear Forces-Case 3

Case 3 VDE due to:	**Force Used**					
	I	**II**	**III**	**IV**	**V**	**VI**
Case 3a: (Single Commonwealth State)	50%	50%	50%	50%	50%	50%
Case 3b: (Entire Commonwealth)	66%	42%	77%	82%	73%	25%

Dynamic Target Valuation

Dynamic target valuation in response to changing decision maker priorities and preferences is demonstrated in Case 3. Case 3 is restated below:

> **Case 3.** NCA orders an escalation control counterforce strike against one commonwealth state. If available, conventional weapons will be used exclusively. Unfortunately, the situation escalated into a full scale counterforce/ countervalue exchange involving all commonwealth states.

In this scenario, initially a counterforce strike is used to "disarm" the errant commonwealth state. Consequently, military targets are heavily weighted, receiving 16,000 of the 20,000 total points assigned. This allocation produces high value damage expectancies as well as satisfying the specified constraints (hedges). However, once the scenario escalates to include the entire commonwealth, a revised target base is created, and new weightings are assigned to the various major target categories. Since the war now becomes a combined counterforce/countervalue exchange, only 12,000 of the 20,000 total points are assigned against the military category. Emphasis on leadership category targets has doubled from 3000 points to 6000 points in Case 3b.

Interestingly, the high value damage levels achieved against a single commonwealth state in the counterforce strike will appear less significant (i.e. smaller) when considering the entire commonwealth's target set. This is due to the revised target category weightings and is best illustrated with a specific example.

Using Force VI, 50% value damage expectancy was achieved against the single commonwealth state; however, once the revised and enlarged target set for the entire commonwealth was created only approximately 10% value damage had (in effect) resulted from the first strike. There are two reasons for this apparent contradiction. First, a relatively smaller percentage of targets had been destroyed when the target set is essentially tripled in size. Secondly, changing target values in the transition from a strict counterforce strike to a combined counterforce/countervalue strike means that most of the destroyed targets now have a lower individual value. In the case under consideration, only a 25% value damage level was achieved in the multiple exchange, thereby illustrating the effects of changing target values. In any multiple exchange scenario, separating the effects will be critical in reporting and interpreting results.

Marginal Returns

Since the Arsenal Exchange Model is actually a linear programming tool, model output provides information about the dual variables. These dual variables provide an analyst the opportunity to study marginal returns by weapon type with a narrow range about the value in question. Figure 5.2 graphically illustrates the meaning of dual variables.

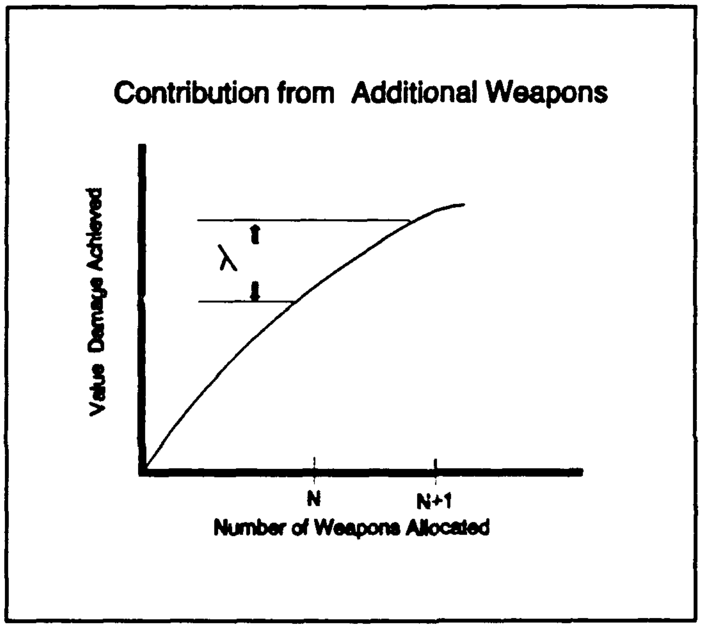


Figure 5.2. Marginal Returns (AEM dual variables)

For illustration we will again examine Force VI as used in Case 1. The results reveal that the dual variables for Poseidon and Trident SLBMs are 35.9 and 86.1, respectively. Interpreting this, an analyst can infer that 10 additional Poseidon warheads would likely produce an increase of approximately 360 points in total value damage expectancy.

By examining all the dual variables from a particular run, an analyst can make a determination about which weapons are contributing the most (or the least). For example, the dual variables for Iron bombs in Case 1, Force VI was a meager 2.5, as contrasted with 8.9, 8.9, and 15.6 marginal value points for the precision guided munitions, laser glide bombs, B-52 cruise missiles, and Tomahawk cruise missiles.

Summary

This chapter reviewed allocation results from the various combinations of forces and scenarios, discussed the utility of conventional weapons in strategic roles, considered dynamic target valuation, and explained marginal returns. The next chapter presents conclusions and recommendations.

VI. Conclusions and Recommendations

Introduction

This thesis reviewed literature on deterrence, strategic targeting, and force modeling, developed a methodology to evaluate combined nuclear and conventional strategic forces under varying decision maker preferences in the post-Soviet era and demonstrated that methodology using the Arsenal Exchange Model. Applying a value damage expectancy measure of effectiveness, the methodology was used to examine several dramatically different strategic force structures and target valuation schemes to see if minimum levels of deterrence could be satisfied. This chapter considers future threats to U.S. national security, important distinctions between deterrence and warfighting, strategic force mixes, active defenses, and recommends further areas to study.

Future Threats to United States Security

Although the Soviet threat has all but disappeared, the United States stills needs a strong, flexible military in order to quickly react to National Command Authority directives. The Department of Defense has postulated some possible scenarios that might face the United States in the future. They include (28:31):

- An even bigger war with a rearmed, more aggressive Iraq.
- War with a nuclear-armed North Korea.

- War with Iraq and North Korea simultaneously.

- War between Russia and NATO sparked when a new, authoritarian regime in Russia tries to re-establish dominance over republics of the former Soviet Union, particularly the Baltic states.

- A Filipino revolution in which several hundred Americans are seized as hostages and 5,000 other American civilians there are threatened.

- Chaos in Panama when the national police force and the Panamanian Defense Force join with narco-terrorists and threaten to seize the Panama Canal.

- A new Soviet-like threat arises when a nation or coalition of nations threatens U.S. interests on a global scale.

Because of instability in many parts of the world there could be little advance notice of an impending crisis or war. Therefore, U.S. strategic forces must be kept in high states of readiness and be capable of rapid, clandestine deployment from the United States to forward operating locations. Because of foreign basing limitations with respect to nuclear weapons, conventional weapons are far better suited for this deployment. It is likely that nearly any country where the United States had a military presence would support such a deployment.

