

AFIT/GST/ENS/01-4 91M-4

AD-A238 385



INCORPORATING VALUE SYSTEMS
IN
STRATEGIC FORCE ANALYSIS

THESIS

Nancy Diane Snyder
Captain, USAF

AFIT/GST/ENS/01-4 91M-4

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REPORT DOCUMENTATION PAGEForm Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and reviewing the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE March 1991	3. REPORT TYPE AND DATES COVERED Master's Thesis	
4. TITLE AND SUBTITLE INCORPORATING VALUE SYSTEMS IN STRATEGIC FORCE ANALYSIS			5. FUNDING NUMBERS	
6. AUTHOR(S) Nancy D. Snyder, Captain, USAF				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Air Force Institute of Technology, WPAFB OH 45433-6583			8. PERFORMING ORGANIZATION REPORT NUMBER AFIT/GST/ENS/91M-4	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution unlimited			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) Detering potential Soviet aggression depends on our ability to hold at risk those assets they value most. This research investigates target valuation as an added dimension to force structure analysis. An extensive literature review is followed by the development and demonstration of a methodology defining development and use target values. The literature review covers arms control concepts to give a foundation for an important use of force structure analysis. It also covers measures of effectiveness. The final part of the review is comprised of definitions of perspectives on nuclear war. The methodology defines motivations for force structuring in the form of four wars: the deterrent and warfighting wars from both the United States and Soviet perspectives. Once the target bases are established, weights are assigned to each target category and ultimately target values are assigned to each target. To demonstrate the methodology, the Arsenal Exchange Model is used as a tool. The Blue Deterrent and Warfighting Wars are demonstrated using unclassified and notional data to test the effect of target valuation. The analysis of value systems can be helpful to develop understanding among all players in the strategic arena. ✓				
14. SUBJECT TERMS Target Value; Force Structure Analysis; Deterrence; Warfighting; Nuclear Perspectives; Objective Functions; Measure of Effectiveness; Arms Control; Perceptions; Target Weighting			15. NUMBER OF PAGES 100	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL	

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THESIS

**Presented to the Faculty of the School of Engineering
of the Air Force Institute of Technology
Air University**

**In Partial Fulfillment of the
Requirements for the Degree of
Master of Science (Operations Research)**

**Nancy Diane Snyder, B.S.
Captain, USAF**

March, 1991

Approved for public release; distribution unlimited

THESIS APPROVAL

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CLASS: GST-91M

THESIS TITLE: Incorporating Value Systems in Strategic Force Analysis

DEFENSE DATE: 21 February 1991

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Accession For	
NTIS GRA&I	<input checked="checked" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By _____	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

Preface

Strategic force structuring issues are still a significant part of military planning. The Soviets continue to modernize and increase their forces and a strategic balance must be maintained. This research investigates how value systems can be incorporated into strategic force analysis. The value systems are based on perspectives which are reviewed in this research. The methodology demonstrated in this research is a small piece of a much bigger picture. Notional and unclassified data are used to examine the effects of changing value systems on force structures.

My advisor, Major Morlan got me thinking about strategic issues. His ideas and guidance were most vital in the completion of this project. Thank you sir, for your encouragement and your inexhaustible patience. My reader, Major Auclair provided the Pentagon perspective to round out my "strategic" education. Thank you sir, for all your help and ideas. There are so many other people to thank. Göksel, I couldn't have LaTeX'd without erkek kardesim! Carrie, you provided me a safe haven and periodic sanity checks! Mike, thank you for all your words of encouragement when things were tough! Most of all, thank *you* Gary and Scotty for taking care of me throughout all the months of late nights and no weekends! I know I was the luckiest student at AFIT because I had your unwavering love and support! Things can (and will) only get better!

Nancy Diane Snyder

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Abstract

The Cold War may be over, but the Soviets continue to modernize their nuclear forces. Deterring potential Soviet aggression depends on our ability to hold at risk those assets they value most. This research investigates target valuation as an added dimension to force structure analysis. Force structure analysis is essential to develop negotiation positions in arms control talks. An extensive literature review is followed by the development and demonstration of a methodology defining a way to develop and use target values. The literature review covers arms control concepts and terms to give a foundation for an important use of force structuring. It also covers measures of effectiveness. The final part of the review is comprised of definitions of perspectives on nuclear war. The military, political, "informed civilian," and Soviet perspectives are discussed. The methodology defines motivations for force structuring in the form of four wars: the deterrent and warfighting wars from both the United States and Soviet perspectives. Once the target bases are established, weights are assigned to each target category and ultimately target values are assigned to each target. To demonstrate the methodology, the Arsenal Exchange Model is used as a tool. The Blue Deterrent and Warfighting Wars are demonstrated using unclassified and notional data to test the effect of target valuation. The analysis of value systems can be helpful to develop understanding among all intranational and international players in the strategic arena.

INCORPORATING VALUE SYSTEMS

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I. Introduction

1.1 Background

(Maintaining) Peace...is our profession.
General Thomas S. Power, Commander in Chief
Strategic Air Command Motto from 1958-1990

War is our profession. Peace is our product.
General John T. Chain, Commander in Chief
Strategic Air Command Motto from 1990 to now

The world is continually changing, but one thing has remained constant since the end of World War II—our need for a military strategy of nuclear deterrence. The recent events in Kuwait have put the Soviets side-by-side with the United States as unlikely allies. But the truth remains—Soviet strategic nuclear forces remain intact and on alert, presumably targeted at the U.S. The words of General Larry Welch as recently as 1988 justify the continued interest in strategic nuclear forces.

The Air Force must ensure that potential adversaries perceive that they have much more to lose through aggression than they stand to gain ... it is an absolute necessity that we achieve assured deterrence at the strategic nuclear level. We simply cannot afford the terrible consequences should deterrence fail at this level. (33:1-2)

The world has managed to maintain strategic peace for 45 years. Hundreds of billions of dollars of the U.S. budget goes to the military and its programs. Over \$51 billion of that funding goes to our strategic nuclear capability which is primarily used to deter the Soviet Union from nuclear war.(15:14)

Deterrence is basically defined as inhibiting the enemy's first use of force through means of threats, showing of force and the will to use that force. Deterrence is required to provide nuclear stability. Stability, in this sense is a homeostatic state wherein the major nuclear powers exist, equally deterred from accomplishing any type of nuclear first strike on each other. Stability, as measured in force levels, is addressed in this work. 'Stability should be the primary objective both of the modernization of our strategic forces and of our arms control proposals' (30:23). The pursuit of arms control agreements maintains continuous dialogue between the superpowers and this communication is as valuable as the outcomes of the talks.

Since the Soviets have a greater number of strategic weapon delivery systems than the United States, limits must be determined that will simultaneously reduce the USSR inventory to an acceptable number, and establish a reasonable goal for strategic modernization of U.S. forces. Arms control does not necessarily mean

elimination of weapons, as that could be quite destabilizing. (31) But appropriate limits and reductions are necessary to enhance stability.

1.2 Problem Description

In order to develop stabilizing limits, and transform them into stabilizing force structures, some sort of suitable measures of effectiveness must be used. Common measures which are currently used are very quantitative in nature. Equivalent Megatonnage, Counter Military Potential, and Damage Expectancy are examples of static quantitative measures. These types of figures cannot measure deterrence or stability very effectively. A good measure of nuclear force effectiveness must account for a myriad of conditions. One of the purposes of this research is to define some of these conditions and try to relate them to a suitable method of resolution of issues concerning force structure. This work attempts to quantify measures of stability and deterrence through force structuring, by considering complex issues of target valuation.

The conditions that are being defined concern perceptions. The entire concept of deterrence (and thus, stability) is based on perceptions. If the Soviets perceive that we have the capability and the will to carry out our national objectives, they will be deterred by our strategic forces. However, if the Soviets perceive that they can win a nuclear war, their responses will be different than those of a country that believes there can be no winners. When considering nuclear war, it is obvious that

there are outcomes other than a pure win or loss; deterrence, a perception, is one of those outcomes.

There are other perceptions at work in the grand scheme of nuclear strategy. Within our country, there are many players contributing toward our policies. They see themselves as playing specific roles in the process. They view conflict on a different plane and with different motivations.

Three specific and important viewpoints are useful to examine. There are scientists (and other informed civilians) who see both the U.S. and the Soviet Union as having too many weapons: "What good are more weapons if we can all blow the world up hundreds or thousands of times over?" There are politicians who control the purse strings. They want to provide public defense at minimal cost. They are willing to explore alternatives, but they have their own concerns, other than defense issues, to contend with. The other intranational group that this research addresses is the military. While all three of these groups are concerned with deterrence, they see it differently. The military agenda is to convince everyone who will listen that by providing the appropriate deterrent force structure, war will not occur. These perspectives are explored more deeply in Chapter II.

A specific problem statement for this research is to develop a methodology to analyze force structure from various perspectives by investigating the use of target value as a measure.

1.3 Research Questions

Force structure issues of arms control decisions must somehow integrate as many real world perceptions as possible. Is there a way to 'outguess' the Soviet Union to determine its motivations for force structuring? In this research these motivations will be labeled and described as "types of wars." Is there a way, using values systems, to determine the types of U.S. strategic force structures that will deter those wars? Is there a common way to look at deterrence so that all facets of our society can carry on meaningful discussions or even come to an agreement about the requirements for our strategic forces? These are the types of questions that this thesis addresses from the standpoint of target valuation.

1.4 Methodology

By labeling and defining the potential types of wars, this research examines objective functions which can be used to structure forces that optimize value of deterrent and warfighting capabilities. There is not necessarily a direct correspondence between value in the model world and value in the real world, but the model gives a feel for potential outcomes in the real world. Values for targets in the target base are developed notionally to represent each type of war using different prioritization schemes. Static measures of effectiveness like value damage expectancy are the foundation upon which is built a more complex model based on the layers of perceptions.

1.5 Outline

This chapter contains a brief overview of the research problem. Major areas are outlined and the research questions are posed. Chapter II contains the literature review which is divided into sections. One section describes measures of effectiveness and their use in analysis. There is a section devoted to arms control that introduces terms and established arms control measures used in arms control analysis. The final section contains a detailed discussion of the aforementioned intranational and international perspectives. Chapter III applies the implications of the multiple perspectives on the formulation and development of a measure of effectiveness. A value system model is established, to evaluate different force structuring options to represent the "types of wars" that our forces must be prepared to fight. Chapter IV demonstrates the methodology using notional data. A linear force allocation model using goal programming, as implemented in the Arsenal Exchange Model (AEM) is used for the calculations. Objective functions are developed and force structures are evaluated. Conclusions and recommendations for further study are contained in Chapter V.

1.6 Conclusion

This chapter is a concise overview of the research problem and the approach toward developing a new analytical agenda for incorporating value systems into strategic force analysis. A background for strategic analysis has been laid. The problem

description, research questions and a brief outline followed. The next chapter reviews pertinent literature.

II. Literature Review

2.1 Introduction

This chapter reviews applicable literature relating to the research problem. Measures of effectiveness and their use in analysis will be described. A section on arms control covers its purpose, Strategic Arms Reduction Talks (START) and static arms control measures of effectiveness. Several terms are introduced here, to add clarity to this thesis. The final section details a discussion of intranational and international perspectives and perceptions of nuclear policy

2.2 Arms Control

Arms control has been an integral part of strategic planning for the past 30 years. The term 'arms control' covers "activities designed to limit, control, reduce or eliminate armaments of nations under international agreement ... In the U.S., 'arms control' is not synonymous with 'disarmament;' in the United Nations the terms are used interchangeably" (21:3). Arms control agreements decrease the likelihood of nuclear war and increase the probability of restraint, should conflict arise. The main purpose of arms control is to strengthen international stability by reducing uncertainties and increasing understanding between countries.

According to Joseph Nye, a major benefit of the arms control process is the increase in transparency and communications among adversaries. Arms control also

reassures the domestic public, who can readily understand reductions in numbers of weapons as easy measurements of progress. (27:45)

Those who have only seen arms control agreements achieved when neither side had much of an advantage tend to be critics. These critics were only looking at the technical details, without observing the political significance of the arms control process.

Now that 'peace has broken out all over [Europe],' critics claim arms control is unnecessary because the U.S.- Soviet relationship has improved in the Gorbachev era. Nye contends that these critics 'fail to understand the institutional role of arms control agreements.' Once agreements are accepted, leaders and planners are less likely to base their strategies on worst case scenarios (27:45). Now, is the time to obtain solid agreements, while Gorbachev is in power and the Soviet Union's approach seems less oriented toward nuclear superiority. These are quickly changing times, the Soviets are making some reductions in their military but there is always the possibility of a return to cold war relations.

The world looks very favorably on and benefits from any Soviet military disarmament, but for Soviet armed forces 'less' is only relative. Even with its predominantly conventional reductions, the Soviets will maintain the largest military force in the world. According to John T. Correll, Editor in Chief of the Air Force Magazine,

By U.S. reckoning, the Soviets cut their military spending by about five percent in 1989, but Secretary of Defense Dick Cheney maintains that

the new total is 'higher than when Mr. Gorbachev came to power' and at a level that will permit considerable Soviet force modernization.(7:6)

Strategic force modernization has been continuously accomplished during all the talk about peace in Europe and force reductions. The Intercontinental Ballistic Missile (ICBM) force is being completely upgraded as if it is exempt from all reductions. Even within treaty limitations, the Soviets will hold a first strike capability against United States missiles and forces not on alert. It is hard to evaluate Soviet policy directions or objectives by observing their actions in the strategic arena. Mr Correll quotes General Colin Powell, Chairman of the Joint Chiefs of Staff, in his 15 October 1990 speech,

Now and in the future the Soviets will remain a military superpower, one that I never forget has the capability to destroy the United States in thirty minutes. (7:6)

The United States can never let its guard down. Preservation of deterrence is the goal of our strategic forces. The "U.S. priority should be to determine what force structure best assures stable deterrence and lessens the likelihood of attack and *then* [emphasis added] seek arms control agreements that are compatible with it, not the other way around"(6:11).

