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Soviet Strategic Nuclear Measures of Effectiveness

Claire Mitchell Levy

RAND

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Prepared for the
United States Air Force

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PREFACE

RAND has conducted work under Project AIR FORCE's National Security Strategies Program examining Soviet objectives and concepts for the employment of nuclear forces. This work emphasized a Soviet-style approach to force employment, seeking to shed light on how Soviet planners might view the strategic nuclear balance, specifically how they would quantify the balance and the likely results of nuclear exchanges.

One element of this work was the development of measures of effectiveness (MOEs) which the Soviets might employ in their assessments of the balance. This Note examines possible Soviet measures which *might* be used at the General Staff level[1] and which could be appropriate in analyses using a U.S.-style strategic exchange model, in order to compare Soviet balance assessments with U.S. evaluations. It is important to note that this work only *examines* these measures and assesses the likelihood of their use today. The *application* of these measures is a central purpose of the project, and will be described in a forthcoming publication.

Dramatic changes have taken place since this work began, principally the breakup of the Soviet Union. The emerging countries of the former Soviet Union (FSU) have not yet fully formulated their nuclear doctrine, but it is likely that this will be built on the experience of the Soviet military. It is in this context that this Note might be of some interest. A complete list of project documentation is available through the Air Force Intelligence Agency/INI, which sponsored the research, or Project AIR FORCE.

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[1]The operative word here is might. To the best of the author's knowledge no one in the West has exact knowledge of which analytic tools the General Staff uses for its planning purposes.

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SUMMARY

SOVIET TAXONOMY OF MEASURES OF EFFECTIVENESS

The Soviets have a well-defined, integrated and scientific framework for measures of effectiveness of military forces, including definition, purpose, requirements, and form.[1] This differs somewhat from the West where the science of measures of effectiveness (MOEs) has been developed separately for intercontinental nuclear and theater forces, but an overriding structure of MOEs for all force types is lacking.

The Soviets place several requirements on the determination or selection of a criterion of effectiveness. The simplicity of these requirements should not belie the difficult task of providing a balance between accuracy and simplicity. These requirements include:

- The efficiency criteria must objectively characterize the process of combat activity;
- They must have direct relationship to the target of combat action;
- They must be sensitive (or as is said, quite critical) to changes in those quantities the values of which must be defined as a result of investigation;
- They must be quite simple so that their physical meaning is understandable and it is convenient to calculate, graphically depict, and analyze them.

This Soviet taxonomy of MOEs is useful both in understanding and using Soviet MOEs, as well as in developing U.S. measures of effectiveness. *Appropriate* use of MOEs is critical, ensuring that the measure selected appropriately reflects what it is trying to measure.

SOVIET STRATEGIC NUCLEAR MEASURES OF EFFECTIVENESS

The purpose of this research is to analyze the specialized Soviet military operations research and modeling literature for insights into Soviet views about measures of merit for assessing the intercontinental nuclear balance and the effectiveness of intercontinental nuclear forces. It seeks to identify specific measures which might be used at the General Staff level, and which could be appropriate for use in a U.S.-style strategic exchange model, in order to compare Soviet balance assessments with U.S. evaluations.

[1]The existence of such a framework does not imply that the substance of that framework, specifically the MOEs, are any better than U.S. measures, or that they can measure them adequately.

Four different Soviet MOEs for strategic nuclear forces are identified and defined, all of which are a type of correlation of forces:

1. Quantitative Correlation of Nuclear Forces (QCNF)
2. Equivalent TNT CNF (ETNT CNF)
3. Anureyev CNF (ACNF)
4. Destruction Potential CNF (PD CNF).

The first Soviet MOE for strategic nuclear weapons, the quantitative CNF is a simple ratio of numbers of similar types of weapons. It was the first MOE for strategic nuclear weapons. The ETNT CNF takes account of qualitative differences in the destructive power of warheads through a ratio of equivalent TNT. The Anureyev CNF provides a full complement of qualitative factors, including both ETNT to account for differences in warheads, and planning factors to account for differences in weapons launchers. Finally, the PD (Destruction Potential) CNF accounts for qualitative differences in weapons through explicit damage calculations, rather than a TNT proxy.

The conclusion of this research is that the PD CNF is most likely the form of measure used today. The Anureyev and ETNT forms of the correlation of nuclear forces provided a bold first cut at MOEs for strategic nuclear forces, but they were only adequate for assessing damage to soft targets. They were inadequate in assessing damage to hard targets, which numbered approximately 900 in the mid 1960s,[2] and whose ranks have substantially grown in the past 25 years, both quantitatively and qualitatively. A second measure which is still used today is the quantitative correlation of nuclear forces. Sources indicate that while this is not an ideal measure, it is still widely used in the community, largely because it is simple and familiar.