The threat of a damaging military response must be forcefully and clearly delivered to potential opponents. Unless the U.S. leadership can effectively communicate a <u>willingness</u> to use military force (i.e. deterrence) to foreign leaders, it may become necessary to actually <u>demonstrate</u> a military capability. Again, this can be done much more easily with conventional weapons.

Nuclear Proliferation. It has been reported by a former director of the Central Intelligence Agency that "15 or more nations, many from the developing world, could possess nuclear weapons in the next century" (5:66). This possibility makes it important for the U.S. to create a force structure capable of deterring those developing nations acquiring such weapons of mass destruction. While most such countries recognize that the U.S. possesses a strong military capability, it is doubtful that they would perceive nuclear forces alone as a basis for credible deterrence against them.

More than ever, the United Nations is now in a strong position to communicate and enforce a "no nuclear proliferation" policy against its member states. It will be far easier militarily and cheaper politically to disarm states in the very early stages of nuclear armament. As was demonstrated in the Persian Gulf War, precision guided conventional munitions are well suited for this type of mission. Without a clear signal to the contrary, an increasing number of Third World countries will seek to obtain the status that a nuclear capability offers. Should that happen, regional conflicts could easily escalate into full scale wars. Additionally, the radioactive fallout from nuclear weapon bursts in one geographic area is capable of literally travelling around the globe, endangering millions of people. In the arena of nuclear warfare, "regional" may be a term with little practical meaning.

Deterrence versus Warfighting

Cimbala notes that historically scholars have treated deterrence and warfighting as separate issues. As a result, during periods when the United States had large arsenals, it often lacked credibility concerning the use of nuclear weapons because political will wavered (7:36). Additionally, there were numerous situations where it was clear that nuclear weapons would not be used. That weakened deterrence. However, visibly incorporating conventional weapons into the U.S. strategic arsenal will greatly increase deterrence, especially among the Third World countries, because virtually all world leaders recognize that the U.S. could employ conventional weapons with minimal political fallout. This was effectively demonstrated in the recent Persian Gulf War.

In the U.S. form of government, civilian leadership changes frequently. With each leadership change comes new, and often radically different, views of national defense policy and how military forces can and should be employed. The question of "How should political policy be mated to U.S. military options?" (6:36) remains a difficult one to answer. Perhaps the best that the military can accomplish is to build great flexibility into the current and future military force structures while at the same time keeping close contact with the values and preferences of the civilian leadership. Highly accurate precision guided munitions are inherently flexible weapons because they can be employed with minimal risk of collateral damage.

Finding the Right Strategic Weapon Mix

As Jordan notes, "it is possible to specify an optimal force that maximizes or minimizes some important measure subject to specific damage goals" (11:46). While it may not be possible to satisfy all decision maker preferences such as total system costs, number of warheads, high survivability to enemy attack, etc..., a target valuation scheme such as that proposed here is useful in analyzing the effectiveness of a particular force structure.

It will likely remain important for the U.S. to have a prompt hard target kill capability. Without that capability, an adversary might correctly perceive that a large number of his hardened missile silos and command bunkers were invulnerable in the important early hours of an exchange. This analysis effort indicates that whichever weapon mix is selected for U.S. strategic forces, it should contain prompt, accurate nuclear weapons. Given current weapon capabilities and vulnerabilities, a full TRIAD, even if it has a downloaded and reduced ICBM leg, would be highly successful in achieving large value damage expectancy levels.

Limitations of Nuclear Weapons. There are clearly some situations where the U.S. would not use nuclear weapons. For example, it is implausible to think that the U.S. would employ nuclear weapons against a conventionally equipped force in the Middle East. As a result, nuclear weapons have little or no deterrent value against such a country. While nuclear weapons are not likely to be used against a Third World country without that country first breaking the nuclear threshold, they do hold value primarily as a U.S. status symbol. In Gray's words nuclear weapons are:

> not instruments of military decision in war...Strategic nuclear forces can accomplish a great deal, but they cannot reliably win wars against enemies who are similarly equipped (37:55)

Reed further argues that the United States "must keep nuclear weapons to protect its fundamental interests...including a healthy and growing U.S. economy" (34:13). This claim about the economic value of nuclear weapons seems implausible. However, it does seem clear that world opinion about the United States as a superpower is shaped to a certain extent by the size of its nuclear arsenal.

Utility of Conventional Weapons. Conventional weapons placed in a strategic role can contribute greatly toward a more credible U.S. deterrent. In comparing the relative values of nuclear and conventional weapons, Powell says:

> I think there is far less utility to these [nuclear] weapons than some Third World countries think there is. What they hope to do militarily with weapons of mass destruction I can increasingly do with conventional weapons and far more effectively. (2:38)

When precision guided conventional weapons are mated with long range delivery systems such as the B-52 bomber and nuclear powered submarines, they become effective substitutes for nuclear weapons when employed against point targets. This concept was aptly demonstrated in the recent Persian Gulf War when 2000 pound laser glide bombs were successfully used against hardened underground targets such as command bunkers.

Active Defenses. Active defenses are defined as those measures taken to intercept, deflect, destroy, or otherwise render ineffective incoming enemy weapons prior to their detonation. Most active defense systems are in the form of land based interceptors such as antiballistic missile systems, air defense artillery batteries, and fighters. However, active defenses might also be space based systems such as the proposed "star wars" strategic defense initiative.

In the past, active defenses have been viewed by United States and Soviet arms controllers primarily as force multipliers in the sense that an opponent had to dedicate more weapons against a defended target. This meant that additional weapons were needed to achieve the same level of damage against an enemy target base. Therefore, active defenses tended to fuel the arms race with each side scrambling to match the other's advances. For this reason, the U.S. had previously resisted the building of such defensive systems. That reluctance officially ended (1991) with Congress approving a potentially 100 billion dollar missile defense system to be stationed at Grand Forks AFB, ND. The system would be capable of not only intercepting missiles from the Soviet land mass but also those fired from Third World countries (38:F5).

Active defenses appear to have bipartisan support in Congress. According to Aspin, as reported by Canan, the: (11:14)

> enormous changes in the military dangers we face are forcing a basic realignment in the way we think about defenses. We are increasingly likely to face adversaries who are not deterred by the possibility of terrible retaliation. That means ballistic missile defenses look more attractive in this new world...

Correll feels that "We should regard active defenses as complementing deterrence, not competing with it" (11:6). This would seem especially true when one considers the possibility that many terrorist groups or Third World countries might reasonably believe that the United States could be attacked in a secretive fashion that would take hours or days to figure out.

Conclusions

Conventional weapons can play a vital deterrent role in any reduced nuclear arms environment of the future. Because conventional weapons likelihood of use is much greater (i.e. lower political threshold) they can actually enhance deterrence. This occurs because the conventional weapons threshold of use is lower and their probability of use is higher.