The only way that arms control can contribute to national security is if there are assurances that all parties are complying with the agreed-upon force structures. Verification is the criterion for evaluating the utility and effectiveness of the arms

control process and the agreements. Nations will only ratify agreements they believe can be adequately verified. "In today's environment, the verification *tail* seems to be wagging the arms control *dog*" (13:237). Verification issues are now standing in the way of signatures on a Strategic Arms Reduction Talks (START) agreement.

2.2.1 *START*. Arms control analysts look optimistically toward the bilateral START agreement. There is high regard for the improvement in the counting rules. The Strategic Arms Limitation Talks (SALT) Treaty limited delivery vehicles and launchers, encouraging both sides to maximize the number of warheads per delivery vehicle. This use of Multiple Independently Targetable Reentry Vehicles (MIRVs) can be destabilizing by offering fewer targets and making it easier for a successful preemptive strike (18:3). There is a large regret for absorbing a MIRV attack and a large payoff for the first strike with MIRVs. START, on the other hand, establishes a 'finite budget of strategic warheads' (9:8). By reducing the number of warheads, each side would be motivated to maximize the number of delivery vehicles which would in turn maximize the number of targets an adversary would have to cover. This would strengthen deterrence by making it harder for either side to successfully preempt the other (18:13).

There are several other aspects of START that lead to increased stability, but space does not permit their discussion here. However, one important concept about stability through force modernization ran through independent group studies of strategic policy and strategic systems at the Center for Strategic and Interna-

tional Studies (CSIS) in Washington D.C. One of the CSIS group studies concluded that 'START would be more viable and stabilizing if accompanied by sustained modernization of U.S. strategic forces ... Selective modernization which promotes crisis stability and conforms to other national objectives is possible within fiscal constraints' (5:53). The other CSIS study concluded that the U.S. must maintain a

triad of forces collectively capable of surviving a preemptive attack and penetrating Soviet defenses with a retaliatory strike of unacceptable proportion. The U.S. must carry out the modernization essential to fulfill this criterion ... (6:19)

Both studies emphasized ICBM modernization as a high priority, specifically in a road or rail mobile configuration. The U.S. dropped its demand for a ban on mobile missiles during START negotiations in the summer of 1989 (27:50). That has legitimized the operational Soviet SS-24 (rail) and SS-25 (road) mobile systems. It also has led to serious discussion of configurations of U.S. mobile systems. Mobile missiles are considered to significantly contribute to stability and deterrence; they are also a serious aspect of arms control negotiations since the Soviets have deployed mobiles and the U.S. has not.

2.2.2 Mobile ICBMs. The following discussion reviews what has been reported in the literature about the qualities and the theory of deploying mobile ICBMs based on current Soviet and anticipated U.S. deployment.

During negotiations, the Soviets have accepted limits which demonstrate that they intend to divide their ICBM force between heavy missiles (1540) to preserve counterforce capability and mobile missiles (800) to preserve a survivable retaliatory force (9:12). Their land based mobile systems meet several criteria of an 'ultimate' strategic force. They offer a degree of survivability comparable to SSBNs, and they overcome the difficult command and control problems associated with submarines.

Besides the SS-24 and SS-25 mentioned above, another Soviet missile, the SS-18, is currently their most potent counter-silo weapon. Their SS-18s are "sufficient in number and capability to destroy a substantial portion of our land based missiles which are deployed in silos" (6:7). The U.S. has not been blind to this heightened vulnerability and increased need for more survivable forces. The Air Force has been studying and developing two mobile ICBMs for several years: the Rail Garrison Peacekeeper (RGPK) and the Small ICBM (SICBM). There has been a deadlock between supporters of the rail-mobile Peacekeeper and the road-mobile SICBM. This deadlock has virtually paralyzed U.S. decision making about mobile ICBMs (9:12).

Any type of mobile missile has certain qualities and merits. Mobile missiles are survivable enough to ride out a first strike and remain capable of inflicting damage on an aggressor. They are able to maintain communications with the National Command Authorities via reliable and redundant communications systems. They are designed to endure independently for long periods of time to project a strong deterrent force. They are accurate and reliable. (18:59-62) A Congressional Research

Service (CRS) study inferred that "the Soviet insistence in retaining mobile ICBMs may imply the intention to adopt a no-first-use policy. In terms of deterrence, this [quality of mobiles] is desirable to both sides." (18:56). Mobile targets are more difficult to acquire so they complicate an adversary's attack plan. Despite their shared qualities, each mobile missile basing alternative has different characteristics.

The CSIS report explains how mobiles would be targeted. RGPK disperses upon strategic or tactical warning on to public rail systems. This would presumably force an attacker to barrage vast stretches of rail line to assure destruction of the missiles. Of course, thoughtful targeting of bridges, junctions and checkpoints or the use of smart weapons to limit barrage could counteract the system and make targeting complicated for the adversary. SICBM would be dispersed on tactical warning (minutes) forcing an attacker to barrage vast land areas to assure destruction of the missiles (6:7-8). These barrages would require use of a large fraction of a limited supply of warheads, a major consideration of an arms control-constrained attacker. There is more stability when both sides are subject to the same constraints.

RGPK has the potential of carrying ten warheads, and that would make it a valuable target, assuming it could be located. SICBM, although a more costly system for the U.S., would carry only one or two warheads; that would cause the Soviets to expend many more warheads in pursuit of a SICBM kill unless their detection and retargeting technologies improve considerably (6:9). Soviet modernization of offensive and defensive capabilities is likely to continue at a steady pace (5:53). The

consensus in all of the literature is that U.S. commitment to modernization and improvement of strategic missiles must progress to maintain an adequate balance of forces that will ensure stability among all nations. Any discussion of arms control would be incomplete without a discussion of stability.

2.2.3 Stability. If deterrence is a long term, enduring goal of the establishment of U.S. force structure, stability is the near term objective. This review has discussed some aspects of force structure that contribute to stability. This section will focus on stability itself.

If both sides perceive a set of conditions such that neither could gain an advantage in attacking the other, the situation is stable. If one side perceives that the gains of attacking outweigh the risks, then the situation is unstable. (14:12)

Kent and Thaler developed an intricate methodology to evaluate strategic forces based on first-strike stability. While their methods may be complex, their definitions are clear. They explain that first-strike instability arises only from the strategic force structure and the force postures within that force structure. Crisis instability is distinct in that it arises from numerous factors such as psychological stress, bad information or assessment of intent, and misperceptions. Crisis instability includes first-strike instability. (16:2)

Survivable weapons in a force structure enhance stability by deterring attack. The CSIS study co-chaired by Kupperman and Taylor explains that all perspec-

tives on crisis stability share one concept: rendering U.S. retaliatory forces and their command and control links invulnerable to a first strike and ensuring that the remaining forces are able to reliably penetrate Soviet defenses to reach their assigned targets. Therefore, "stability places a premium on mobility, hardness, dispersal and concealment of strategic forces" (5:9). Since these are also several qualities of mobile missiles, the obvious implication is that they contribute to stability.

Unless the aggressor can destroy all of his opponent's strategic weapons in a preemptive strike, his country will be subject to the damage of a retaliatory strike. J-8, the Joint Chiefs of Staff Force Structure, Resource, and Assessment Directorate, has used a cost/benefit type analysis where benefit is damage an attacker inflicts and cost is the damage sustained by the attacker's homeland. A stability index was proposed as a quantifiable index responsive to changes in the arsenal and the target base. As a measure of effectiveness, it must depict stability from both sides' perspectives and it must reflect mutual deterrence. This thesis develops a measure of effectiveness and attempts to incorporate, or at least consider, some different perspectives which are described later in this chapter.

2.2.4 Definition of Arms Control Terms.

AEM Arsenal Exchange Model. 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.

Collateral Damage Damage to an adjacent installation caused by the detonation of a nuclear weapon aimed at some other target

Counterforce 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.
(21:15)

Counter Military Potential (CMP) Index of explosive power of a weapon and expected delivery accuracy (2:246)

Countervalue Strategic concept which calls for the destruction or neutralization of selected enemy population centers, industries, resources and/or institutions which constitute the social fabric of a society

Damage Expectancy 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.

DGZ Desired Ground Zero; intended aimpoint

Drawdown A plot of some quantitative measure of effectiveness versus the level of some resource, as the level changes and the resource is applied. Often used to

plot surviving ICBMs or cities as a function of the number of attacking RVs.

Drawdown curves are parametric over time, with one axis being a measure of Red forces and the other being the same measure, but of Blue forces. Following a curve shows relative levels over time (or at each phase of the exchange).

Dynamic Measure An analytic measure of force effectiveness which assumes selected weapon-target interactions in a way which preserves dominant effects between major strategic force elements, and may consider opponent responses.

Equivalent Megatonnage 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.(2:246)

Expected value destroyed The expected number of targets destroyed in a nuclear attack, with each target weighted by a 'value' index

Fratricide Destruction or neutralization of one nuclear weapon by another belonging to the same country or coalition. Collision caused by failure to properly deconflict the trajectories, or effects of blast, dust, heat, and radiation may contribute to fratricide.

Hard Target A target hardened against the blast, heat and radiation produced by nuclear explosions. There are many degrees of hardening, VNTK is an index of target hardness.

Hedge In the Arsenal Exchange Model, an analyst specified, auxiliary goal, side condition or extra requirement which must be met by an allocation, while at the same time maximizing the basic objective function.

Installation Examples of installations are hangars, runways, wing headquarters, weapon storage areas. They could all be located on the same base, but each item is an installation.

Launch-on-warning Retaliatory strikes involving aircraft and ballistic missiles, triggered upon notification that an enemy attack is in progress but before hostile forces or ordnance violate friendly soil.

MIRV Multiple Independently Targetable Reentry Vehicles

R-95 For a target assumed to have a circular normal distribution, the radius of a circle which contains 95% of the target value

SIOP Single Integrated Operational Plan. The U.S. contingency plan for nuclear force employment. If deterrence fails it affords the President many options.

SNDV Strategic Nuclear Delivery Vehicle (ICBM, SLBM or Bomber) This term is used in arms control counting lingo as opposed to counting warheads directly. A delivery vehicle, such as a Peacekeeper ICBM, could carry as many as ten warheads but be counted as one SNDV.

Static Measure (also called **calculated measure**) Based on characteristics of weapons and targets, not involving generation of weapon-target interactions

or allocations. Simply a multiplication of a characteristic factor for a weapon (or target) times the number of weapons (or targets).

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

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.

Yield The energy released by the detonation of a nuclear weapon, measured in equivalent kilotons or megatons of TNT.

2.2.5 Arms Control Summary. This section of the literature review traced a circular path. It began with a discussion about the need for arms control, as its purpose is stability. It ended with a discussion of stability, after considering related topics along the way.

As mentioned before the purpose of arms control is stability, but the tenets of arms control agreements must be verifiable. Verification is one of the obstacles

of START negotiations. Several sources cite modernization of strategic forces as a requisite for START to become a stabilizing effect on the world. Mobile ICBMs were designated as a priority modernization task due to their survivability and other stabilizing attributes. Mobile missiles promote first-strike stability and crisis stability, which were both defined. The need for a good measure of effectiveness for stability and deterrence was shown. Good arms control agreements will be based on effective ways to evaluate the stability of various force structures.

A quote from Michèle Flournoy's article succinctly summarizes the purpose of current arms control efforts in light of many different perspectives.

If, in the end, the myriad of strategic, political, and economic factors involved can be successfully balanced, START could well lead to a reduced but more robust U.S. triad and to an environment of enhanced stability.
(9:1)

2.3 Measures of Effectiveness

2.3.1 Introduction. The central problems in the design of analyses to aid military decision makers lie in selecting operationally useful objectives (word statements about goals), measures of their attainment (computable values that approximate objectives), and criteria (measurable values that are used to compute measures of attainment) (1:54). This section discusses measures of effectiveness and their development and use in analysis. A suitable measure (or measures) must be chosen for any

analysis. After defining a measure of effectiveness as a gauge indicating achievement of a goal they can be classified as either calculated or dynamic.

2.3.2 Calculated and Dynamic MOEs. Calculated measures of effectiveness are simply calculated numbers based on characteristics of weapons or targets. Characteristic factors for each weapon (target) are multiplied by the quantity of weapons (targets) in the arsenal. Their calculation does not involve any weapon to target allocation. These measures are very common in model output and are used to determine other (dynamic) measures of effectiveness. Examples of these static MOEs are Equivalent Megatonnage (EMT), number of warheads, hard target kill capability, total yield and throw weight.