It is important to note that the Soviets recognize that none of these measures is perfect, citing that "it is obviously impossible to establish a single and universal effectiveness criterion."[3] Although a difficult task, Soviet military writings have traditionally placed great emphasis on the importance of and difficulty in selecting a measure of effectiveness.[4] Therefore, it is likely that the correlation of nuclear forces measure will continue to evolve in

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[2]In 1966 the United States had 904 ICBM silos (see Appendix C). Unclassified data for other hard targets, such as underground command and control bunkers, is unavailable.

[3]V. I. Varfolomeyev and M. I. Kopytov, *Design and Testing of Ballistic Missiles*, Voyenizdat, Moscow, 1970.

[4]The golden era of Soviet military operations research, when considerable assets were devoted to the topic of measures of effectiveness, was from the mid 1960s through 1980.

the future, or completely new measures might be developed. This is particularly important in the context of recent changes in Soviet military doctrine. Since MOEs measure the ability of forces to implement military doctrine, if that doctrine changes, it is plausible that the measures used to gauge the capability of their military forces might change, as well. While it is still too early for any concrete evidence, there are several key factors which could have an impact on Soviet MOEs:

- Entrance of civilian researchers into the modeling field
- Doctrinal changes
- Development of a more balanced triad
- Development of Soviet strategic measures along the same lines as Soviet conventional measures.

ACKNOWLEDGMENTS

The author has benefited greatly from an exchange of ideas on this topic with a number of people. In particular I would like to express appreciation to John Battilega, Michael Phelps, Allan Rehm, and Paul Rossa for a variety of interesting discussions. RAND colleagues Edward Warner and Robert Nurick provided comments on earlier drafts, as did the Office of the Secretary of Defense/Net Assessment and the Air Force Intelligence Agency. The Director of Research and Soviet Studies, Headquarters, Air Force Intelligence Agency, Lt. Col. Murphy Donovan, was an active and enthusiastic supporter of this work. Glenn Buchan's thorough review of the document has only enhanced its value. Peter Stan served as project leader for the overall effort. These contributions have all helped to strengthen the value of this document.

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FIGURES

1. INTRODUCTION

There has been much discussion among analysts in the United States in recent years concerning measures of effectiveness (MOEs) for strategic nuclear forces. As these forces have evolved in capability, so has the need for providing a better measure of the effectiveness of those forces, and of their contribution to national security objectives.

Virtually all parties agree that static measures of strategic nuclear forces[1] do not provide a true measure of the capability of those forces. A more *dynamic* measure of the use of those weapons is needed, although there is skepticism regarding the relevance of even dynamic measures in assessing the strategic balance. In the United States, aggregate damage expectancy (DE)[2] has become the most widely used currency of strategic force effectiveness. While this is the best *single* measure of effectiveness available, it is widely recognized that this measure falls short in many areas.[3] Thus, efforts have been underway in this country for many years to either improve upon DE, or to find additional or alternative measures that incorporate many or all of the necessary factors.

The Soviet military community has entertained a similar debate concerning MOEs for intercontinental nuclear forces. This debate dates back to at least the mid 1960s when Soviet military analysts recognized that strategic nuclear weapons were fundamentally different from existing conventional armaments, and therefore, traditional measures were inadequate to capture the capabilities of these new weapons.[4] New measures would be required to assess their effectiveness and their contributions to military goals and objectives.

[1]Static measures describe weapon inventories prior to any force employment. Some examples of traditional static measures are numbers of launchers or warheads, and equivalent megatonnage (EMT).

[2]DE attempts to assess the capability of a set of forces to damage a given target set. DE factors into the probability of kill of a weapon against a target of specified hardness; these factors include prelaunch survivability (PLS), reliability, and probability to penetrate the defenses (PTP).

[3]DE incorporates more key factors than any other single strategic MOE, taking into account many qualitative characteristics of weapons and targets in estimating damage achieved against a specified target list (thereby also incorporating a set of targeting rules into the MOE). Current uses of DE, however, represent only a partial measure of how strategic forces contribute to attaining the hierarchy of U.S. national security objectives, national military objectives, and regional operational objectives. It fails, for example, to take into account any value system for targets (e.g., that an SS-18 silo with 10 hard-target-kill (HTK) capable warheads is "worth more" than an SS-11 silo whose missile has only one warhead with no HTK capability), a whole host of operational considerations (e.g., timing requirements). Many of these technical shortfalls could be incorporated into a new form of damage expectancy. There still remains the question of how well such a measure answers whether or not our national security objectives were met.