From the analysis performed, it is clear that moderately reduced target bases, coupled with greatly reduced weapon sets, will force a change in current targeting practices. The future strategic situation might well be described as target rich, weapon poor. Therefore, countervalue targeting objectives will become increasingly difficult to meet as nuclear weapons levels decrease further. That unfavorable trend could be slowed or even halted by the inclusion of approximately 2000 precision guided conventional munitions in the U.S. strategic arsenal.

Probability to penetrate will continue to play an important role in achieving high levels of damage expectancy when employing fighter delivered conventional weapons. Because laser glide bombs have a relatively short delivery standoff range of 1 - 40 miles, the aircraft must penetrate deeply into enemy held terrority and may be exposed to terminal defenses. Iron bombs have an even shorter delivery standoff range which would likely expose the carrier to most terminal defenses. This system characteristic makes probability of arrival the more uncertain element in any damage expectancy calculation performed.

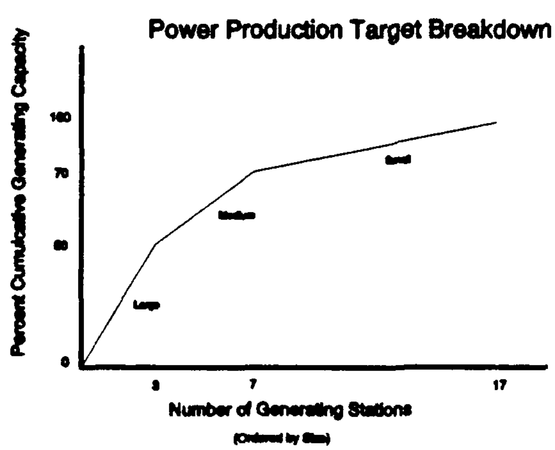
Recommendations for Further Study

A number of further related areas merit research. First, actual classified databases of U.S. weapons and enemy target sets should be used to see whether similar results could be obtained with real world data. An analyst could obtain classified data on strategic forces and enemy target sets from either the Air Force Center for Studies and Analysis at the Pentagon or the Joint Strategic Planning Staff at Offutt AFB, Nebraska. Further analysis could be done using the B-2 bombers stealth characteristics to see how much improvement might result from replacing aging B-52s.

This thesis equally weighted all targets in a particular catergory. For example, no effort was made to separate silo targets into subsets according to number of warheads. Clearly though, silos might have different target values.

Further analysis could be done using a Pareto type target analysis which might help an analyst more accurately assign target values. An example, using electric power production facilities, effectively illustrates this concept (31).

If intelligence estimates were available describing not only the number of power plants, but also their relative outputs, then an analyst could construct a plot of electric power production capacity versus number of generating stations. Note that the plot is nonlinear due to differing plant capacities. However, within the "small", "medium", and "large" sections of the plot, curves are piecewise linear. This plot might resemble Figure 6.1.



(31)
Figure 6.1. Power Production Plot

From this plot, a more detailed target tree could be constructed. Figure 6.2a illustrates the target valuation method used in this thesis. Figure 6.2b illustrates how a revised target tree section for power targets might appear. Note that this proposed method results in varying target values being assigned which may be more appropriate to power plant size.

		Number of Targets	Points per Target
Power 1000 pts	All sizes	17	58.82

Figure 6.2a. Target Set Without Subdivision

		Number of Targets	Points per Target
Power 1000 pts	0.5 Large	3	166.67
	0.3 Medium	4	75.00
	0.2 Small	10	20.00

(31)

Figure 6.2b. Target Set With Subdivision

Clearly this proposed target weighting scheme would force weapon allocations that were more appropriate to the real world target base composition. Additionally, an analyst would have more detailed results from which to examine model allocations.

A standardized DOD wide target valuation system for determining the value of individual targets is not currently available. By developing such a system, future force analysis using a target valuation scheme may be much easier. In depth work should be done on dynamic target values to assess how certain enemy assets might change importance over the course of a battle. Also, careful analysis of allocation constraints (hedges) needs to be done to ensure that only the minimum number necessary are used. Overconstraining a problem can lead to suboptimization and in a weapon poor/target rich environment, negate the usefulness of a target valuation system.

Various measures of effectiveness outside those mentioned in Chapter II merit study in light of the current budgetary and political environment. Typically, politically charged measures of effectiveness such as total cost and total number of nuclear weapons carry greater weight during congressional testimony and often become prime drivers in determining force structure. Therefore it may be necessary for the DOD to justify force structure decisions based on cost effectiveness.

This thesis does not consider the effects that any space based or terminal defenses might have on deterrence. Further work is clearly needed in this area since it appears that strategic defense systems are quite likely to be part of any future U.S. force structure (37:49), (38:F5). Such a system may dramatically alter, or even nullify, the effectiveness of various strategic weapon systems.

There are some analysts who feel that a launch on warning policy may not be viable (8:29). Since there are differing views on this topic, it may be prudent to conduct additional analysis on U.S. force survivability and retaliatory capability.

Summary

Deterrence is often viewed as the product of two factors, military capability and national will. The recent Persian Gulf War effectively demonstrated the former. Current and future leaders must be careful to explicitly communicate the latter to our adversaries.

In the final analysis of an international crisis, it may be the method in which American leaders first handle the crisis that is crucial to its successful resolution. In the United States political system it is the president who serves as chief communicator with other nations:

> In a discussion about who creates perceptions, there was a consensus that the President is the single most important articulator of American national will and an important contributor to creating American self-perceptions. ...When there is an abdication or even a brief delay of government policy choice, then the mass media enter the breach, structure the issues, and force choices in an artificial manner which may be contrary to the interests of the states involved. (26:197)

It is therefore crucial that he avoid the common errors of perception discussed in Chapter Two and demonstrate, clearly and convincingly, that the United States has the firm resolve to employ its strategic arsenal. Successfully communicating that resolve will remain an indispensable element of deterrence.

Should negotiations fail to resolve a crisis prior to the onset of military action, it is crucial that the United States strategic forces be brought to bear swiftly and effectively. In the reduced nuclear arms environment that the United States will soon face, precision guided conventional weapons must be incorporated into the Single Integrated Operational Plan. The Persian Gulf War has unequivocally proven their value.

Appendix A: Glossary of Technical Terms

Certain terms are used in this thesis which require precise definition in order to avoid misunderstandings.