Dynamic measures of effectiveness result from weapon-to- target allocations. They may cause modification to the objective function of a linear program (as in the Arsenal Exchange Model); they can drive the allocation or be a by-product of the allocation. Examples include target value destroyed, residual weapons, goal satisfaction, minimum cost, optimal force structure, surviving ICBMs, surviving targets, warheads on target and several others. (8:19) According to Niskanen, as quoted by Zenk:

The appropriate measure should have two characteristics: first and most important, it must be relevant; preferably, but less important it should be measurable. (34:7)

Zenk succinctly adds, 'Deterrence and stability seem the most relevant, but are also the hardest to measure.' His work goes on to summarize definitions of static measures such as Equivalent Megatonnage (EMT), Counter Military Potential (CMP), Effective Counter Military Potential (ECMP), in a numerical sense.

$$EMT = Yield^{\frac{2}{3}} = (MT)^{\frac{2}{3}} \quad (2.1)$$

$$CMP = \frac{EMT}{CEP^2} = \frac{(MT)^{\frac{2}{3}}}{(NM)^2} \quad (2.2)$$

$$ECMP = \frac{\ln(1 - PA + PA \times (.5^{(CMP \times LR^2)}))}{\ln(0.5) \times LR^2} \quad (2.3)$$

In these formulas, PA is probability of arrival of a given warhead, LR is lethal radius, in feet, computed as a function of target hardness. Yield is measured in megatons (MT); CEP is reported in nautical miles (NM).

Damage expectancy is a quasi-dynamic measure of damage done to the enemy's targets as a percentage of targets destroyed within a class of targets. Weapon to target allocations must be made by a model (such as the Arsenal Exchange Model (AEM)) to determine damage based on characteristics of the weapons and the targets. It is very important to remember that the MOE to be used should be determined by the requirements of the study rather than the limitations of the model. (8:19) Often we define our studies to match the MOEs that the models produce, but this thesis attempts to build new models to measure the MOEs we need.

2.3.3 Developing an MOE. A measure of effectiveness is developed by first evaluating the requirements of the analysis. These requirements form the guidelines and objectives of all aspects of the study. Then it must be determined which parameters should be specified in these requirements. Then, an appropriate level must be set for the parameters, based on those requirements and any assumptions that are considered. (29) Measures of effectiveness should reflect the essence of the problem; they should be viable and easily understood (1:60).

Care should be taken when a problem has alternative measures of effectiveness available. First, it is important that each MOE does in fact measure an aspect of the issue which is relevant to the problem under consideration. Second, the measures should be relatively independent of each other and any interdependencies should be made clear in the analysis. Third, there must be a clear understanding (or at least an agreement among users) of the meaning of each measure. (19:256) The analysis assumptions, input data, and range of uncertainties can affect the meaning and the understanding of MOEs.

2.3.4 MOEs and Arms Control Analysis. Assumptions, data and uncertainties can influence the use of MOEs in models and further influence the use of models in analysis. In arms control analysis, uncertainties abound, especially in these transitional times in world events. Future weapon systems operation and use, target hardness, and weapon accuracy are some common uncertainties which have been addressed by classical analyses. Treaty verification capability is another uncertainty

which must be modeled and it can represent different assumptions to different people. It is difficult to determine if force limits can be violated without detection. It is even more difficult to estimate the results of changes that would occur if provisions of the agreement could be violated without detection. Breakout presents another uncertainty to be represented in arms control analysis. The potential for one side to suddenly abrogate the treaty constraints must be examined with relation to the time and the capability the other side has to take adequate counteraction. (19:250) These parameters and their range of values must be considered along with other parameters and values when developing and using measures of effectiveness in arms control analysis.

Mr. Lieberman, who has been Chief of the Operations Analysis Division of the U.S. Arms Control and Disarmament Agency, also presented some other significant issues about MOEs in arms control analysis. He stressed that because of the "proliferation of MOEs" certain problems have surfaced. Some MOEs show that the strategic balance favored the Soviet Union while some show that it favors the United States. Also he explained that in some cases the "units of effectiveness themselves became the quantity to be limited under the proposed arms control agreements. This factor tends to indicate which features of the forces the policy makers consider most important." (19:254)

In SALT I and II the unit of limitation was the number of launchers. In SALT I that number was fixed at the quantity each side had at that time. Since

the Soviets had more launchers, the equity of the treaty was questioned. In SALT II, an equal number of launchers was set for each side, but then there was still an imbalance of other aspects of the strategic forces. One of the most crucial issues in the development of the United States' START position was the selection of the units of limitation. The number of warheads and their size are now considered by negotiators to be significant. The Strategic Nuclear Delivery Vehicles which carry the warheads are considered, since the SNDVs are major contributors to the speed of delivery and accuracy of the weapon. Sometimes the units of limitation are selected by analysts as measures of effectiveness and here Mr. Lieberman emphasizes careful analysis to ensure the results are not a product of circular reasoning.

2.3.5 Final Thoughts on Measures of Effectiveness. MOEs can be used to judge the efficacy of changes in strategies or to rate performance of systems. Ratios which flag improvements in weapons or strategies often become useful MOEs. MOEs can highlight trends over time. MOEs must be consistent.

A highly respected analyst at the Pentagon, Clayton J. Thomas explains the importance of choosing an appropriate measure of effectiveness.

Deciding what to measure (formulation of a measure of effectiveness) is critical ... The classic paper of Charles Hitch emphasizes [its] importance ... 'the shrewdness with which criteria (objective functions, pay-offs) are selected' has much to do with the usefulness of operations research. (32:64)

This section of Chapter II has shown different types of measures of effectiveness and the considerations involved in developing an MOE. It also has described issues related to MOEs and arms control analysis. Depending on one's perspective, however, the measures can suggest different things. The next section of this chapter examines different perspectives on nuclear policy and arms control.

2.4 Perspectives

2.4.1 Introduction. Many different perceptions of nuclear war exist in our country. Three perspectives are of particular interest to this research: the informed civilian perspective, the political perspective and the military perspective. Informed civilian perspectives comprise scientists, physicians, newsmen and journalists, writers and others. The political perspective includes those who are not in the military chain-of command. The military perspective includes military analysts, military leaders and the civilian leaders in the military chain-of-command. These perspectives exist, and are important to differing degrees both in the U.S. and the USSR.

Many papers and books have explained people's perceptions and perspectives on nuclear issues. This section samples these writings to illustrate the complexity of the search for some kind of unifying perspective. After defining the term perception, the 'informed civilian,' political, and military views will be examined.

2.4.2 Perceptions. Carl Jung was a Swiss psychiatrist and psychologist who based his theories on the "belief that much seemingly random variation in human be-

havior is actually quite orderly and consistent, being due to certain basic differences in the way people prefer to use perception and judgement." (25:1) Perceptions are understood to include the processes of coming to conclusions about what has been perceived. Decision makers have their own assumptions and beliefs about the world. The perceptual process involves acquiring, classifying, evaluating, and integrating or rejecting information. "If people differ systematically in what they perceive and in their subsequent conclusions, they may as a result show corresponding differences in their reactions, in their interests, values, needs and motivations." (25:1) These motivations and values lead people to make judgements about their national defense and its requirements. As Some of those people are in positions to sway public opinion or lobby in the government, their views are important to government and military planners.

2.4.3 'Informed Civilian' Perspective. As mentioned before, the group this research refers to as 'informed civilians' includes scientists, physicians, journalists and newsmen. All these people have their own opinions; this section can only sample their perspectives on nuclear war and arms control. One of the most noted and outspoken scientists has been the astronomer, Carl Sagan. He asserts that "no species is guaranteed its tenure on this planet" and points out that our species is the first to devise a means for self-destruction. He believes there is "no cause more urgent than the elimination of the threat of nuclear war." (28:1) As many scientists are quick to do, Sagan studies the effects of Hiroshima and relates them

to present arsenals. In Paulson's book, Carl Sagan explains the comparison in clear terms. At Hiroshima a 13-kiloton weapon killed 100,000 people. Today's arsenals have the potential to exchange the equivalent of one million Hiroshima bombs and that would be enough to kill a hundred billion people. But since there are only 5 billion people on the planet, this demonstrates that over-kill is an understatement. In his perception, Sagan assumes linearly scaled effects which may be a questionable conclusion. However this is *his* perception and it is what he presents to the public. The dangers of nuclear war are not readily apparent to the public because of the psychological factor of denial. No one really wants to think about the consequences of such an event. Sagan believes that one of the most important jobs that "scientists have in this dialogue, this polylogue on the dangers of nuclear war, is to state very clearly what the dangers are." (28:13)

Carl Sagan has views on the number of nuclear weapons. Increases by one nation have never deterred any other nation from stockpiling its own nuclear arsenal. "Proliferation leads to exponential growth of nuclear weapons, worldwide. No nation is ever satisfied that it has enough weapons." He also believes that a "concerted effort by one nuclear power to decrease its stockpile of nuclear weapons and delivery systems might ... [lead] to a decline in the [arsenals] of other nations." Since the U.S. was the nation that first developed and used nuclear weapons, he thinks we have an obligation to decelerate the arms race. He is not blind to the concept of deterrence: "Mutual arms reductions, done in such a way as to preserve deterrence

against nuclear attack, are in everybody's interest." Toward this end, he advocates that more of the resources of nations throughout the world must be devoted to organizations devoted to peace. His example is the Arms Control and Disarmament Agency (ACDA) whose budget is "less than one-hundred thousandth of the budget for the Department of Defense." (28:16)

Hugh Downs, a newsman and chairman of the National Space Institute and U.S. Committee for UNICEF has two very clear analogies. In his analogy about the over-kill issue he states, "It is no longer a military matter. It is, rather, as though two people in a vat of gasoline up to their necks are arguing over who has the most matches." (28:18) Like, Sagan, he cites denial, ignorance, and feelings of helplessness as things that cause public apathy. Education and political pressure are his answers; survival will depend on one country "refusing to up the ante, taking the lead by stepping aside and backing away from the brink." His other analogy summarizes that view. "We are not doomed in the way we would be if the sun were scheduled to become a nova in a few years. We have it in our power to reverse our course." (28:19)

An empowered and educated citizenry seems to be a common theme among the 'informed civilians.' They quote Liddell Hart who wrote, "If you desire peace, *understand* war." Bernard Lown, a cardiologist, is co-president of a 150,000 member organization called *International Physicians for the Prevention of Nuclear War*, an organization that won the Nobel Peace Prize in 1985. His feelings, and that of his

community, are basically that the fact nuclear war has not yet occurred is largely irrelevant, because it only has to happen once. The feeling seems to be that developing and stockpiling weapons does not lead so much to deterrence as it leads toward the use of those weapons. They further believe that Americans have a misperception of the Soviets as an absolute enemy due to the fact that we have based our strategic security on an absolute weapon. They see nuclear war brought on by accidental or inappropriate actions and its consequences, magnified and unacceptable. Mr Lown doesn't think of nuclear war as a war, but as an act of "suicidal genocide." (28:21)

The other co-president of the International Physicians for the Prevention of Nuclear War is Eugene Chaszov, a Soviet cardiologist. His beliefs echo Lown's beliefs. Their organization calls nuclear war the final epidemic. Two other organizations, The Physicians for Social Responsibility (PSR) and The Union of Concerned Scientists understand, medically, the incurable consequences of nuclear war. Their charters are to save humankind from 'omnicide' through education and advocating their views.

One of the positions held by the Union of Concerned Scientists is the policy of 'no first use' of nuclear weapons to counter a non-nuclear attack. In contrast to arms control policies which are based on long, drawn-out negotiations and do not necessarily constrain the use of weapons, this policy would strengthen the NATO alliance and produce less perilous relations with the Soviet Union in times of crisis, lowering the risk of nuclear war. (11:41) They cite that there is no plausible scenario for the use of nuclear weapons in a conflict between superpowers that does not carry

with it the danger of 'catastrophic escalation.' To opponents of their theories, this emphasizes the value of *first-use* doctrine as a deterrent. Relegating nuclear weapons to only one task of retaliating to nuclear attack, somewhat decreases their usefulness and could potentially lead to a build-down. Due to public debate on the use of force, no first-use may only constrain Western democracies and not the USSR. (24)

In the literature many other 'informed civilians' advocate the idea of a build-down of forces. Some even, to a modest degree, propose force structures. They see nuclear weapons as serving no military purpose as there is no ongoing conflict to justify procurement and modernization of the arms race. It is worth noting that these beliefs apply to many of the scientists in the United States as well as in the Soviet Union. Flora Lewis, a U.S. foreign affairs columnist, who also believes that widespread education about modern weapons and strategy is most important, supports build-down proposals and opposes freeze proposals. She states "Multiple Independently Targetable Reentry vehicles (MIRVs) were a big mistake which can be corrected in this way." (28:66) This theme about MIRVs ran through much of the literature.

Ralph K. White, a professor of psychology of East-West relations proposes many things that can be done to alter force structures. First, each side destroys some of its more destabilizing nuclear weapons. Second, a drastically lowered ratio of warheads to missiles — no MIRVs. He also supports a joint no-first-use statement and a comprehensive test ban. He proposes a freeze agreement, modified to allow

substitution of less destabilizing weapons. Finally, prior to the actual events leading to their elimination, he supported elimination of the Pershing II's, ground launched cruise missiles, and SS-20s. (28:82)

One last scientific viewpoint which needs to be mentioned is explained by Matthew Bunn and Kosta Tsipis. Along the lines of education, they stress the importance of evaluating all the uncertainties associated with nuclear war. Military analysts must make several assumptions and do simple calculations which Bunn and Tsipis claim do not represent all the uncertainties. Gambling with the uncertainties of nuclear war is on an unprecedented scale; the entire network of civilization hangs in the balance. They do acknowledge that uncertainty does act as a powerful deterrent. They address the uncertainties concerning reliability, estimates of target hardness, weather effects, effects of the debris in the atmosphere during an exchange, fratricide, and kill probabilities. They address arms control from the aspect of limitations on testing. As testing reduces uncertainties, confidence in the weapons and confidence in prediction of the outcomes both increase. This confidence could lead to the temptation to launch a surgical or a first strike, increasing the probability of an all out nuclear war. They stress that limitations on testing and deployment of ballistic missiles are necessary to forestall technological advances. These limitations must be a major component of arms control efforts. (3:47)

2.4.4 Military Perspective. From the military perspective, nuclear weapons seem to be here to stay. The scientists and other 'informed civilians' may not totally

grasp the theories behind deterrence and the need for nuclear weapons. The military understands most of what the 'informed civilians' say and does not believe the scientists are wrong; however, the military has a job to do and the nuclear deterrent force is, and will be, a part of that job.