[4]S. Kozlov, "The Development of Soviet Military Science After World War II," *Military Thought*, February 1964.

The purpose of this research is to analyze the specialized Soviet military operations research and modeling literature for insights into Soviet views about measures of merit for assessing the intercontinental nuclear balance and the effectiveness of intercontinental nuclear forces. It seeks to identify specific measures which might be used at the General Staff level, and which could be appropriate for use in a U.S.-style strategic exchange model, in order to compare Soviet balance assessments with U.S. evaluations.

Certain caveats must be attached to this work. First, no one other than the Soviet General Staff itself knows exactly how it does its calculations, including the equations that go into the models, and how those models are used.

Second, even with perfect knowledge of the equations, we lack much of the Soviet data to feed into these equations. What penetration probabilities do they assume for bombers and missiles? What scenarios do they use? What specific forces do they ascribe to each side? (For example, are Backfire bombers or FB-111s included?) Some of these data are themselves outputs from more detailed models to which we do not have access.

Third, once Soviet-style measures are developed, it might be inappropriate to employ them in a U.S. strategic exchange model. Soviet military literature provides only a discussion of the measures themselves, not the overall model that houses those measures. Do they use stochastic optimization models, purely rule-based deterministic models, or some hybrid of the two? The same MOE might yield different results depending on the form of the model.

The lack of information on this topic is significant.[5] Only one article available to this study (a piece by General I. I. Anureyev, written in 1967) is devoted primarily to the issue of the correlation of nuclear forces. There are several secondary sources which deal with strategic nuclear force issues, including criteria of effectiveness for these forces.[6] Finally, there is the Soviet operations research literature, which includes work on Soviet measures of effectiveness in general. Virtually all of these sources are from the 1960s and 1970s, presenting a tremendous void of information for at least the last ten years.

However, the absence of adequate information is common to all areas of Sovietology. Lacking perfect information on measures, models, and data, this work can still make an

[5]Whether the information on this topic simply does not exist, or whether it does exist and is secreted away in highly classified documents is unclear. It is the view of the author that the Soviets have not taken strategic nuclear analysis to the lengths and depths to which it has been studied in the United States. The author further believes that information available at higher levels of classification in the Soviet Union would not dramatically alter the analysis developed in this Note.

[6]V. I. Varfolomeyev, and M. I. Kopytov, *Design and Testing of Ballistic Missiles*, Voyenizdat, Moscow, 1970, and A. I. Ivanov, I. A. Noumenko, and M. P. Pavlov, *The Nuclear Missile and Its Destructive Effect*, Voyenizdat, Moscow, 1971.

important contribution. The Soviet military clearly values models, specifically as a major aid to decision-making for the development, procurement, deployment, and employment of weapons. References to their importance in these processes occur frequently in Soviet military writings, although they fall short of informing us as to the specific role mathematical calculations and models play in Soviet policy formulation. A 1972 article in the General Staff publication, *Military Thought*, states that: "In the Soviet Armed Forces considerable importance has always been attached to utilization of mathematical methods for military research."

Recently, General Akhromeyev provided a general example of a policy issue where calculations of balance assessments played a role.[7] Regarding the Soviet government's 1988 decision to reduce their Armed Forces by 500,000 men during 1989 and 1990, Akhromeyev describes the inputs to this policy decision, which include *calculations of the balance of military forces*.

> During the latter half of 1988 a great deal of research work was done: Command-staff and staff exercises were conducted at various levels, calculations were made of the balance of military forces in the future, the possible course of arms reduction negotiations was critically analyzed. . . . As a result of all this work, by late 1988 the figure of 500,000 men emerged.

With respect to strategic nuclear forces, in the same article Akhromeyev cites a policy decision in the mid 1960s regarding the mix of their unbalanced triad. At that time there was concern that the Strategic Rocket Forces had evolved too much and the Air Forces too little. The question was raised as to whether actions should be taken to mitigate these trends. The answer is based on calculations performed at that time that "showed that it was irrational to alter the structure again and would cost more than developing and improving the existing structure."

The examples given show the value that Soviet decision-makers have attached to policy decisions as recently as 1988. The work undertaken in this Note is therefore valuable to better understand the Soviet valuation of strategic nuclear weapons. Insights on Soviet views of the balance are important in forming our own assessments of (1) deterrence, since that concept is firmly based upon the perceptions of our adversary, (2) arms control negotiations, in discerning the motivations and intentions of Soviet negotiators, and (3) alternative force postures under future arms control agreements.