Arsenal Exchange Model (AEM): "An aggregated, two sided strategic exchange model with a diverse set of scenarios and analyst controls. It simulates a nuclear exchange by allocating weapons to specified targets, while satisfying prioritized objectives and maximizing damage expectancy. Designed for many uses, including Arms Control Analysis." (36:2-10)

Arms Race Stability: "A measure of our ability to control and limit the proliferation of nuclear weapons, as well as our ability to control and limit arms initiatives that may undermine crisis and/or deterrence stability." (33:18)

Counterforce (CF): "Employment of strategic air and missile forces to destroy, or render impotent, the opponent's military forces and war making potential to achieve victory. Bombers and their bases, ballistic missile submarines, ICBM silos, control centers, and weapon storage areas are examples of counterforce targets." (36:2-10)

Counter Military Potential (CMP): Index of explosive power of a weapon and expected delivery accuracy. (36:2-10)

Countervalue (CV): The employment of weapons against enemy population centers, industries, agricultural centers, and other "civilian" targets.

Damage Expectancy (DE): The cumulative probability of damage to a target which is computed to account for the product of Probability of Arrival, the Probability of Launch Survival, Weapon System Reliability, Probability to Penetrate, and the Probability of Damage. (36:2-10)

Deterrence: The prevention from action by fear of the consequences. The goal of deterrence is to create, in an opponent's mind, a credible threat that actions promised will in fact occur if certain triggering criteria are violated.

Deterrence Stability: "A measure of our ability to control escalation, maintain intrawar deterrence, and successfully conduct war termination efforts." (33:18)

Downloading: The process of reducing the number of warheads on a system. Downloading may be partial or complete. For example a ten warhead system might be downloaded to either a three or one warhead system.

Equivalent Megatonnage (EMT): "Measure of the relative capability of effectiveness compared with a 1 MT weapon's capability to cover a large target with stated lethal overpressure. EMT calculation normalizes the region of lethal overpressure effects and sums the normalized results over the entire set of weapons in an arsenal." (36:2-11)

Expected Value Destroyed: "The expected number of targets destroyed in a nuclear attack, with each target weighted by a 'value' index." (36:2-11)

Multiple Independently Targetable Reentry Vehicle (MIRV): Usually used in reference to a missile with more than one warhead. (For example, a MIRVed Peacekeeper missile which might carry up to ten warheads.)

Nuclear Parity: A condition at a given point in time when opposing forces possess nuclear offensive and defensive systems approximately equal in overall combat effectiveness. (37)

Single Integrated Operational Plan (SIOP): A contingency plan directing the wartime use of United States nuclear forces. Constructed and managed by the Joint Strategic Target and Planning Staff at Offutt AFB, NE.

Stability: "If both sides perceive a set of conditions such that neither could gain an advantage in attacking the other, the situation is stable." The situation where one side either perceives an advantage from attacking first, or fears that a delay in attack will be result in greater damage to itself would be considered highly instable. (36:2-8)

Tactical Warning: A short notice warning after initiation of hostilities. In the tactical warning situation, an attack may be underway, yet warheads may not have yet impacted.

TRIAD: "The mix of U.S. nuclear delivery systems: Bombers, ICBMs,and SLBMs. As a concept, the TRIAD justifies the three differing components of strategic forces as protection against failure of any one leg." (36:2-13)

VNTK: Index of target hardness. "It is a three part index. First there is a vulnerability factor (VN) in pounds per square inch for susceptibility of a target hit by a 20 kiloton weapon. Second, the type of target (T) is represented by L,M,N,O, or P for an overpressure target (crushable buried target) or by Q,R,S,T, or U for a dynamic pressure target (wind damaged above ground target). Third, the ductility factor (K) shows vulnerability to yield size by representing brittleness, a function of pulse duration." (36:2-13)

Yield: Explosive power of a nuclear weapon.

Appendix B: Soviet Arms Control Violations

Soviet Arms Control Compliance

The success of any arms control agreement depends on the willingness of all parties to comply. While popular rhetoric among peace groups is that any reduction in superpower arsenals makes the world a safer place, knowledgeable military and political leaders realize full well that instability can directly result from hasty reductions. This is especially true if one side does not abide by the treaty dictates.

There have been numerous arms control agreements in the past that the Soviets violated, either in spirit or letter. (Of course the Soviets might not agree with United States' assertions that these actions constitute violations.) Table 1 contains a list of suspected and actual violations.

Table 1
Potential, Probable or Actual Violations of SALT

1. Krasnoyarsk Radar (Actual Violation)
2. Mobility of ABM System Components (Potential Violation)
3. Concurrent Testing of ABM and Air Defense Components (Probable Violation)
4. Development of More than One New Type ICBM (Actual Violation)
5. Strategic Nuclear Delivery Vehicle Limits (Actual Violation)
6. SS-16 ICBM Deployment (Probable Violation)
7. Encryption of Ballistic Telemetry (Actual Violation)
8. Concealment of Association between an ICBM and its Launcher (Actual Violation)
9. Use of "Remaining Facilities" at Former SS-7 Sites (Actual Violation)

extracted from (19:52)

Apparently Soviet compliance with arms control agreements occurred only when the compliance did not complicate the Moscow war plan. Table 2 clearly demonstrates how the Soviets most often violated arms control agreements terms proposed by the United States. Table 2 shows who proposed the treaty terms which were violation.

Table 2
Potentially Violated Provisions of the SALT Agreements Correlated With Who First Proposed Them in the Original Negotiations

Provision	Proposing Side
1. Restrictions of Large Phased Array Radars	U.S.
2. Ban on Mobile ABM Components	U.S.
3. Ban on Concurrent Testing of ABM and Air Defense Components	U.S.
4. Development of More than One Type ICBM	U.S.
5. Strategic Nuclear Delivery Vehicle Limits	USSR
6. Ban on SS-16 ICBM Deployment	U.S.
7. Encryption of Ballistic Missile Telemetry	U.S.
8. Ban on Concealment of Association between an ICBM and its Launcher	U.S.
9. Ban on Use of "Remaining Facilities" at Former SS-7 Sites	U.S.

adapted from (19:53)

This information has been included since the newly formed Commonwealth of Independent States arms control negotiating team will likely be made up of former Soviet officials for the near term. Furthermore, until the Commonwealth establishes a separate compliance record, the best information available to the West will be the Soviet's performance record.