The primary mission of our strategic forces is to deter nuclear war and provide a war-fighting capability should deterrence fail. They must be able to survive a nuclear attack and to retaliate. Our forces are in a state of readiness to permit immediate operations against an aggressor; that aggressor is assumed to be our cold war opponents, the Soviet Union.

There has been a lot of talk of the "end of the cold war." First and foremost, this issue must be addressed. The changes in the Soviet Union have led to vast improvements in relations between our two countries. However these improved relations have not resulted in any decreases in Soviet nuclear force structure or the end of their nuclear force modernization programs. The Soviet newspaper *Izvestia* announced on 2 December 1990 that Moscow had increased its military spending by \$50 billion. They have been spending 25 percent of their gross national product on their military in comparison to the 4-6 percent spent by the U.S. This is all in a time of decreased tensions and a severe food shortage. Major General Mohr quotes the Cardinal Mindszenty Foundation when they speculated that the "Soviet Bear may be merely hibernating." It is possible that when the Bear awakens he could be just as dangerous as before (23:2).

The Soviets have upgraded their heavy SS-18 'first strike' missiles to carry twice the number of nuclear warheads as earlier versions. This modernization would nullify the effects of a proposed START reduction of 50 percent of the SS-18s leaving them with as much firepower with half as many missiles. Last year the Soviets built 140 new Intercontinental Ballistic Missiles (ICBMs) while the United States built only 12. The Soviets have deployed at least 270 road-mobile SS-25 missiles, 33 rail-mobile SS-24 missiles and 50 more SS-24 missiles in hardened silos. (23:2) The U.S. has no mobile missiles. The Soviets are modernizing their strategic bomber forces with the new Bear H and Blackjack aircraft equipped with longer range cruise missiles. They continue to produce Typhoon and Delta IV class submarines.

Other indications of the questionable intentions of the Soviet military machine are in allegations that they are cheating on the Conventional Forces in Europe Treaty by taking more than half of the equipment that the treaty would have required them to destroy, and moving it to areas east of the Ural mountains. Anatoli Golitsyn, a KGB defector predicted much of this behavior in his book *New Lies for Old* published in 1984. He explained a long range policy which included false liberalization designed to weaken U.S. defense and ultimately isolate the United States, confronting it with overwhelming Communist power. Many of his predictions have come true and our military believes it must protect against the culmination of their plan as Golitsyn explains it.

Recent Soviet behavior indicates that the cold war may not be totally over and this time period may be just a short respite. Paul Harvey, a noted commentator said it best ... "the Nobel Peace Prize winner [Gorbachev] deserves our encouragement and our applause, but not yet our unilateral disarmament." Much documentation and literature written by the military supports constant modernization and keen awareness about the events in the world.

2.4.5 Political Perspective. As mentioned earlier, the political perspective is formed by government officials who are not in the military chain of command. The influence of this perspective is largely exerted through the legislative function of national budgeting and appropriations. Such a process clearly requires judgments and tradeoffs in expenditures between starkly different and competing needs. Although this process directly affects the defense budget, it doesn't add a significantly different opinion to the nuclear debate between the informed civilian and the military camps. Thus, the debate in this research will be limited to the two previously described perspectives.

2.4.6 The Soviet Perspective. As mentioned earlier, decision makers and leaders have a plethora of inputs to their decision processes supporting force structuring decisions. In the Soviet Union, perceptions are conditioned by a very deep fundamental Marxist-Leninist belief system. A fundamental tenet of their beliefs is the view that the social development is a natural evolutionary process whereby

mankind moves through historical stages until it reaches the final stage of communism. (10:5) This view profoundly affects Soviet perceptions of nuclear war. They, as we, believe that nuclear war should be avoided, but Soviet leadership is confident that should it occur, the USSR will survive and capitalism will be destroyed.

The key objective of their military posture is survival. To that end, they base their strategy on a "combination of a preemptive first counterforce strike, an active defense and a comprehensive civil defense program." (12:1) Civil defense is an integral part of the Soviet Union's posture and planning. Leon Goure wrote about the Soviet use of civil defense, basing his information on Soviet open sources materials. In his paper written for the Defense Nuclear Agency as part of an ongoing study of strategic targeting options and vulnerabilities, Goure stated that civil defense "bears directly on the correlation of forces between the opposing systems as well as the attainment of superiority in the course of a war and its outcome." (12:1) Civil defense priorities are in accord with Soviet strategic targeting doctrine which reflects the primary war aims. These aims are the destruction of the opponent's political system and his sources of military power including the military economic potential. The Soviet Union is aware that the U.S. does not have the same level of survival capability and could exploit their advantage to weaken U.S. resolve. Perceptions on both sides play a key role in the actions of each nation.

Dr. Noguee, in a paper written for the Strategic Studies Institute, stated that Soviet nuclear proliferation policy is based on the "Soviet government claims that it

opposes and has long opposed the spread of nuclear weapons.” (26:1) As mentioned earlier in this chapter, their actions and behaviors do not exactly match these claims. It is commonly known that their history is full of inconsistencies and contradictions in this area.

2.5 Conclusion

This chapter covered a great deal of literature that will be needed to produce an adequate measure of effectiveness for arms control force structuring. The study of perceptions and perspectives provides the basis needed to develop new ways to view aspects of nuclear policy. The next chapter will use implications of these perspectives to develop and formulate a methodology to develop force structures.

III. Methodology

3.1 Introduction

So far this thesis has discussed basic tenets of arms control and stability, measures of effectiveness and various perspectives on nuclear policy issues. The intent of this chapter is to synthesize these concepts into a methodology to analyze and develop force structures using value systems. There are several considerations in developing measures of effectiveness toward this end.

3.2 The Considerations

The first consideration is the type of war which will be fought. This thesis introduces a concept of "four wars" as a way to present the dynamics involved in strategic analyses. Each of these "wars" requires a specific type of force structuring which can be evaluated using different assumptions, priorities, and interpretations derived from implications of the different perspectives, presented in Chapter II. From the results of these evaluations force structures can be refined and measures can be used to compare and communicate the merits of alternative force structures.

In addition to the type of war, other considerations include target types and weapon types. This chapter includes sections which enumerate targets that each 'war' requires and a description of a weighting scheme for those targets. The targets and their values are determined by specific perspectives evaluating a 'war.'

3.3 Disclaimer

All of the perspectives and each of these descriptions of the wars are based on notional and unclassified data. The objectives and constraints are created for the purposes of illustrating this methodology and are not based verbatim on published guidance. Presented here is only a methodology or a shell from which true force structures, based on published guidance, can be evaluated.

These four wars are illustrated in Table 3.1 and each war is subsequently described.

	U.S.	USSR
..wants to win	1	3
..doesn't want to lose	2	4

Table 3.1. The Four Wars

These wars are based purely on the goals and motivations of each side. Therefore they are assigned the "war ...wants to win" and the "war ...doesn't want to lose." The goals and motivations lead to value systems which in turn, lead to targeting priorities.

3.4 The Four Wars

Using this 'four war' methodology produces requirements which present applicable force structures for arms control negotiation limits. The sides in the negotiation process are the Soviet side and the U.S. side. For each side the negotiation process

is based on that side's perceptions of their own objectives and that same side's perceptions of the other sides objectives, as gleaned from intelligences estimates. The four wars methodology is not designed to establish any type of "ground truth" but it is designed to demonstrate dynamics of a force structuring process based on *our* perception of U.S. and Soviet deterrent goals as well as *our* perception of U.S. and Soviet warfighting goals. This methodology, when used by the Soviets, shows the dynamics based on *their* perceptions of the same four sets of goals. Study and evaluation of these types of goals by both the Soviets and the Americans lead each to evaluate force structures for both sides and to ultimately understand and determine fair positions to negotiate from. The objective of the "Four Wars" methodology is to look at both deterrence and warfighting from both the U.S. and the USSR perspectives.

3.4.1 *BLUE DETERRENT WAR: The War The U.S. Wants To Win.* The primary mission of our nuclear forces is to *deter war*. The United States must be able to demonstrate to the Soviets the capability and the will to use these forces in order for the deterrent to be effective. To win this war the military must develop force structures which are feared and respected by potential adversaries – forces that can prevent war completely by inhibiting the first use of force. The forces for this 'war we want to win' must be structured to demonstrate that an adversary has few options. He must believe that an attempted first strike would lead to a retaliatory strike of such dimension that his civilization and forces would be put at severe risk.

To deter we must threaten what the enemy values most. For example, Soviets value the central authority of the state. To deter them we must be able to hold the highest levels of this authority at risk. To hold "at risk" can be defined with respect to a significant damage as viewed by the defender. The party leadership is a significant representation of this authority; consequently, the USSR might believe its headquarters would be targeted in the "deterrent war." One should note that targeting only indirectly deters the enemy. It is not the highly classified targeting plans that deter an adversary, but rather the capabilities that support such targeting. An enemy will translate these capabilities conservatively into a *perceived* attack plan that could actually be more devastating and more of a deterrent than our *actual* targeting plans.

Deterrence is the prize of the first type of war. Should that war be lost, should deterrence fail, there must be forces that provide a warfighting capability to end a war as soon as possible on terms favorable to the United States. This part of the mission of our strategic forces helps describe the second type of war, the Blue Warfighting War.

3.4.2 BLUE WARFIGHTING WAR: The War the U.S. Does Not Want to Lose. If deterrence fails, we must be able to demonstrate through our capabilities that we are prepared to fight a war that would be over quickly with a minimum of damage to our nation, preventing coercion of U.S. civilian authorities. In this war we assume that the Soviets have targeted what the United States values most;

for example, *our* highly populated cities and industries would be targeted. This is probably the war that the American "informed civilians" fear the most. It is the war they would want to prevent (at best) or defend against (at worst). Soviet targeting could go well beyond military aimpoints.

However, in this war it might be assumed that even our population centers are targeted. This war requires defensive as well as offensive forces and tactics. Forces are required to overcome an immediate threat. Our objectives in this war are to avoid the massacre of our society. Communications must remain available before this war to demonstrate intent and will, and during this war to allow negotiations before the war is escalated beyond rational control.

3.4.3 RED DETERRENT WAR: The War the Soviets Want to Win. This is the war where the Soviets target our values to deter the U.S. from attacking first. This war is representative of *our perception* of what the Soviets believe to be of highest value to the U.S. It is apparent from the literature that the Soviets scorn the capitalist system, while they know how valued it is to us. This further leads to the conclusion that the foundations of capitalism might define the targeting objectives of this war. It could also be possible that capturing these foundations could be part of the objective of a war.

These objectives would mainly put our cities and industries at risk. If the Soviets can violate our national domain, the correlation of forces would be in their favor and it can be assumed that it would be more possible that they could fulfill

objectives like expansion of the Soviet system. This type of attitude on their part provides a deterrent to the United States which does not want to be overcome by Communism or destroyed.

3.4.4 RED WARFIGHTING WAR: The War the Soviets Do Not Want to Lose. This war is based on our estimate of what would constitute the Soviets objectives, when their goal would be to avoid losing a nuclear war. This is harder to evaluate than the war the U.S. does not want to lose because it is difficult to know or understand all of their motivations.

Up front it must be noted that Soviets appear to believe a nuclear war is winnable whereas we do not. While this would imply the need for our Strategic Defense Initiative (SDI), SDI systems and its theories are not discussed within the scope of this thesis. Among the indications that suggest this is their intricate and comprehensive Civil Defense program. Their most valued assets seem to be their leadership, their Command, Control and Communications, their energy systems, transportation, defense, oil, chemical, electronic, machine building and instruments industries, their reserves and stockpiles. They appear to anticipate some loss of transportation ability so they have developed many areas into self-sufficient regions capable of functioning for some time without normal supplies. They have done a great deal of planning and preparing for nuclear war.

Civil defense is only one aspect of the Soviet warfighting capability. Their defenses protect systems required for long term warfighting. The Soviets are prepared

for prolonged nuclear exchanges and have structured forces to fight in this manner.

Soviet strategic offensive forces can achieve "decisive" strategic objectives in a brief period of time to end a war on terms favorable to the Soviet Union. These objectives would put our land based ICBMs, bombers on the ground, and our military command at risk. The correlation of forces is the Soviet method of measuring stability and comparing their strengths with the rest of the world. If the enemy can render our forces impotent early in the war and break our spirit, the correlation of forces would be in his favor and he could fulfill his other political objectives of national survival and expansion of the Soviet system.

3.5 Targeting Implications

The nature of each 'war' leads to different valuations of its own targets compared with other wars' target valuations within a fixed target set. These target sets can be distinguished and described further, based on the different perspectives. This section describes these targets based on the objectives of each of the four wars. This research is actually assigning notional values to installations and calling them targets for ease of explanation.