[7] S. Akhromeyev, "Open Letter to Vitaliy Korotich," *Ogonek*, December 1990.

2. SOVIET MEASURES: THE THEORY AND FRAMEWORK FOR MOEs

The Soviets have a well-defined and integrated[1] framework for measures of effectiveness of military forces, including definition, purpose, requirements, and form. The fact that the Soviets have such a framework does not imply that they have the *right* MOEs, or that they are using them in the correct manner. Soviet military literature in the 1970s emphasized the need to develop better measures of effectiveness and cited historical examples where MOEs were improperly used. The framework is interesting when contrasted with the West, where the science of MOEs has been developed separately for intercontinental nuclear and theater forces, without an overriding structure of MOEs for all force types.

What is not always evident is how Soviet MOEs are used on a practical level. This section will both present the Soviet view on MOEs, and suggest a framework consistent with that view, which helps to provide a context for understanding how these measures are used with respect to strategic nuclear forces.

DEFINITION OF TERM(S)

A parallel concept to our term *measures of effectiveness* in the West is what the Soviets call *criteria of effectiveness* (COEs).[2] *Criterion of effectiveness* is defined in the 1983 Soviet *Military Encyclopedic Dictionary* as: "An indicator the numerical value of which is used to estimate the effectiveness of weapons, combat equipment, and the actions of troops (forces)."

Another definition provided by V. Ye. Savkin in his book, *The Basic Principles of Operational Art and Tactics* (1972) is:

> The criterion of effectiveness is taken to mean an indicator which, by its numerical value, we (or an electronic computer) can draw a conclusion about how good is a result which has been attained or a decision which has been made. Such a criterion permits a judgement about the effectiveness of employing combat means or about the relative value of different versions of decisions in a battle or operation.

The distinction between the Western term *measure* and the Soviet term *criterion* is significant. The latter goes one step further by indicating that there is a specific level, or norm, above which values are acceptable or unacceptable. The Soviets have devoted

[1]Integrated in the sense that the same framework applies to *all* MOEs, both strategic and theater, and nuclear and conventional.

[2]A second term, *indicators of effectiveness* is also employed by Soviets in their operations research literature to mean measures of effectiveness.

considerable attention to compiling tables and books of norm values for different measures across a variety of scenarios.

PURPOSE OF COEs

The primary purposes or uses for criteria of effectiveness are similar to those we might list in the West:[3]

1. to aid in decision-making (troop control);
2. to estimate or forecast the effectiveness of weapons and combat equipment;
3. to aid in weapons design.

However the emphasis and priority among these uses from the Soviet perspective is different from those in the West. In general, Soviet emphasis is more on real time support for force operations rather than on longer-term requirements for weapons acquisition and force planning.

Support of troop control has been the most important application for COEs in recent years. With the time of conflict reduced dramatically by the speed, range, and destructive power of nuclear weapons, the Soviets have attempted to reduce decision-making time through automation. Criteria which provide key information in a format most useful to the decision-makers are central to this effort.

REQUIREMENTS FOR COEs

The Soviets place several requirements on the determination or selection of a criterion of effectiveness. The simplicity of these requirements should not belie the difficult task of providing a balance between accuracy and simplicity. If the measure is made too complex in an attempt to capture realism, then its utility almost inevitably drops because it is too cumbersome and complex to use. On the other hand, measures which are too simplistic do not adequately reflect reality, and therefore lose credibility.

Although the requirements are not canonized in a particular vocabulary, General I. I. Anureyev[4] provides the essential aspects of these requirements:

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[3]V. Ye. Savkin, *The Basic Principles of Operational Art and Tactics*, Voyenizdat, Moscow, 1972, and Varfolomeyev and Kopytov, 1970.

[4]I. I. Anureyev, a Major-General of the Engineering troops, is one of the most prominent figures in recent Soviet military operations research, and a pioneer in the field of measures of effectiveness. These characteristics are cited in I. I. Anureyev, and A. Ye. Tatarchenko, *Application of Mathematical Methods in Military Affairs*, Voyenizdat, Moscow, 1967.

- The efficiency criteria must objectively characterize the process of combat activity.
- They must have direct relationship to the target of combat action.
- They must be sensitive (or as is said, quite critical) to changes in those quantities the values of which must be defined as a result of investigation.
- They must be quite simple so that their physical meaning is understandable and it is convenient to calculate, graphically depict, and analyze them.