Appendix C: Arsenal Exchange Model Input Code for Case 1, Weapon Set VI

```
C                                   McCormick Thesis, 1992
C
C******************UNCLASSIFIED*************************
C
C Test case 16a -  US Downloaded/Sub only with enhanced conventional)
C  (US has a counterforce/countervalue exchange with entire
C   commonwealth)
C
C   This run contains conventional strike scenario.
C
C*******US conventional weapons in strategic role
C
%w name,    number,   whpc
 lgb        100       1
 ccm        346       8
 Thawk      350       1
 iron       1000      1
%
C
C Notional commonwealth 1 target base (20000 pts)
C
C  Military        -  .4
C  Soc/Econ        -  .2
C  Leadership      -  .4
C
%t name,   number,  value
  silo      1000     .77
  sslbm      700     .73
  ntw        160     2.0
  tcom      1100     2.09
  ntcom     1000      .58
  hdcc        90    16.0
  sftcc      600      .8
  base       500     1.5
  port        10     20.0
  space        3    133.0
  suppl      600      .93
  rsrc       150      .53
  defin      700      .23
  food      1000      .24
  power     1800      .80
  ndef      1000      .72
  peopl      700      .69
  trans     1200      .93
  hdldr       90    71.11
  sldr       300     5.33
 %
 wcname= precision, gravity,allwpn,
 precision=1-3,gravity=4,allwpn=1-4,
 %
 C
 tcname=mil,comm,ldr,pwr,alltgt,
 mil=1-3,comm=4-5,ldr=19-20,pwr=15,alltgt=1-20,
```

```
C
C Damage expectancy information for various weapon/target combos.
C      (values represent DE = PSSK * PA)
%
C
READPT=1,
P(1,1)=.25,
P(2,1)=.50,
P(3,1)=.90,
P(4,1)=.80,
P(5,1)=.90,
P(6,1)=.85,
P(7,1)=.90,
P(8,1)=.80,
P(9,1)=.90,
P(10,1)=.90,
P(11,1)=.90,
P(12,1)=.90,
P(13,1)=.90,
P(14,1)=.95,
P(15,1)=.90,
P(16,1)=.90,
P(17,1)=.95,
P(18,1)=.90,
P(19,1)=.85,
P(20,1)=.90,

C
C
P(1,2)=.25,
P(2,2)=.60,
P(3,2)=.90,
P(4,2)=.80,
P(5,2)=.90,
P(6,2)=.85,
P(7,2)=.90,
P(8,2)=.85,
P(9,2)=.90,
P(10,2)=.95
P(11,2)=.90
P(12,2)=.90
P(13,2)=.90
P(14,2)=.96
P(15,2)=.90
P(16,2)=.90
P(17,2)=.95
P(18,2)=.90
P(19,2)=.80
P(20,2)=.90
```

```
C
P(1,3)=.40,
P(2,3)=.65,
P(3,3)=.80,
P(4,3)=.80,
P(5,3)=.90,
P(6,3)=.88,
P(7,3)=.92,
P(8,3)=.85,
P(9,3)=.90,
P(10,3)=.95,
P(11,3)=.90,
P(12,3)=.90,
P(13,3)=.90,
P(14,3)=.95,
P(15,3)=.90,
P(16,3)=.90,
P(17,3)=.95,
P(18,3)=.90,
P(19,3)=.80,
P(20,3)=.92,
C
C
P(1,4)=.01,
P(2,4)=.20,
P(3,4)=.10,
P(4,4)=.20,
P(5,4)=.25,
P(6,4)=.25,
P(7,4)=.10,
P(8,4)=.25,
P(9,4)=.10,
P(10,4)=.25,
P(11,4)=.50,
P(12,4)=.80,
P(13,4)=.50,
P(14,4)=.80,
P(15,4)=.11,
P(16,4)=.50,
P(17,4)=.80,
P(18,4)=.80,
P(19,4)=.11,
P(20,4)=.11,

C The following hedges are used to ensure that US NCA
C objectives are met.
C
Hedge(1)=Value destroyed on (mil) by (allwpn) must be GE.7
Hedge(2)=Value destroyed on (silo) by (allwpn) must be GE.9
Hedge(3)=Value destroyed on (ldr) by (allwpn) must be LE.8
Hedge(4)=Value destroyed on (alltgt)by(allwpn)must be GE.6
C
C*************************UNCLASSIFIED**********************
%end
```

```
C                              McCormick Thesis, 1992
C
C*******************UNCLASSIFIED*************************
C
C Test case 16b -  US Forces Downloaded/sub only with conventional)
C  (US has a counterforce/countervalue exchange with entire
C   commonwealth)
C
C   This run contains nuclear strike scenario.
C
C*******US conventional weapons in strategic role
C            nuclear strike for phase II

%w name, number, whpc,  cep, yield, jtype, rl, ptp, av
Posie    200      1    1500   .04     2     .8  .95  .8
Trid     240      1     400   .1      2     .9  .95  .8

%
C
C Remaining Notional commonwealth 1 target base (Balance of 20000 pts)
C
C  Military        -   .4
C  Soc/Econ        -   .2
C  Leadership      -   .4
C
%t name,  number,  value
silo      575     .77
sslbm     534     .73
ntw        16     2.0
tcom      220     2.09
ntcom    1000      .58
hdcc        2    16.0
sftcc     600      .8
base      454     1.5
port        0    20.0
space       0    133.0
suppl     600      .93
rsrc      150      .53
defin     700      .23
food     1000      .24
power    1800      .80
ndef     1000      .72
peopl     700      .69
trans    1200      .93
hdldr      13    71.11
sldr      300     5.33
%
C
C  Target Hardness in psi follows
C
HARD(1,2)=250,30,5,3,3,20,3,5,5,3,3,3,5,3,10,3,3,4,30,5,
%
C
wcname= ICBM,SLBM,Bomber,missile,allwpn,
SLBM=1-2,missile=1-2,allwpn=1-2,
```

```
%
C
tcname=time_urgent,comm,hard_tgt,ldr,pwr,alltgt,
time_urgent=1-2,comm=4-5,ldr=19-20,pwr=15,alltgt=1-20,
C
%
C
C The following hedges are used to ensure that US NCA objectives
C are met.
C
Hedge(1)=Value destroyed on (silo) by (missile) must be GE.5
Hedge(2)=Tgts covered of type(time_urgent)by(allwpn) must be GE.8,
C
C************************UNCLASSIFIED*********************
%end
```

Appendix D: Arsenal Exchange Model Weapon to Target Allocations

This Appendix contains specific weapon to target allocations for all model runs performed during this thesis effort. Information has been extracted from AEM report R-12, Compressed Strategy Summary.

Following is a key (listed in the order of use) of the target category abbreviations.