3.5.1 Blue Deterrent War. The goals of these U.S. forces are based on 'winning' the deterrent war. In other words, when the U.S. has the ability to hold the enemy's most valued assets at risk the enemy is deterred from initiating nuclear hostilities against the U.S. The essence of deterrence is to "influence an adversary's

perception of the costs and consequences of aggression when certain types of retaliation may be provoked."(17:13) For the enemy, the perceived cost of a target increases with respect to the value he places on that target. This makes a target serve as part of a good deterrent strategy.

The target categories in this 'war' include those targets which we perceive are of high value to the Soviet Union. As mentioned earlier, one example of a highly valued target category of this 'war' might be the central state authority and party leadership. It must be noted that we can only guess at Soviet values and priorities based on the existing literature. This section continues by listing examples of target categories based on a value system suggested by the literature.

The military command structure is a highly valued entity. Command, Control, Communications (C3) capability can be seen as a similarly highly valued asset. Communications and the command structure lie at the heart of any military operation. If military commanders cannot transmit orders or if their troops cannot receive those orders in an accurate and timely fashion, commanders lose the lifeline of their military might. Targeting this highly valued lifeline would serve as a useful deterrent if enemy commanders knew they would not be able to carry out their operations according to their prearranged plans.

Long term warfighting capability also seems to be highly valued. The Soviets believe they can fight a prolonged nuclear war and they have weapons and reserve forces to accomplish this objective. These weapons and reserves would be a logi-

cal part of the target set in the Blue Deterrent War. Targets would include Red's hardened silos and warhead storage areas. Economic targets such as manufacturing facilities (warfighting products and other industrial products), and resources for recovery and reconstitution of the economy would also possibly fall into this category. Cutoff of reserve forces, weapons, and supplies would prevent an adversary's prolonged participation in a conflict that they might start. If they knew they would not be able to finish, they would be reluctant to initiate hostilities and war would be deterred.

The population would not necessarily be represented in this war's target set because, from all indications, the Soviets do not seem to attach much value to civilians — in or out of war. There are other possible target categories based on other values; this section has covered the most significant ones.

3.5.1.1 Implications for Blue Force Structure. The presumed implications for Blue forces for this war are briefly stated here. Because most of their highest value targets are probably sheltered in hardened structures, the weapons Blue would require would seem to be those with hard target kill capability. A full study done by a model designed for aggregate force analysis would demonstrate the actual distribution of suitable weapon systems that would prove the most effective in the war which Blue deters Red from a first strike. If deterrence fails the U.S. must be prepared to proceed with the war which displays a different characterization.

3.5.2 *Blue Warfighting War.* When deterrence fails, we must be prepared to fight a war we do not want to lose — a warfighting war. Our goals are to end this war as soon as possible on terms most favorable to the U.S. When it comes down to our actually fighting a nuclear war we automatically assume our population or at least our country, our allies, or our interests are targeted. Drastic times call for drastic measures. The targeting requirements for this 'war' include some of the same targets as the Deterrent War (for example – remaining weapons), but several categories are added here to ensure our goals are met.

What are our *goals* in this type of conflict? The objectives of this "war" are to avoid annihilation of the network of our civilization and to end the war quickly on terms most favorable to us. To accomplish these Blue objectives they must be interpreted into types of Red targets which must be targeted and/or destroyed.

The types of targets would include the Soviet' nuclear forces, especially their remaining ICBMs and alert bombers. Ships in port or ships locatable at sea would be significant targets in this war, as would reserve forces. Basically all weapons and forces would be appropriate targets in this type of war. Ground Control Indicator (GCI) radars and navigation radars would also be likely targets to mislead Soviet fighters and bombers. Warfighting supply lines and logistics would also be targeted. Energy generation facilities and transportation access both take on increased importance in this 'war' to help bring about an early end to the conflict by making basic existence and travel in or out of the country impossible.

Many of the targets mentioned in this section are normally collocated with major urban areas. In order to end the war as soon as possible, it is necessary to destroy the adversary's will, as well as his facilities. A 'rational' enemy may consider destruction of its cities as a final straw and may choose to end hostilities on our terms to avoid further damage. It is questionable whether the Soviets fit into this category. It has been suggested that the irrational side may have an advantage in a conflict; the other side never knows what to expect and that could also serve as a deterrent (24).

In this Warfighting War, it could be very important to keep some of the Soviet command structure intact. Their availability would be needed to order cease fires or surrender. This could be essential for ending this war as soon as possible.

3.5.2.1 Implications for Blue Force Structure. Once again, these implications are presumed and would only be proved by the outcome of numerical analysis. Weapons would most likely have to include Blue ICBMs and alert bombers to react as soon as possible to a Red first strike and provide a substantial retaliatory attack. Another quality of the weapons which would seem to be most suitable for Blue to use in this type of war would be *accurate weapons*, so specific targets could be pinpointed in order to maximize the efficiency of the forces. While fighting this war, the enemy would have goals and requirements; they would also be looking to target our values.

3.5.3 *Red Deterrent War.* Deterrence has a different definition in the Soviet Union than it does in the United States. According to Dr. Stephen Miller, the Soviets interpret deterrence as the prevention of imperialist attack on the socialist camp in an attempt to reverse any shift in the 'correlation of forces' in favor of socialism. The Soviet correlation of forces is a qualitative estimate of the ratio between the capitalist block and the socialist camp. It includes military power, but it also encompasses economic factors, domestic as well as international politics between the adversary classes, and ideological fervor. This definition was taken from two Soviet writers, A. Sovetov and A. Sergiyev as referenced by Dr. Miller in Air University Review.

The Soviets feel like they can never be sure that the 'imperialists' will not launch a nuclear attack. As a result, they must always be prepared to wage war that can destroy our military might and eliminate our industrial capabilities. This capability to wage war is the "prime essence of deterrence as well as the best assurance for survival if the irrational [sic] imperialists cannot be deterred." (22:54) The article goes on to explain that they consider that their first strike would be preemptive only in a sense of defensive rather than offensive aggression.

However, using the "four war" rationale, we perceive that the Soviets would assess our valued aimpoints and target them based on a priority scheme that they would develop. In this research only this one layer of perception can be evaluated, i.e. our perception of what they think we value most. Before listing targets which would provide appropriate deterrents to an American - initiated nuclear war, it must

be noted that first strike is not the policy of the United States. It is demonstrated here solely to define the war that the Soviets want to win.

Our primary values include our concerns are for our population. In order to produce a deterrent, this would lead the Soviets to target our major cities, like New York, or Los Angeles. Our industry is a significant concern, but not necessarily our war support industry. That would depend on whether the informed civilian or the military is making the judgement. Defense oriented or non-defense oriented industry and technology centers would comprise suitable threats depending on the perspective chosen in the analysis.

Our space technology centers would include targets such as Cape Canaveral or Vandenberg Air Force Base. These targets would represents threats to different aspects of our society. Civilian, military research and intelligence capabilities could be destroyed. This would put the U.S. at a disadvantage in military operations and in the "space race," not to mention in the dollars lost. Other technology centers such as Silicon Valley in California would be targets in the Red Deterrent War for the same reasons; we could lose our "edge."

Energy sources from natural resources to power generation facilities constitute something valued by environmentalists, the ultimate product, power, is essential to our survival and valuable to everyone. Food is a valuable commodity of course, so our farmland could be a target which, when put at risk, provides a good deterrent. Transportation is a necessary part of American life, so road and rail networks and

both civilian and military airfields would be suitably targetable in this type of war. In reality, any targeting within the United States would comprise enough of a deterrent to us since violation of our land is unthinkable and unacceptable.

3.5.3.1 Implications for Red Force Structure. Just as with targets, any weapons aimed at the U.S. constitute a suitable deterrent. However in targeting the aforementioned valuable targets in the United States, bombs with large megatonnage producing widespread effects would seem to be appropriate in light of: the size of our country (less spread out than the Soviet Union), the psychological effect of *any* detonations on our soil, and the accuracy of their weapons. The Soviet perspective has always been different from the American perspective and this is true for the fourth type of 'war,' the Red Warfighting war.

3.5.4 Red Warfighting War. The Soviets' objectives (as we perceive them) in this war would be a prolonged conflict and the ultimate capitulation of capitalism. The Soviet Union believes that nuclear war would be total war and the final battle in the class conflict between the capitalists and the socialists. They see themselves as winners in this type of war; they also see the final collapse of capitalism. Their ideology cannot accept the possibility of losing such a war to the West. Military power being in their favor at the beginning and at the end of a war is a prerequisite for this victory. Therefore targeting would first consider our strategic weapons to give the Soviets the decided advantage in the early stages of a war. Since correlation

of forces comprises all aspects of economics and politics, they could also target our leadership, our manufacturing, our airfields, our cities, and warfighting resources to gain a continued advantage and ultimate victory.

Just as in the Blue Warfighting war, the Red Warfighting war targets a wide range of targets. The difference in beliefs and in potential outcomes of these wars results from the comprehensive Soviet civil defense program. Soviet leadership can feel almost invulnerable due to intricate systems of underground protection. This feeling of security was validated in the early days of the Operation Desert Storm in the Persian Gulf. Saddam Hussein was able to maintain control while living and working four stories beneath ground level in a shock isolated facility covered by tons of concrete and steel. Because of these kind of protections, any war orchestrated by the Soviets could be more aggressive than America would ever be.

Here are some of the targets which the Soviets would aggressively pursue based on objectives stated in this section. They would try to hit Blue strategic weapons early in the war. Since Soviet ICBMs constitute the bulk of their counterforce capabilities, they would feel vulnerable to American ICBMs targeted at their ICBMs. Silos would be their primary target category in this war. Bombers, airfields and ships would also be targeted as well as warfighting resources. Our leadership and manufacturing would be appropriate targets in this war. Priority of some target categories would depend on whether the Soviets would prefer to maintain parts of our country's infrastructure for their own use after their imagined victory.

Now that the four wars have been described with respect to target categories, targets must be assigned values, so the methodology can transition to a more detailed model.

3.6 Notional Target Valuation

In order for any type of model to effectively produce optimal force structure, each target must be assigned a value. The targets first need to be prioritized and then a scale must be developed to assign values with respect to those priorities. This is where different perspectives would make their contributions, since each perspective (informed civilian and military) offers a potentially different value structure.

Let us now see how this might work in practice, using a notional target base. The target building blocks have been established. The three primary target classes are Military, Social/Economic and Government Leadership. Table 3.2 lists the target class pyramid.

Weighting for the valuation scheme is done mathematically based on a 20,000 point scale. The 20,000 is an arbitrary number based on the ease of reading the ultimate 'per target' values. The points are initially fixed and weights apply to each target class. Points are multiplied by the fractional weights at each level of the tree to assess points per major target class. Weights are allocated by priority of the target type in the class. Weight fractions assigned in each level of the tree are normalized to sum to one for consistency among levels and categories. The weight assignment

Military	Weapons	Non Time Sensitive Time Sensitive	Silo SLBM
	C3	Soft Control Centers Hard Control Centers Communications	Time Sensitive Non Time Sensitive
	Operations	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	

Table 3.2. Target Base

and subsequent multiplication is done at each level until, at the bottom of the tree, the most specific target class' points are divided by the number of targets in that class. See Figure 4.1 as one example of the assignment of weights and points.

3.7 Conclusion

This chapter has described the general approach to the methodology. The next chapter describes an example of a use of the methodology. The final chapter describes implications of the results of the example used.

IV. Demonstration of Methodology

4.1 Introduction

This chapter demonstrates a use of the method described in Chapter III. The chapter begins with basic assumptions for this particular demonstration and is followed by a description of target categories, weightings, and valuation schemes. Finally, the results of applying the methodology in a quantitative manner, using an aggregate linear goal programming model (the Arsenal Exchange Model) are presented.

4.2 Assumptions

Only two of the four wars are generated in this demonstration. The Blue Deterrent and the Blue Warfighting wars are chosen. The methodology could have been demonstrated with any combination of the four wars and these are chosen for their ease of explanation of weapon and targeting information. They are also chosen to show the importance of comparing force structures which result from different objectives in war. Both sides' forces are considered generated to alert/alert status, prepared to launch on tactical warning. This assumption helps establish target hardness and vulnerability and the capability of the forces.

Numbers of forces in Table 4.1 are based on open source force structures (20:63).

NAME	NUMBER	WARHEADS/ CARRIER	CEP (FT)	YIELD (MT)
MINUTEMAN 2	450	1	2048	1.2
MINUTEMAN 3	200	3	715	.17
MINUTEMAN 3A	300	3	715	.335
PEACEKEEPER	50	10	293	.3
POSEIDON	256	10	1495	.04
TRIDENT	384	8	423	.1
B-52 G/H	141	8	330	1.08
B-52 G/H/ALCM	122	12	293	.2
B1B	16	12	330	.75

Table 4.1. Total U.S. Forces

The forces are further constrained in the model by a set of unclassified proposed START limits to form a feasible region of interest.

Numbers and categories of targets are notional. Estimates for numbers of targets have been compiled from various sources. A study done by Air Force Studies and Analyses provides ideas on round numbers of communications targets and leadership. Target categories are based on Chapter III descriptions of types of targets required in each of the four wars.

An analyst performing this analysis for arms control negotiations in the real world would use current targeting guidance provided by SAC and the Joint Strategic Target Planning Staff (JSTPS) to establish an actual target data base.

The notional target weightings are based loosely on an interpretation of the Military perspective for this demonstration. This could also be done from the other

perspectives to provide further insight. For this research only the Military perspective is developed to demonstrate the methodology.