The first two requirements have to do with choosing the basic form or structure of the measure. The selection of a measure that properly and adequately represents the combat process is given in an example by Varfolomeyev and Kopytov: "Since a missile complex is designed for the destruction of targets, the effectiveness criterion should contain a measure of the destruction delivered or other results of the effect of missile warheads."[5]

Further refinement of the measure is made by selecting a *form* which is directly related to the target, or objective of the combat action.[6] The latter two requirements identified by Anureyev, which deal with the sensitivity of the parameters and the simplicity of the measure, have more to do with the technical question of how detailed to make the measure.

There is evidence in recent years that as computers have become more widely used, the Soviets have begun to move toward the development of more complicated combat simulation models.[7] However, there is no evidence that the simple measures have been replaced by these models, nor that they will be replaced by such models. There is the recognition of the delicate balance between parameters that add to the solution of the problem, and parameters that do not: "Criteria of effectiveness should be as simple as possible. Introduction of secondary quantities may complicate the investigation without producing more precise conclusions."[8]

Once again, this inclination toward simplicity is consistent with using measures that can be calculated quickly (e.g., during the course of a war) and used by a wide range of military personnel.

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[5]Varfolomeyev and Kopytov, p. 14.

[6]Anureyev and Tatarchenko, 1967.

[7]M. V. Sergeyev, and Kh. I. Leybovich, "On the Question of the Methodology of the Mathematical Modeling of Operations," *Military Thought*, December 1988.

[8]Yu. V. Chuyev, *Research of Military Operations*, Voyenizdat, Moscow, 1971, pp. 11–12.

CAVEATS

The Soviets place several qualifications and caveats on the employment of COEs. The selection of a criterion of effectiveness is taken very seriously by the Soviets, who acknowledge that "selection of the criterion of effectiveness is one of the most difficult elements of mathematical investigation of military operations."[9]

But despite the massive efforts they pour into this effort, and the important role it plays, they recognize their shortcomings in this area, as well. Contrary to the image they are sometimes given of having fully worked out a scientific approach to all military problems, Soviet military analysts acknowledge that there is no single magic COE which answers all questions: "it is obviously impossible to establish a single and universal effectiveness criterion."[10]

With respect to the COEs which do exist, the Soviets recognize the fallibility of these measures, particularly the correlation of forces. In their literature, historical examples are cited where this correlation of forces has been wrong in predicting who will win the war. One example states that a favorable correlation of forces was insufficient for a U.S. victory in Vietnam:

> the United States . . . has seriously erred more than once in evaluating the overall *QUALITATIVE* correlation of forces participating in these wars. . . . Possessing a superiority in the quantity of weapons and military equipment over Vietnam, . . . after six years . . . the Americans have not achieved victory and are at an impasse.[11]

While that article accused enemies of the Soviet state of improperly calculating the correlation of forces, the point is also made more generally:

> Victory or defeat in modern war depends not only on the correlation of forces but also on the correlation of levels of command and control of these forces. History contains many examples whereby even superior forces have suffered defeat and where numerically smaller forces have gained victory as a result of superior direction and control.[12]

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[9]V. Ryabchuk, "Some Trends in the Development of Operations Research Theories and Systems Analysis," *Military Thought*, Voyenizdat, Moscow, August 1971.

[10]Varfolomeyev and Kopytov, pp. 13–14.

[11]Colonel S. Tyushkevich, "The Methodology for the Correlation of Forces in War," *Military Thought*, June 1969.

[12]General I. I. Anureyev, "The Correlation of Military Science with the Natural Sciences," *Military Thought*, November 1972.

TYPES OF COEs

A wide variety of COEs can be found in the Soviet military literature. The sheer volume of these measures is overwhelming and an overarching framework is necessary in order to categorize and comprehend their meaning and use.

There are several characteristics which define the structure and content of COEs. First, there is the question of the mathematical form of the measure. Employed most often are mathematical expectation or probability. As mentioned previously, a probability is typically used in situations where the results are completely defined, and it is a question of achieving those results or not. In cases where the results are not well-defined, an expected value would likely be used. For example, if the military objective were to damage 60 percent of all U.S. silo-based intercontinental ballistic missiles (ICBMs), the measure used to gauge success would be the *probability* of achieving 60 percent damage to ICBMs. If, on the other hand, the objective were to achieve as much damage to silo-based ICBMs as possible the criterion used would be the expected *value* of damage they could achieve.