SILO	-	ICBM Silo
SUB	-	SLBM Bunker
NTW	-	Non Time Sensitive Weapons
TCOM	-	Time Sensitive Communications
NTCOM	-	Non Time Sensitive Communications
HDCC	-	Hard Control Centers
SFTCC	-	Soft Control Centers
BASE	-	Army/Air Force Bases
PORT	-	Naval Bases
SPACE	-	Space Launching/Tracking Facilities
SUPPLY	-	Depot Storage Facilities
RSRC	-	Military Resources
DEFIN	-	Defense Related Industries
FOOD	-	Agriculture/Food Processing Facilities
POWER	-	Electrical Power Production Facilities
NDEF	-	NonDefense Industries
PEOPLE	-	Military Reserve Units
TRANS	-	Transportation Services
HDLDR	-	Hard Leadership Bunkers
SFTLDR	-	Soft Leadership Bunkers

Case 1, Force I (nuclear)

Target	#	DE	MM2	MM3	MM3A	PKPR	POSIE	TRID	B52	ALCM	B1B
SILO	405	.72	1								
SILO	595	.72					1				
SUB	400	.72					1				
NTW	110	.81								1	
TCOM	736	.81			1						
TCOM	364	.90				1					
NTCOM	894	.42							1		
HDCC	33	.99				2					
SFTCC	600	.81								1	
PORT	10	.99				2					
SPACE	3	1.0								4	
SUPPLY	554	.81						1			
SUPPLY	46	.81								1	
POWER	823	.72					1				
POWER	74	.81			1						
POWER	903	.81						1			
NDEF	540	.72		1							
NDEF	230	.72					1				
NDEF	230	.64									1
PEOPLE	692	.64									1
PEOPLE	9	.42							1		
TRANS	1000	.81						1			
HDLDR	50	.99									3
SFTLDR	200	.96									2

Case 1, Force II (nuclear)

Target	#	DE	MM[illegible]	MM3A	PKPR	TRID	B52	ALCM	B1B
SILO	783	.42					1		
SILO	217	.81						1	
SUB	119	.42					1		
N[illegible]W	110	.64							1
TCOM	1100	.81				1			
HDCC	33	.96						2	
PORT	10	.96						2	
SPACE	3	1.0						4	
SUPPLY	242	.81		1					
SUPPLY	357	.81				1			
POWER	811	.64							1
POWER	180	.72	1						
POWER	750	.81						1	
TRAN	1000	.81				1			
HDLDR	50	.99						3	
SFTLDR	135	.90			1				
SFTLDR	14	.96		2					
SFTLDR	200	.96						2	

Case 1, Force III (conventional)

Target	#	DE	LGB	CCM	THAWK	IRON
NTW	160	.90		1		
TCOM	634	.80		1		
TCOM	260	.80			1	
TCOM	176	.67				5
TCOM	30	.59				4
HDCC	90	.88			1	
PORT	10	.90	1			
PORT	0	.90		1		
SPACE	3	1.0		2		
HDLDR	90	.85	1			

Case 1, Forces IV and V produce identical results.

Case 1, Force III (nuclear)

Target	#	DE	POSIE	TRID	B52	ALCM	B1B
SILO	585	.85		1			
SILO	414	.64					1
SUB	626	.42			1		
SUB	74	.64					1
NTW	16	.85		1			
TCOM	248	.85		1			
HDCC	33	.98		2			
SFTCC	600	.76	1				
BASE	500	.85		1			
PORT	1	.98		2			
SUPPLY	600	.81				1	
POWER	1250	.76	1				
POWER	433	.64					1
POWER	117	.81				1	
NDEF	276	.42			1		
TRANS	199	.76	1				
TRANS	1000	.85		1			
HDLDR	13	1.0		3			
SFTLDR	300	.96				2	

Case 1, Force IV (nuclear)

Target	#	DE	MM2	MM3	MM3A	PKPR	POSIE	TRID	B52	ALCM	B1B
SILO	382	.81								1	
SILO	618	.81			1						
SUB	540	.72		1							
SUB	160	.72	1								
NTW	16	.85						1			
TCOM	148	.90				1					
TCOM	100	.85						1			
NTCOM	843	.42							1		
NTCOM	156	.64									1
HDCC	33	.98						2			
SFTCC	600	.76					1				
BASE	500	.85						1			
PORT	1	.99				2					
SUPPLY	600	.85					1				
RSRC	59	.42							1		
POWER	736	.76					1				
POWER	127	.81			1						
POWER	936	.81								1	
NDEF	712	.76					1				
NDEF	65	.64									1
NDEF	222	.72	1								
PEOPLE	700	.64									1
TRANS	63	.81			1						
HDLDR	13	1.0						3			
SFTLDR	300	.90				1					

Case 1, Force V (nuclear)

Target	#	DE	MM3	MM3A	PKPR	TRID	B52	ALCM	B1B
SILO	414	.42					1		
SILO	585	.85				1			
SUB	359	.42					1		
NTW	16	.85				1			
TCOM	248	.85				1			
HDCC	33	.98				2			
SFTCC	54	.72	1						
BASE	500	.85				1			
PORT	1	.98				2			
SUPPLY	330	.81						1	
SUPPLY	270	.81		1					
POWER	129	.42					1		
POWER	922	.64							1
POWER	126	.72	1						
POWER	624	.81						1	
TRANS	364	.81						1	
TRANS	836	.72				1			
HDLDR	13	1.0				3			
SFTLDR	135	.90			1				
SFTLDR	165	.85				1			

Case 1, Force VI (conventional)

Target	#	DE	LGB	CCM	THAWK	IRON
SILO	5	.44	2			
SILO	350	.40			1	
SILO	645	.44		2		
SUB	127	.36				2
SUB	560	.20				1
SUB	12	.60		1		
NTW	160	.90		1		
TCOM	1100	.80		1		
HDCC	90	.91		2		
BASE	183	.25				1
PORT	10	.99		2		
SPACE	3	1.0		2		
HDLDR	90	.85	1			

Case 1, Force VI (nuclear)

Target	#	DE	POSIE	TRID
Silo	192	.85		1
Silo	147	.17	1	
Hdldr	13	.63	1	

Case 2, Force III (conventional)

Target	#	DE	LGB	CCM	THAWK	IRON
SUB	200	.65			1	
NTW	100	.90		1		
TCOM	15	.99	3			
TCOM	5	.99		3		
NTCOM	100	.90		1		
HDCC	25	.88			1	
SFTCC	125	.92			1	
SFTCC	75	.90		1		
BOOST	3	1.0		3		
REFIN	2	.99	2			
NUCPRO	5	1.0		2		
SUPPLY	100	.90		1		
RSRC	64	.80				1
DEFIN	68	.75				2
DEFIN	32	.90		1		
POWER	350	.90		1		
TRANS	800	.80				1
HDLDR	25	.98	2			
SFTLDR	10	.90		1		

Case 2, Forces IV and V produce identical results.