It is a fact that nuclear arms limits are necessary for both sides, due not only stability factors but also due to budgetary limitations. One of the assumed motivations for developing and testing this methodology is to contribute toward development of rational force structures which represent a reduction in nuclear forces. This methodology uses target valuation to develop force structure and target weights must be designated to compute target values.

4.3 Relative Target Weighting

Based on whether the war being evaluated is the Blue Deterrent or the Blue Warfighting war, relative weights for each target class had to be assigned for the ultimate assessment of target valuation. Each category is assessed a weight relative to the other categories on the same level of the tree depending on their respective worth in each situation. For example, in a notional illustration of the Mild Deterrent War, Figure 4.1, Leadership targets are weighted with a factor of .6, the Soft Leadership category is weighted with a factor of .2, so the total points in this Soft Leadership category are $.6 \times .2 = .12 \times 20,000$ or 2400 points. With 300 targets in this category, that corresponds to a value of 8 points per target. Weights are assigned so that, in each level of the tree, they are normalized to sum to equal one to ensure consistency within and among the categories and between levels of the tree. See Figure 4.1

through Figure 4.4 for notional illustrations of all four types of wars.

What follows is a description of weighting schemes for two wars so comparisons can be made. Note again that these values are notional based on interpretation of the literature. As discussed in Chapter III the numbers for the Blue Deterrent represent an interpretation of our military's perception of the Soviets' values, while the Blue Warfighting values represent an interpretation of Blue objectives in a war when deterrence has failed.

4.3.1 Blue Deterrent War. In this war State leadership would be the most valued target and would therefore carry the highest weight. The most important government leadership positions would reside in hardened structures. Soft leadership centers are not as important to our targeting, but they are easier to damage. The ability to damage softer, less valued targets with relative ease leads to a concern about linking target value to VNTK since Damage Expectancy (DE) is easily accrued on softer targets at the expense of ignoring more valuable targets. Hardened targets must be considered high value targets since they are so well protected. Value in this regard would be measured by weapons needed and ultimately used. VNTK is the surrogate measure of survivability that is chosen for this research. Other measures of survivability that could have been considered are dispersion or number of redundant targets.

The Social/Economic category would carry the least weight. Even though, for both of the wars which are described here, the Social/Economic category car-

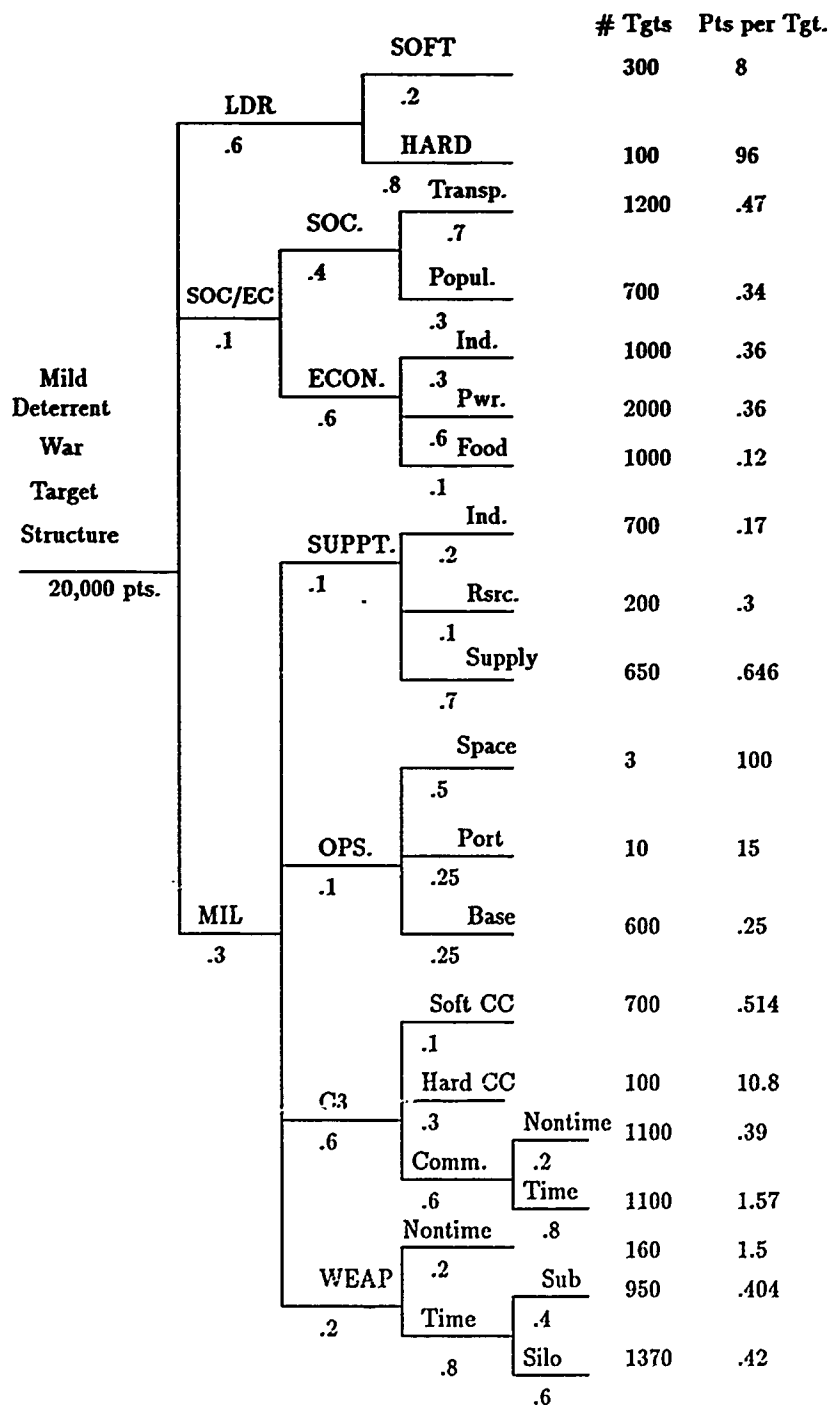


Figure 4.1. Mild Deterrent Tree

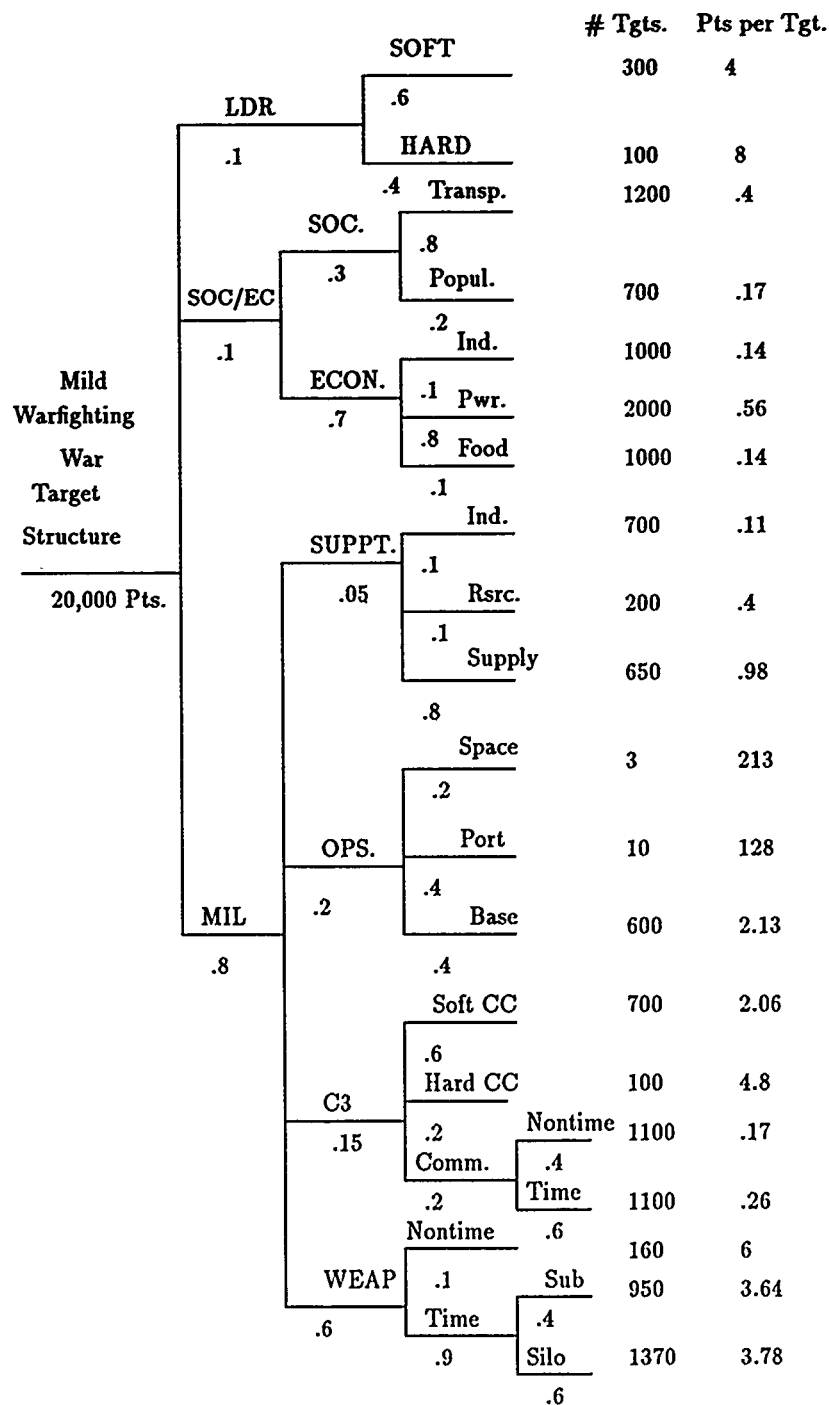


Figure 4.2. Mild Warfighting Tree

ries such a small weight, it must be represented in the scheme to provide a sense of consistency in all wars which could possibly be represented. For example, our Social/Economic structure would serve as the highest value to the Red planners in valuation of targets in the Red Deterrent war. In this category, infrastructure targets such as transportation and power generation facilities are the most valued targets based on our perception of the enemy.

In the Military category, Command, Control and Communications sites (C3) are the most important targets and the C3 category is weighted appropriately. Time sensitive Communications comprise a highly weighted category since leadership would need the contents of this category to communicate launch orders to the forces which would most likely not launch without positive communication from their leadership. Hardened military control centers as a category would shelter the most significant actors in military decision-making, so its value is highest in C3 sub-category. Time sensitive communications would constitute an important method for leadership to convey orders so it has relatively high value in its sub-category.

Support and Operations are not weighted as highly for this war but must be present for weighting and valuation consistency in all wars. Attacks on space assets, defense industry and supply would constitute significant losses as they appear to be highly valued by the Soviets based on the proportion of the budget allotted to them.

4.3.2 Blue Warfighting War. In contrast to the Blue Deterrent War, this war sees the state leadership with a much lower value as a target, since the objectives of

this war seek to maintain government leadership to facilitate negotiations to end the conflict as early as possible. Soft control centers would have much higher weight as a target since the important leadership would most likely reside in hardened facilities. The low weightings on the hardened leadership control centers would contribute to the survival of the most important government leaders. Transportation links in the social category would be highly weighted because their destruction would prevent their use as military byways for equipment or road and rail mobile weapons. Power generation facilities are also relatively highly weighted as they are a significant aspect of the infrastructure and have potential military applications.

The military category has extremely high value and, therefore, weight in this war since the quicker and the more completely we can destroy the enemy's military capability, the sooner the war can end. That is the major goal of the warfighting war. For illustrative purposes in this example, the enemy's weapons have the highest value as targets. Time sensitive missile silos and nuclear submarines have the most important priority.

Other operational bases including Space resources are the next priority since the missions they support are integral to the war effort of the enemy. As the Support category has been established in this example, support areas are not so heavily weighted. There is not as much time urgency to destroy the defense industry or its resources. Supply is weighted most highly as a sub-category since it could provide assets to the Red war effort.

In this example, C3 is weighted quite low since it is necessary to the blue war effort for red communications lines to remain undamaged in the event that either side needs to negotiate a surrender.

4.3.3 The Red Wars. As stated earlier, this research will only illustrate the target valuation methodology from the Blue perspective, but it is clearly appropriate to apply differing perspectives. Target class weights for each of the Red deterrent and warfighting wars would be developed similarly. Their target weights would be dependent on what is perceived to be of value to the Blue society, and the goals and objectives of the Soviet military policies and guidance. Perceptions about how the Soviets view our values would have to be evaluated in order to do justice to the weighting system.

4.4 Target Valuation Scheme

As mentioned in Chapter III, valuation is based on a 20,000 point scale. Values are distributed for each war as summarized in Table 4.2.

In order to model behaviors of different types of people who assign values, two different philosophies are modeled. They are designated as Dramatic and Mild value systems. They are defined by the ratio of highest class weight to lowest class weight within the entire targeting system. In the dramatic value system, lowest and highest weights differ by orders of magnitude as illustrated in the Tree figures.