Second, the measure can be either one-sided or two-sided. If the question is whether the necessary results have been achieved (e.g., a missile complex has destroyed its target), only a one-sided measure is needed. If the question is of quality of performance relative to someone or something else (e.g., answering the question "who is winning?") then a two-sided measure is in order.

Third, there are several alternative units of measure, or what it is that is being measured. One prominent Soviet operations research analyst cites three basic classes: damage infliction, spatial, and temporal.[13] The first class incorporates not only direct measures of damage, such as probability of damage, or damage expectancy, but also residual force counts, before or after damage has been inflicted. (Included here would be the correlation of forces.) COEs that capture spatial characteristics are ones which take some account of the territorial aspect of combat. Measures such as requirements for penetrating the enemy's defenses, maximal withdrawal depth, and the size of territory captured are all spatial COEs. Finally, the primary COE in the temporal realm is time requirements, both time required (and maximally feasible) to conduct the whole operation or battle, and time required to conduct individual segments of that operation or battle. These three classes of MOEs and some examples are summarized in Fig. 2.1.

[13]K. V. Tarakanov, *Mathematics and Armed Combat*, Voyenizdat, Moscow, 1974.

1. **Damage infliction characteristics**

   COE: Correlation of forces factor (mutual damage infliction)

   EXAMPLES:
   - Probability of individual target or group target destruction
   - Mathematical expectation of the number of friendly and enemy means available as a result of a battle or operation

2. **Spatial characteristics**

   COE: Territorial factor

   EXAMPLES:
   - Required penetration of enemy's defense
   - Size of territory captured
   - Maximal withdrawal depth

3. **Temporal characteristics**

   COE: Time factor

   EXAMPLES:
   - Required and maximally feasible time expenditures on the conduct of the whole operation or battle
   - Required and maximally feasible time expenditures on the conduct of the individual segments

Figure 2.1—Types of COEs: Units of Measure

There is one further distinction to be made. Soviet operations research literature specifies that when one criterion is insufficient to fully define the mission being measured, as is often the case, then *auxiliary* or *partial* criteria may be used to supplement the primary criterion. While it is preferable to combine all of the criteria into one generalized criterion, this is not always practical. It is possible and sometimes necessary to have one main criterion, and one or more auxiliary criteria to further specify the goal or mission.

> During the investigation not one but two or more criteria may be chosen. In this case either an effort is made to combine all the criteria into some generalized criterion or one of the criteria which corresponds to the greatest extent to the stated purpose is considered the main one and the rest auxiliary. . . . [14]

One example of the use of more than one criterion in measuring the success of an operation or mission would be to have a damage requirement of 80 percent for a given target set, achieved within a specified time, *t*. The main (or general) criterion is to damage 80 percent of a given target set. The requirement to do this within time *t* is an auxiliary

[14]Anureyev and Tatarchenko, 1967.

criterion. The role of time as an important auxiliary COE is explicitly pointed out by Savkin:[15]

> The time fulfillment of a mission can be a secondary, but nevertheless a very important and relatively independent criterion in military tasks. . . . Therefore optimization of target destruction according to any selected main criterion must be done only within the framework of time set aside for delivering the attack.

HOW COEs ARE USED

The most difficult question to answer with regard to Soviet measures of effectiveness is how these criteria are used on a practical level. Would they be calculated prior to conflict, or is there a possible application for use in wartime? Are they used by the General Staff, or at lower levels of command? Identification of Soviet MOEs is difficult enough. Assessment of how or even whether they are used is even more difficult.

One element which seems to be the key in solving this puzzle is the concept of *levels*, or *scales of conflict*. Just as the Soviets emphasize the importance of developing and using conventional COEs for the appropriate scale of conflict in the theater, there is some evidence to suggest that a similar framework might be used for intercontinental nuclear COEs.

The topic of scales of conflict with respect to COEs for nuclear weapons is extensively discussed in the 1967 article by General I. I. Anureyev on the correlation of nuclear forces, and in a commentary on that article in the following year by Khabarov et al.[16] In the original article, Anureyev outlines a measure which is "the correlation of forces of nuclear weapons on a *strategic* scale." He also proposes to examine measures for the operational and tactical scales. In the commentary, Khabarov et al. provide a description of the impact of scales of conflict on COEs:

> The fact is that calculations on the strategic scale are accomplished prior to the start of a war and are based on comparatively slowly changing initial data. In the process the factor of time does not limit the preparation of calculations. It is a different matter with calculations on the operational-tactical scale. Here time plays a decisive role, and the character of initial data, depending on the situation, will be most variable as a result of rapid changes in the situation. Account must be taken of the great difficulties involved in the collection of essentially countless indicators required for the computations. Therefore at operational-tactical levels the requirement for maximum simplicity in the

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[15] Ye. V. Savkin, 1972.