Case 2, Force VI (conventional)

Target	#	DE	LGB	CCM	THAWK	IRON
SILO	175	.64			2	
SILO	77	.44		2		
SILO	17	.58	3			
SILO	132	.58		3		
SUB	200	.84		2		
NTW	100	.99		2		
TCOM	20	1.0		4		
NTCOM	100	.99		2		
HDCC	25	.98		2		
SFTCC	200	.90		1		
BOOST	3	1.0		3		
REFIN	2	1.0		3		
NUCPR	5	1.0		3		
SUPPLY	100	.99		2		
RSRC	0	.90		1		
RSRC	200	.80				1
DEFIN	100	.90		1		
POWER	350	.90		1		
NDEF	400	.90		1		
TRANS	800	.80				1
HDLDR	25	.98	2			
SFTLDR	10	.90		1		

Case 3a, Force I (nuclear)

Target	#	DE	MM2	MM3	MM3A	PKPR	POSIE	TRID	B52	ALCM	B1B
SILO	207	1.0								6	
SILO	59	1.0		8							
TCOM	10	1.0		7							
TCOM	48	1.0	8								
TCOM	92	1.0									10
HDCC	12	1.0								6	
HDCC	18	1.0				5					
PORT	3	1.0				5					
SPACE	1	1.0				5					
SUPPLY	3	1.0					7				
SUPPLY	68	1.0				5					
HDLDR	30	.72					10				

Case 3b, Force I (nuclear)

Target	#	DE	MM2	MM3	MM3A	PKPR	POSIE	TRID	B52	ALCM	B1B
SILO	733	.85						1			
SUB	468	.85			1						
SUB	21	.42							1		
SUB	310	.85			1						
NTW	159	.85			1						
TCOM	186	.76					1				
TCOM	764	.85						1			
HDCC	60	.98			2						
SFTCC	443	.42							1		
SFTCC	156	.76					1				
PORT	7	.98			2						
SPACE	2	1.0			3						
POWER	1041	.76					1				
POWER	259	.42							1		
HDLDR	60	.98			2						

Case 3a, Force II (nuclear)

Target	#	DE	MM3	MM3A	PKPR	TRID	B52	ALCM	B1B
SILO	23	1.0	8						
SILO	24	1.0							10
SILO	220	1.0						6	
TCOM	150	1.0				5			
HDCC	30	1.0				5			
PORT	3	1.0						2	
PORT	3	1.0					17		
SPACE	1	1.0				5			
SUPPLY	27	1.0			5				
SUPPLY	38	1.0							10
SUPPLY	6	1.0		5					
HDLDR	30	1.0							10

Case 3b, Force II (nuclear)

Target	#	DE	MM3	MM3A	PKPR	TRID	B52	ALCM	B1B
SILO	732	.85				1			
HDCC	60	.85		1					
PORT	7	.85		1					
SPACE	2	.98		2					
POWER	84	.85		1					
POWER	509	.85				1			
POWER	678	.42					1		
HDLDR	60	.85		1					

Case 3a, Force III (conventional)

Target	#	DE	LGB	CCM	THAWK	IRON
SILO	45	.68		4		
SILO	3	.68	4			
SILO	175	.64			2	
SUB	128	.94		3		
SUB	80	.89				10
SUBM	24	.88		2		
TCOM	177	.80		1		
HDCC	30	.98	2			
PORT	3	.99		2		
SPACE	1	1.0		2		
SUPPLY	200	.50				1

Case 3a, Forces IV and V produce identical results.

Case 3b, Force III (nuclear)

Target	#	DE	POSIE	TRID	B52	ALCM	B1B
SILO	378	.96				2	
SILO	476	.85		1			
SUB	586	.85		1			
NTW	159	.96				2	
TCOM	819	.85		1			
TCOM	139	.94	2				
NTCOM	1000	.76	1				
HDCC	61	.99				3	
SFTCC	600	.76	1				
BASE	63	.64				1	
PORT	7	.99				3	
SPACE	2	1.0				4	
SUPPLY	480	.85		1			
SUPPLY	20	.76	1				
RSRC	150	.76	1				
POWER	902	.42			1		
POWER	813	.64					1
HDLDR	48	.98		2			
HDLDR	16	.96				2	
SFTLDR	45	.64					1

Case 3b, Force IV (nuclear)

Target	#	DE	MM2	MM3	MM3A	PKPR	POSIE	TRID	B52	ALCM	B1B
SILO	450	.90				1					
SILO	404	.85						1			
SUB	183	.94		2							
SUB	403	.85			1						
NTW	159	.98						2			
TCOM	212	.94					2				
TCOM	659	.96								2	
TCOM	87	.94		2							
NTCOM	297	.76					1				
NTCOM	407	.85			1						
NTCOM	296	.85						1			
HDCC	61	1.0						3			
SFTCC	600	.85						1			
BASE	500	.76					1				
PORT	7	1.0						3			
SPACE	2	1.0						4			
SUPPLY	500	.85						1			
RSRC	150	.76					1				
POWER	422	.64									1
POWER	738	.42							1		
TRANS	676	.76					1				
TRANS	106	.42							1		
TRANS	383	.72	1								
HDLDR	64	.98						2			
SFTLDR	59	.42							1		

Case 3b, Force V (nuclear)

Target	#	DE	MM3	MM3A	PKPR	TRID	B52	ALCM	B1B
SILO	135	.90			1				
SILO	446	.85				1			
SILO	273	.96						2	
SUB	587	.85				1			
NTW	149	.98				2			
NTW	10	.98				2			
SFTCC	54	.72		2					
TCOM	958	.85				1			
NTCOM	62	.64							1
HDCC	61	.98		2					
SFTCC	717	.64							1
SFTCC	412	.81						1	
SFTCC	180	.76	1						
PORT	7	.99						3	
SPACE	2	1.0						4	
SUPPLY	330	.81						1	
SUPPLY	169	.85				1			
POWER	902	.42					1		
POWER	813	.64							1
HDLDR	64	.98				1			
SFTLDR	39	.64							1

Case 3a, Force VI (conventional)

Target	#	DE	LGB	CCM	THAWK	IRON
SILO	88	.87			4	
SILO	56	.90		8		
SUB	24	1.0				42
SUB	150	1.0		11		
SUB	59	.97		4		
TCOM	90	.80		1		
TCOM	100	.80	1			
HDCC	30	1.0		5		
PORT	3	1.0		4		
SPACE	1	1.0		4		
HDLR	30	1.0		6		

Case 3b, Force VI (nuclear)

Target	#	DE	POSIE	TRID
SUB	130	.85		1
NTW	159	.76	1	
SPACE	1	.94	2	
SPACE	2	.85		1
HDLDR	60	.85		1

Bibliography

1. Auster, Bruce B. "The Arms Race in Reverse", U.S. News & Report, 111: 54 (October 21, 1991).

2. Auster, Bruce and Stephen Badiansky. "Tackling the New Nuclear Arithmetic", U.S. News & Report, 112:38 (January 20, 1992).

3. Batteliga, John and Judith K. Grange, editors. The Military Applications of Modeling. Wright Patterson AFB, OH: Air Force Institute of Technology Press, 1981.