Target Name	Number of Targets	Dramatic Deterrent Values	Dramatic Warfighting Values	Mild Deterrent Values	Mild Warfighting Values
SILO	1370	.4200	3.7800	.3920	6.8290
SLBM	950	.4040	3.6400	.2430	4.221
NTW	160	1.5000	6.0000	1.2000	.8440
TCOM	1100	1.5700	.2600	.5500	.0390
NTCOM	1100	.3900	.1700	.0610	.1570
HdCC	100	10.8000	4.8000	25.2000	.0900
SftCC	700	.5100	2.0600	.2400	.9640
BASE	600	.2500	2.1300	.1000	1.8000
PORT	10	15.0000	128.0000	6.0000	54.0000
SPACE	3	100.0000	213.0000	40.0000	360.0000
SUPPLY	650	.6500	.9800	.2770	1.0380
RSRC	200	.3000	.4000	.0600	.2250
DEFIND	700	.1700	.1100	.0690	.2570
FOOD	1000	.1200	.1400	.0075	.0375
POWER	2000	.3600	.5600	.0600	.3000
NDEFIND	1000	.3600	.1400	.0225	.1125
PEOPLE	700	.3400	.1700	.0179	.0179
TRANSP0	1200	.4700	.4000	.0313	.1980
HdLDR	100	96.0000	8.0000	127.5000	.1000
SftLDR	300	8.0000	4.0000	7.5000	3.3000

Table 4.2. Notional Value Systems

The Mild value system represents a decision maker whose values across the broad spectrum do not vary much. The Dramatic value system represents someone with more starkly varied priorities in his value system when comparing weights of target classes. The weights do not translate directly to point values of targets. The number of targets in each class cause per target values to assume altered priorities. Different philosophies also contribute to different values per target, yet lead to force structures that are surprisingly similar. The next section of this chapter will outline

results of the force allocations based on the mild and deterrent value systems for both the Blue Deterrent and the Blue Warfighting wars.

4.5 Results

Several different runs are accomplished with the Arsenal Exchange Model (AEM) to demonstrate the quantitative results of the methodology from many differing aspects. The AEM *optimizes* Damage Expectancy based on input factors such as weapon characteristics, target characteristics, and value, which is calculated and input on a per target scale. The AEM optimizes value damage expectancy subject to force size constraints as well as other constraints, input as AEM hedges. In this analysis, a hedge is used to ensure a value damage expectancy goal of 80%.

Hedges are also used to draw down the original weapons base from current forces to proposed START limits. Figure 4.5 explains the analytical philosophy of using hedges in this way. The "X" Axis represents forces belonging to one leg of the TRIAD, generally by type (ex. ICBM) or specifically by weapon system (ex. MMIII). The "Y" Axis represents another leg of the TRIAD or another weapon system. The simplifying assumption is that no new forces would be built, thus START draw down would be from current forces as further illustrated in the figure. The limits input into the model as hedges, include:

- The total of all warheads could not exceed 6000
- The total of ICBM and SLBM warheads could not exceed 4900

- The sub-limit on ICBM warheads could not exceed 3300
- The total warheads from heavy ICBMs (Peacekeeper) could not exceed 1540

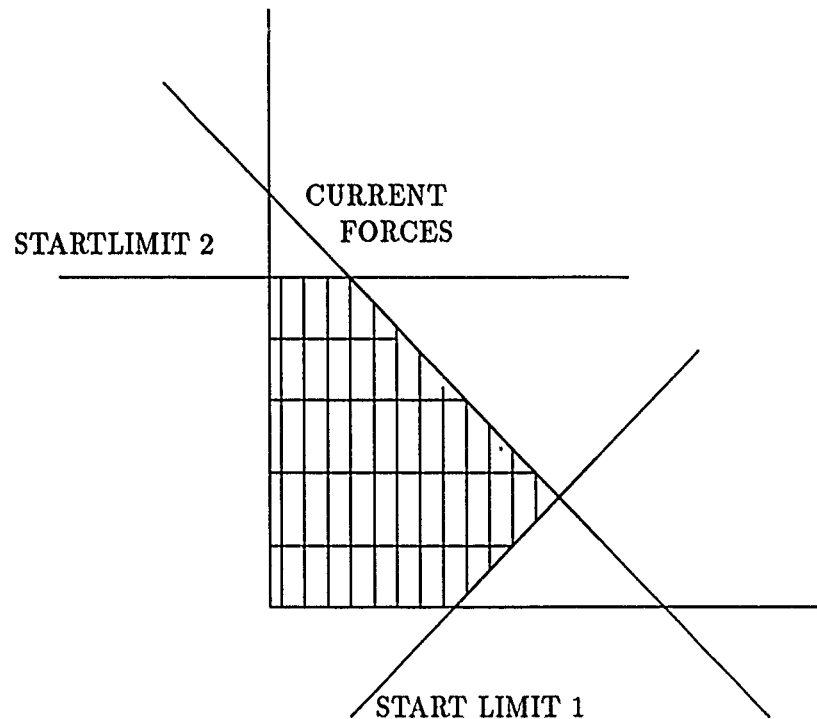


Figure 4.5. Feasible Region

Another use of hedges is to model operational concerns that are inappropriate to target value. In one case, bombers and SLBMs are prevented from attacking silos, SLBMs and time sensitive communications targets to ensure prompt weapons are applied to time-sensitive targets.

Cases examined:

- DRAMDET = Dramatic value system used for Deterrent War
- DRAMWARF = Dramatic value system used for the Warfighting War
- MILDDDET = Mild value system used for the Deterrent War
- MILDWARF = Mild value system used for the Warfighting War

The results of the two wars with respect to hedges and value systems are summarized on Tables 4.3 and 4.4. When the maximum damage is *not* set at 80%, all weapons are allocated, subject to other hedges, with the resulting higher Value Damage Expectancies. The number of weapons allocated in this case represents the force limits set by START. Given reductions to START levels, these forces produce the optimal value destroyed. Later in this thesis, this case is referred to as "optimized" as opposed to the 80% case which is called "hedged" for ease of explanation. The hedged runs produce suboptimal allocations, just decreasing the level of value attacked to reach the 80% level instead of decreasing the number of weapons.

Most of the diagrammed numbers of weapons naturally represent the total of available weapons subject to START force limits because the input constraints did not require a Secure Reserve Force (SRF). The model uses as many weapons as possible, subject to the constraints of the START limits, showing little sensitivity to changes.

	MILDDDET (85%)	MILDDDET (80%)
ICBM	2450	2450
SLBM	1627	763
BMBR	1920	2784
	DRAMDET (97%)	DRAMDET (80%)
ICBM	2450	312
SLBM	763	0
BMBR	2784	545

Table 4.3. Deterrent Force Structures

	MILDWARF (81%)	MILDWARF (80%)
ICBM	2450	2347
SLBM	763	866
BMBR	2784	2784
	DRAMWARF (86%)	DRAMWARF (80%)
ICBM	2450	2450
SLBM	763	763
BMBR	2784	2784

Table 4.4. Warfighting Force Structures

However the results of the optimized Mild Deterrent show a higher SLBM warhead requirement and a related decrease in the Bomber warhead requirement as compared to the MILDDDET with the 80% hedge. A result like this can easily be a source of contention, even between the inter-service perspectives. An informed civilian might agree that an 80% or maybe an even lower percentage is all the value damage required for that type of war. It is interesting here that the constant cost in terms of a simplistic total of (5997) warheads is the same for both percentages. A true dollar cost comparison could be done in a real world analysis because the distribution of weapons is different and may lead to more obvious requirements if dollar cost is considered as an added constraint -- as it clearly would be from the political perspective.

Results of the Dramatic Deterrent runs are even more revealing. There are striking differences in the unrestricted optimized versus the 80% hedged force structures. For example, the unrestricted force structure uses the total START weapon complement and achieves 96% value damage, where the hedged force structure requires only 857 total weapons composed of a diad of forces and achieves 80% damage. This again could be an inter-service source of contention.

It would be possible to build a set of constraints to maintain the politically required triad of forces regardless of the results. By simply turning those constraints off, one could immediately quantify the cost of requiring the TRIAD as a safeguard against failure of one leg due to future technological advances such as a credible,

highly threatening Anti Submarine Warfare (ASW) capability. These results also show that there is a 5140 weapon cost associated with 17% more value damage. Decisions could be made depending on how much that extra value is worth to the decision maker.

Other hedges are tested in the Dramatic Deterrent. From 70% down to 50%, the diad of Strategic Air Command bombers and missiles persist. At 20% it degenerates to a unad of ICBMs. The highest valued targets are the only ones attacked in all of these hedged force structures. The dramatic nature of the value differences forces the severely constrained forces to concentrate on the highest ones only.

VNTK plays a role in assigning the priorities of targets hit. High value soft targets provide the best return since it costs the fewest weapons to achieve the most value damage. Low value hard targets provide the worst return since it costs the most weapons to achieve little value. High value hard targets and low value soft targets compete for the second and third positions in this spectrum, depending on their individual increase of value damaged due to marginally applied weapons. This target value inversion would only occur with marginally applied weapons.

As hard targets represent value to the enemy they are assigned higher values. Since it takes more weapons to achieve a comparable level of damage, they get more attention than softer targets with even higher values, when the marginal value of attacking other targets is not more advantageous. This can further be explained using the concept of marginal value. A hard target returns more value for the

marginal weapons because each extra weapon arrives with more value remaining to be destroyed. The example is in Table 4.5.

# Weapons	DE Hard	delta	DE Soft	delta
1	.500 ₂	-	.900 ₁	-
2	.750	.250 ₃	.990	.090
3	.825	.125 ₄	.999	.009
etc.				

Table 4.5. Marginal Returns

For this example, assume the targets have equal values; without loss of generality, assume that value is 1.0. The first weapon would be fired on the highest (.900) damage expectancy soft target, achieving a DE of .900 and obtaining $.9 \times 1.0 = .9$ value damage points. The second weapon would be fired on the hard target achieving $.5 \times 1.0 = .5$ value damage points. The third weapon would be fired on the hard target, this time achieving $.250 \times 1.0 = .250$ value damage points. The next weapons would be fired on the targets with highest delta DE in order of descending delta damage expectancy.

Warfighting force structures can be analyzed the same way. The primary objectives of this war encompass many hardened silos and therefore the 80% constrained force structures achieve most of their value damage attacking those targets.

In the Mild Warfighting War, both force structures use all 5997 weapons, however the distribution is somewhat different. This time however, there is only one percent difference between the optimized and the hedged results of value attacked.

The Navy gains 103 weapons but this time at the expense of the Air Force missile force instead of the bomber force.

The Dramatic Warfighting force gains six percentage points but both the optimized and the hedged wars require the same total number of weapons. Once again, further analysis could be done on the dollar cost of the distribution of the weapons prior to any ultimate decision. But for our purposes, the aggregate force structures and the resulting value damage expectancies are the most revealing.

The Deterrent and Warfighting wars within each class (Dramatic and Mild) can also be compared. Comparisons of cumulative number of targets attacked versus accumulated value points can be accomplished. Examples of these types of results in the Dramatic class are located in Figure 4.6 and Figure 4.7. Examples of these types of results in the Mild class are located in Figure 4.8 and Figure 4.9. These figures are valuable to show the cumulative value damage achieved with each type of force structure. At first glance these figures could be misused by someone who looks only at these figures for developing ideas for force structuring. In fact these figures should only be considered in conjunction with significant qualitative factors such as military judgement, uncertainties, breakout potential and history, which must temper any quantitative analysis.

Results of numbers of each type of weapon used in each type of force structure are in Table 4.6 and Table 4.7.

Weapon	MILDET	DRAMDET	DRAMDET80	MILDET80
MM2	450	450	312	450
MM3	600	600	0	600
MM3A	900	900	0	900
PKPR	500	500	0	500
POSIEDON	0	215	0	763
TRIDENT	1627	548	0	0
B-52G	1128	1128	0	1128
B-52/ALCM	600	1464	545	1464
B1B	192	192	0	192

Table 4.6. Weapons by Type

Weapon	MILDWARF	DRAMWARF	DRAMWARF80	MILDWARF80
MM2	450	450	450	450
MM3	600	600	600	600
MM3A	900	900	900	797
PKPR	500	500	500	500
POSIEDON	12	763	763	866
TRIDENT	751	0	0	0
B-52G	1128	1128	1128	1128
B-52/ALCM	1464	1464	1464	1464
B1B	192	192	192	192