[16] I. I. Anureyev, "Determining the Correlation of Forces in Terms of Nuclear Weapons," *Military Thought*, June 1967. B. Khabarov, N. Bazarov, Ye. Orlov, and L. Semeyko, "Methodology for Determining the Correlation of Nuclear Forces, *Military Thought*, August 1968.

method of calculating the correlation of forces is considerably greater than on the strategic scale.

Both the original Anureyev article and the Semeyko commentary clearly indicate that there are calculations, or measures for (strategic) nuclear forces, at the strategic, operational, operational-tactical, and tactical levels. The correlation of nuclear forces proposed by General Anureyev is intended as a *strategic* level COE. From the Khabarov piece it is clear that there is a correlation of nuclear forces measure at the lower level scales, as well, which have a different, more simplified form.

What is not clear is what is meant by the strategic, strategic-operational, operational, operational-tactical, and tactical levels for strategic nuclear COEs. In the theater, "scales" directly equate to the size of conflict: strategic is theater-wide, operational is front level, and so on. Since ICBMs and aircraft are deployed in similar formations of regiments and divisions, scales in the intercontinental arena could also refer to the size of conflict, with *strategic* referring to full scale nuclear conflict.

The scale of conflict factors into the measures in two basic ways. First, not all measures are appropriate, or at least equally appropriate at all scales of combat. For example, while the correlation of forces (COF) measure might be appropriate for use at several different levels it could likely take a different mathematical form at different levels. Further, other measures might only be appropriate at one scale that is only used at the tactical level, or at the strategic level. An attempt will be made to show these distinctions by example.

Second, even if the same measure and same mathematical form of that measure may be used at different scales, the acceptable range of values for that measure, or the *norm* values, would likely be different. An unfavorable COF in sea launched ballistic missiles (SLBMs) might be accepted if the overall COF is favorable. However, as difficult as it is to find information on COEs for intercontinental nuclear forces, examples of those measures using Soviet data are virtually non-existent. Therefore, the data needed to show that the same COE can have different norm values at different scales of application is lacking.

In order to better explain how the scales of conflict might apply to strategic nuclear COEs, a few examples are given below of COEs for strategic nuclear forces found in the Soviet operations research literature, and how they might be classified: as strategic, operational, or tactical.

1. *Correlation of Forces*. The correlation of nuclear forces is a broad measure which can be applied at all levels of conflict. The 1983 *Soviet Military Encyclopedic Dictionary*

defines the correlation of forces and means as follows: "Calculated on a strategic, operational and tactical scale throughout an entire area of operations, in the main sector and in other sectors. Various reference manuals, tables, and computers are used to speed calculation."

Applied theater-wide (or for all intercontinental forces), this measure allows for an overall assessment of the status of the conflict at any point in time. It is virtually the only measure which can answer the basic question of "who is winning?" Therefore, it is the principal COE for strategic nuclear weapons, although it can be used at lower scales of conflict as well.

2. *Averted Losses*. This COE provides a measure of how offenses perform against air defenses, and is defined as "the losses hostile aircraft could have inflicted on defended troops or other targets."[17] It is calculated by determining lost (or surviving) targets with and without air defenses, with the difference between the two being the *averted losses* due to air defenses. The application of this measure to date has been in the realm of air defenses. Should the United States and the Soviet Union deploy more substantial ballistic missile defenses (BMD), there is no reason that the averted losses COE could not be applied to ballistic missile defense as well. Provided in ratio form, this measure is a type of COF. However, by definition, this measure does not provide an assessment of all strategic nuclear forces across the intercontinental theater. Rather, it provides only the answer as to who is winning the air battle, and only in those areas with air defenses. Therefore, it would seem to be classified as an operational or operational-strategic COE.[18]

3. *Readiness*. Measures for readiness of a missile complex are given in several different sources.[19] In general, readiness COEs are *temporal* criteria, referring to a time by which the complex must be ready to fire, or the time it takes a missile complex to prepare itself for execution. In the sources listed, readiness of a missile complex is calculated for a squadron of ballistic missiles, and is itself simply an input to other criteria (correlation of forces). In this context it would be a tactical, or tactical-operational calculation.

This section has provided a general framework of Soviet measures of effectiveness. The rest of this Note will be devoted to examining what in the author's view is the primary

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[17]Major General M. Botin, and Lieutenant Colonel P. Ivankov, "Determining the Effectiveness of the Grouping of the Air Defense Equipment of Troops," *Military Thought*, April 1973.