4. Blechman, Barry. U.S. Security in the Twenty-First Century Boulder: Westview Press, 1987.

5. Bluth, Christoph. New Thinking in Soviet Military Policy, New York: Council on Foreign Relations Press, 1990.

6. Boudreau, Donald G. "On Advancing Non-Proliferation," Strategic Review, 19: 61-67 (Summer 1991).

7. Canan, James. "ABMs on the Ascendant," AIR FORCE Magazine, 75: 13-15 (January 1992).

8. Cimbala, Stephen J. "US Strategic Nuclear Deterrence; Technical and Policy Challenges," Air University Review, 38: 24-39 (Jan-Mar 1987).

9. Cimbala, Stephen J. "War-Fighting Deterrence; Forces and Doctrines in U.S. Policy," Air University Review, 34: 36-42 (May-June 1983).

10. Committee on International Security. The Future of the U.S.-Soviet Nuclear Relationship, Washington, D.C.: National Academy Press, 1991.

11. Correll, John T. "Shall We Dump Deterrence?," AIR FORCE Magazine, 75: 6 (January 1992).

12. "Defeat of Iraq Sparks Debate on Which Air Role was Crucial", Aviation Week & Space Technology, 136: 60-65 (January 27, 1992).

13. Drew, Dennis M. Nuclear Winter and National Security: Implications for Future Policy. Maxwell AFB, AL: Air University Press, 1986.

14. Gallagher, Mark A. and Elizabeth J. Kelly, "A New Methodology for Military Force Structure Analysis," Operations Research, 39: 877-885 (November-December 1991).

15. Goure, Daniel. "A New Soviet National Security Policy for the 21st Century," Strategic Review, 17: 36-46 (Fall 1989).

16. Gray, Colin S. "Destination Unknown: From SALT to START," Strategic Review, 19: 32-43 (Spring 1991).

17. Jane's Air Launched Weapons, Alexandria, VA: Jane's Information Group, 1990.

18. Jordan, Brian. A Methodology for START II Analysis. MS thesis, School of Engineering, Air Force Institute of Technology (AU), Wright-Patterson AFB, OH, March 1990.

19. Kartchner, Kerry M. "Soviet Compliance with a START Agreement: Prospects under Gorbachev," Strategic Review, 17: 47-57 (Fall 1989).

20. Kelleher, Catherine McArdle and others editors. Nuclear Deterrence: New Risks, New Opportunities. New York: Pergammons - Brasseys, 1986.

21. Kent, Glenn A. and D.E. Thaler. First-Strike Stability (A Methodology for Evaluating Strategic Forces). Technical Report R-3765-AF, Santa Monica, CA: The Rand Corporation, August 1989.

22. Klare, Michael T. "Who's Arming Who?" Technology Review, 93: 42-50 (May - June 1990).

23. Leary, David A. Optimizing Post-START U.S. Strategic Nuclear Force Mix. MS thesis, Naval Post Graduate School, Monterey, CA, June 1989 (ADA212148).

24. Leopold, George and Barbara Opall. "Air Force Cites 14,000 Mile Raid as Proof of 'Global Reach'", Air Force Times, 52: 17 (3 Feb 92).

25. Lider, Julian. Military Theory. New York: St Martins Press, 1982.

26. Margiotta, Franklin D., editor. Evolving Strategic Realities: Implications for U.S. Policymakers. Washington, DC: National Defense University Press, 1980.

27. Marsh, Gerald. "The Ups and Downs of Downloading", The Bulletin of the Atomic Scientist, 47: 21-23 (November 1991).

28. Matthews, William. "DOD Using War 'Scenarios' to Shape Force". Air Force Times, 52: 31 (March 2, 1992).

29. McCain, John S. III. "Proliferation in the 1990s:Implications for U.S. Policy and Force Planning," Strategic Review, 27: 9-20 (Summer 1989).

30. Morgan, Patrick M. Deterrence: A Conceptual Analysis, Beverly Hills, CA: Sage Publications, 1971.

31. Morlan, Bruce W., 1991-1992. Discussions.

32. Quade, E.S. and W.I. Boucher (editors). System Analysis and Policy Planning Applications in Defense. New York:Elsevier North - Holland Inc, 1977.

33. Reule, Fred J. Dynamic Stability: A New Concept for Deterrence, Maxwell AFB, AL: Air University Press, 1987.

34. Ryan, Randolph. "A Shifting Rationale by the Pentagon on Nuclear Force," Boston Globe, (January 7, 1992).

35. Seiler, George J. Strategic Nuclear Force Requirements and Issues. Maxwell Air Force Base: Air University Press, 1983.

36. Snyder, Capt Nancy M. Incorporating Value Systems in Strategic Force Analysis. MS thesis, AFIT/GST/ENS/91-4. School of Engineering, Air Force Institute of Technology (AU), Wright-Patterson AFB, OH, March 1991.

37. Szafranski, Col Richard. "The Coming Strategic Nuclear Debate," Strategic Review, 19: 54-60 (Summer 1991).

38. Thompson, Mark. "Congress Gives Go-Ahead to Missile-Defense System," Philadelphia Inquirer, 13: F5 (December 1, 1991).

39. Tircuit, Elwood C. "Framework For START II," Air Power Journal, 5:46-55 (Fall 91).

40. Warden, John Col., "Precision Guided Munitions in the Persian Gulf War." Address to AFIT Students. Air Force Institute of Technology (AU), Wright-Patterson AFB, OH, 5 November 1991.

Vita

Captain David C. McCormick was born on 29 August 1956 in Tupper Lake, New York. He graduated from Notre Dame High School in Elmira, New York and entered the Air Force in 1978. After receiving distinction as an Honor Graduate from the Security Police Academy at Lackland AFB, Texas, he was stationed at Plattsburg AFB, New York. Following receipt of an AFROTC ASCP scholarship, he attended the Military College of Vermont and graduated with honors in 1985 as a Distinguished AFROTC Graduate. Upon completion of Undergraduate Missile Training as a Top Performer in 1986, he became a Minuteman III missile combat crew member at Grand Forks AFB, North Dakota. While there he served as an instructor deputy missile combat crew commander, instructor missile combat crew commander, supplemental trainer operator, and as Chief, Training Materials Section. He entered the School of Engineering, Air Force Institute of Technology, in August 1990.

Permanent Address: 237 Moss Hill Road
Horseheads, New York
14845

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13. ABSTRACT *(Maximum 200 words)*

With the Soviet Union's fall there have been widespread calls for drastic reductions in the United States military's strategic nuclear forces. This research considers how the United States should think about strategic forces in the rapidly changing world order of the 1990s. As extensive literature review of deterrence concepts and conventional weapons capabilities is conducted. Using a methodology that considers both target hardness and target value, three test cases representative of possible international deterrence scenarios the United States may face during the 1990s are tested against six postulated strategic force structures in a reduced arms environment. The Arsenal Exchange Model, a linear goal programming allocation tool, is used to demonstrate the methodology. Recommendations are made concerning the utility of including certain precision guided conventional weapons into the United States strategic force arsenal.

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