Table 4.7. More Weapons by Type

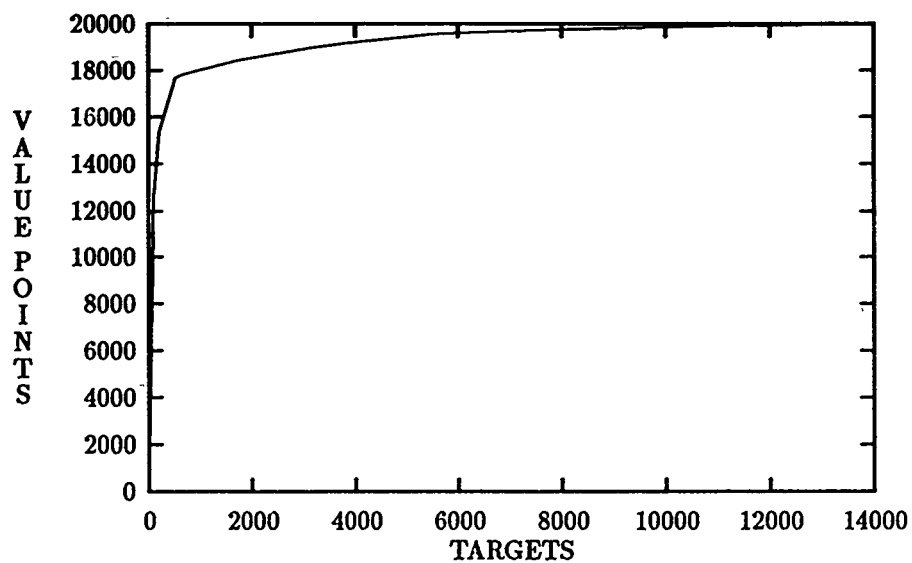


Figure 4.6. Dramatic Deterrent

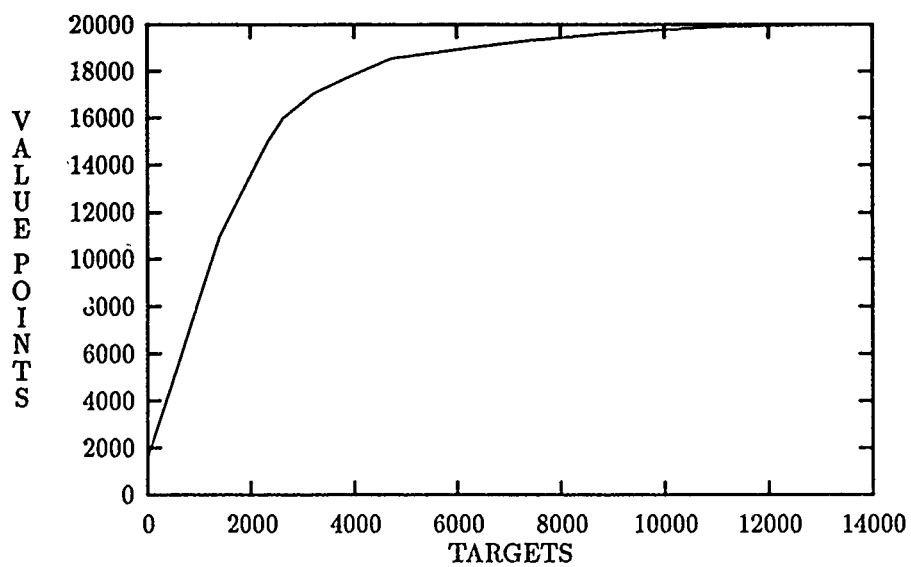


Figure 4.7. Dramatic Warfighting

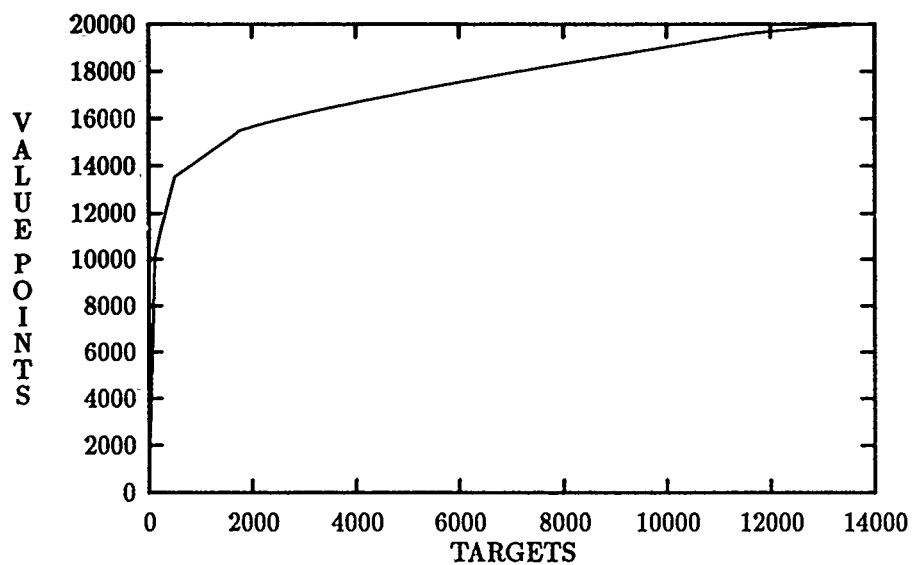


Figure 4.8. Mild Deterrent

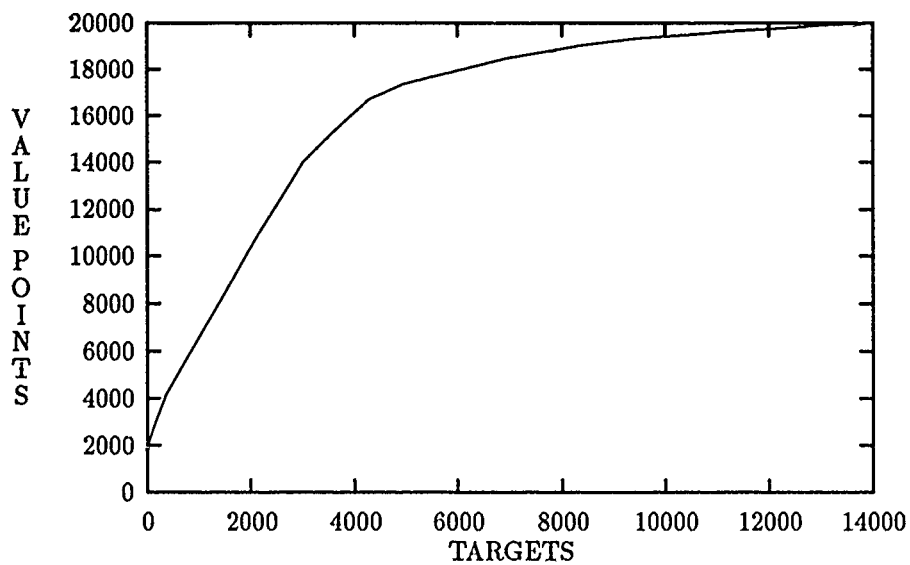


Figure 4.9. Mild Warfighting

Comparing the deterrent versus warfighting within the dramatic class is very similar to comparing them within the mild class. Even though there are differences in coordinates plotted, the basic shapes of the curves are compared and contrasted similarly. The deterrent wars in both classes have an expected steep start on the curve since the highest value targets have much heavier weight associated with them. They peak early and then level off to complete the remainder of the cumulative value points. The warfighting wars have correspondingly smaller slope increases due to less magnitude variation in their target values.

4.6 Implications

These results have revealed valuable observations about the methodology presented and insights into its use. Further implications of these results and thus the methodology are discussed in Chapter V.

V. Conclusions and Recommendations

5.1 Introduction

This final chapter draws some conclusions about the aforementioned results and methodology. Implications of this research can apply to and be useful for analysts throughout the military community. The target valuation approach is a topic which has been of interest for a while and information about its utility is always welcome. This chapter also recommends further research ideas in this area of study since there are always new areas to be explored.

5.2 Conclusions

One of the basic conclusions of this type of analysis is that when there are many more weapons than targets, *target value* does not matter in this weapons rich environment. Thus, in a target poor environment, it is hard to capture the importance of target classes since, in the model we have used (AEM), all weapons are fired and fewer decisions have to be made about the overall size of the force structure. However, when hedges on damage percentages (force limiting) or other hedges are imposed, the allocation does make force structure decisions, which change the number of weapons required. The model optimizes mathematically but it causes politically sub-optimal allocations unless several hedges are included in the input.

When these hedges are imposed and the force structure remains the same (See Dramatic Warfighting in Figure 4.4), this shows clearly that the model (AEM) has just forced all weapons to be allocated. To decrease the value destroyed to 80%, it hits less valuable targets and still uses all the weapons for a sloppier allocation. The result is changing the *use* of the weapons but not enough to change the *allocation of the number* of the weapons. Since this method has forced a sub-optimal allocation, it seems to invalidate the use of the straight value damage percent hedge to represent other perspectives points of view. For example, the ultimate objective (in terms of force structure) of an informed civilian requiring a decreased percentage of damage would be to decrease the number of weapons that the United States would need. If the only results include using the same number of weapons in a different way, this provides no input to force structuring (although close inspection of targets hit may show implications for targeting – but that would be another subject of study). Better use of the model is suggested; perhaps hedges for Secure Reserve Force in combination with hedges for value damage could solve difficulties encountered in this study and make the target value approach more workable.

The Dramatic Deterrent results in Figure 4.3 show another problem with the methodology. Here the number and types of weapons are changed, but too drastically. The analytical weakness here is that weapon value is directly measured by the application of the target value approach. Eliminating one leg of the Triad is a politically unsound result generated by this approach. As mentioned in Chapter IV,

constraints could be added to the formulation of the problems to maintain the triad of forces, but that would be considered an artificial work-around. If all perspectives were to be evaluated, and they all had their particular requirements and/or desires, there would be absolutely no consistency among their results and no common ground on which to discuss the implications of the results.

An observation which must be reported is that target hardness can also indicate to us how important a target is to the Soviet Union and vice-versa. If they take the time and resources to protect a portion of their leadership, for example, we can assume that those military or government leaders are prominent in the country and vital to the country's survival. That translates to a higher value in our target valuation methodology. Knowing hardness factors for various enemy targets can improve accuracy in assigning values to them. However it is also shown that target hardness can also work against the target value system, as it makes the model decide priorities based on how many weapons it takes to destroy a target. Hard targets take more weapons, soft targets get shot at first in our example. That serves as kind of a "double jeopardy." Refer to Chapter IV Results.

Individual target values, as they've been established, may be misleading in appearance of relative importance, since the aggregation in the AEM multiplies each target's value times the number of targets in the class. If the value on each target is low, but its class is large, the class acquires a disproportionate share of the total value, but may not be attacked because the marginal return is poor on each target.

Subjective values are hard to acquire. In this exercise it is difficult to assess relative weights notionally; in the real world there are many considerations to be taken into account based on one's perceptions and allegiances. Developing an instrument to determine decision makers' value systems would be a very difficult and complex task. It appears, from efforts in this work to develop notional values based on only the impressions of the author, that anticipating leadership's requirements and desires might be a very challenging if not an impossible, staff function. The issue of value estimation is addressed further in the Recommendations section.

A decision maker whose value system is comprised of dramatically different values can predispose the results toward a certain answer. In some cases this could be positive; however, it could also prove to be prejudicial and serve some sort of hidden agenda. The target valuation method could detect this result through simple observation of favored results due to excessive skewing of the target values. This type of decision maker can learn very quickly how to game the system. Any of the perspectives already discussed, including inter-service perspectives, could fall into this category and use that type of result to lobby a specific position.

As mentioned in Chapter IV, different results can be interpreted to favor different services. For example the force structures which indicate a diad of Air Force Strategic Air Command missiles and bombers could cause consternation with the Navy due to omission of SLBMs. A proper indication of intent of the study must be made in any case. Typical intents would include political, economic, strategic

optimization of the results. Points of view within and outside the military must be reconciled; political, as well as military goals must be considered. A study which serves to develop force structure, while maintaining the Strategic Triad, would not produce the most optimal results, but it would keep the results politically feasible.

A proper value structure could at least have different participants in negotiations understanding each other's motivations. It can also lead to more understanding among different camps on the same side of the table. When Deterrent and Warfighting wars on one side lead to different force structures, there must be some sort of conciliation in order to produce a position from which to ultimately negotiate. A study of value systems, while it may not produce a significant affect on allocations of major weapon groups based on target valuations, does compel the analyst to learn about different perspectives and the dynamics involved in force structure and policy making. This methodology is designed considering the analyst's use.

5.3 Recommendations

A closer analysis of target data bases and associated weightings in relation to the published guidance could be beneficial to any strategic analyst or student of strategic studies. A look at the percent of the budget dedicated to a target type may provide revealing insights to the enemy's values for input to values in the deterrent war. The enemy's funding budget could also give insight into how his forces are prioritized and structured.

Development of an instrument to analyze leadership's value systems based on the four wars could prove useful. Perhaps a type of survey comparing every possible combination of real target types could be developed. The results of this survey could be run in a specially designed computer program to determine the value structure. The computer program could aggregate many military leaders' answers to develop a clear picture of the military perspective. Within the military perspective, it would be also worthwhile to study inter-service values especially with the currently developing emphasis on joint operations and the "purple suit force."

The same type of instrument could be presented to the informed civilians to the same end. Then their perspectives could be aggregated. Then the informed civilian and the military perspectives possibly could be aggregated to determine a negotiating position the whole country could support. If there was some way to determine the value system in the Soviet Union it would give our leaders a better feel for what we are up against and a better feel for the game theoretical positions in the negotiation process.

Finally, one must exercise extreme caution when using any approach where subjective data is being generated. There could be a tendency to lean a certain way when there is some desired outcome from some unrelated agenda.

5.4 Final Thoughts

Often, force structure decisions seem to be made in a vacuum. The military point of view dominates the process and it is only influenced by budgetary and some political constraints. Viewing force structuring from different perspectives provides a fresh outlook on significant issues. The value approach quantifies the perspective by assigning target values to determine forces deemed necessary by that perspective. Using strictly value approach is somewhat revealing, in that, along with VNTK, value can determine the use of forces. However hedging for a lower percent of damage expected does not seem to accurately represent perspectives primarily due to the use of the model used in this work, as the allocation deteriorates and similar forces are used. Better use of the model could lead to a better indication of the significance of the target value approach.

Methods for determining credible force structuring decisions remain a high interest area for strategic planners. Arms control negotiations depend on substantial forces so stability is preserved. To sum it up, Vice Commander-in-Chief of Strategic Air Command, General Donald O. Aldridge declared:

The U.S. must maintain a credible nuclear retaliatory capability in order to negotiate arms-reduction agreements with the Soviet Union from a position of strength. Such negotiations notwithstanding, the Soviet Union is still the only nation with the means to destroy our society as we know it and nuclear deterrence will be a necessity for the U.S. as long as that [Soviet] capability exists. (4:26)

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Vita

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