[18]Colonel N. Zubkov, "General Principles of the Approach to Appraising the Effectiveness of Combined-Arms Control Systems," *Military Thought*, November 1971. In this article Colonel Zubkov mentions a "coefficient of strike prevention" as a "general criterion of control effectiveness in conducting combat operations employing nuclear weapons" at an operational-tactical level.

[19]Varfolomeyev and Kopytov, 1970, and Captain V. Tsybul'ko, "The Combat Readiness of Weapons Systems and Its Quantitative Appraisal," *Military Thought*, November 1972.

strategic COE for the Soviets: the correlation of nuclear forces. This is the measure which attempts to answer the basic question of "who is winning," and which is consistent with measures used in (strategic) exchange models in the United States.

3. SOVIET STRATEGIC NUCLEAR MEASURES: THE CORRELATION OF NUCLEAR FORCES (CNF)

GENERAL BACKGROUND

The correlation of forces, the principal *strategic* level COE for the Soviets, has at least two levels of interpretation, the political level, and the military-technical level. At the political level, the correlation of forces is a term which encompasses quantitative, qualitative, economic, political, and social factors to express Soviet military potential with respect to an adversary (typically the United States).[1]

At the military-technical level, the correlation of forces is an explicit quantitative criterion of effectiveness, which is used as a decision-making aid and forecasting tool. It is this latter form, the technical level of the correlation of forces, that will be explored in this section. This will provide a basis for developing Soviet measures that will be represented within a U.S.-style strategic exchange model, in order to provide Soviet-style assessment for the capability of intercontinental nuclear weapons.

The correlation of forces and means is defined as an:

> Objective indicator of the combat power of opposing forces, which makes it possible to determine the degree of superiority of one force over the other. Correct calculation and estimation of relative strengths help make substantiated decisions, establish in a timely manner and maintain the required superiority over the adversary in selected sectors. [It is] Determined by comparing quantitative and qualitative characteristics of subunits, units, combined units, and armament of friendly and enemy troops. [It is] Calculated on a strategic, operational and tactical scale throughout an entire area of operations, in the main sector and in other sectors. Various reference manuals, tables, and computers are used to speed calculation.[2]

It therefore can be characterized as:

- A ratio of opposing forces (two-sided measure)[3]
- A determinant of which force is superior (who will win)
- Composed of quantitative and qualitative factors.

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[1]Reference to this can be found in the "laws of armed conflict," quoted in Savkin's book, *The Basic Principles of Operational Art and Tactics*, pp. 65, 89ff.

[2]*Military Encyclopedic Dictionary*, Volume 7, in Russian, Voyenizdat, Moscow, 1983 (JPRS-UMA-88-006-L).

[3]The Soviets occasionally express the correlation as a *difference*, but overwhelmingly use the form of a ratio.

History shows the importance and application of this measure relative to other COEs to be unparalleled. It is clearly still held in high regard as the foremost criterion of effectiveness for the Soviets in assessing force capability, force balances, and the outcome of a conflict, as set forth in two of the basic four laws of war:[4]

1. The course and outcome of war waged with an unlimited employment of all means of conflict are determined primarily by the correlation of strictly military forces available to the combatants at the beginning of the war, especially in nuclear weapons and means for their delivery.
2. The second law of war is that the course and outcome of a war depends on the correlation of military potentials of the combatants.

While extolling the importance of this measure, the Soviets recognize its fallibility, as well. In their literature they cite historical examples where the correlation of forces has been wrong in predicting who will win the war, the very purpose it primarily serves.

> Victory or defeat in modern war depends not only on the correlation of forces but also on the correlation of levels of command and control of these forces. History contains many examples whereby even superior forces have suffered defeat and where numerically smaller forces have gained victory as a result of superior direction and control.[5]

The correlation of forces measure originally applied to conventional weapons. With the development of nuclear weapons Soviet military theoreticians sought to extend this primary criterion of effectiveness to the new class of weapons, as well. It is not clear from the literature, however, whether the measures developed for nuclear forces are intended for theater nuclear or strategic nuclear forces. References to *strategic* nuclear forces most often indicate the use of nuclear weapons in a *theater* strategic operation rather than the use of *intercontinental* weapons. Similarly, references to the destruction of *troops* in the battlefield by nuclear weapons do not exclude intercontinental nuclear forces, since a portion of those forces can also be used to target theater military forces.

It is clear, however, that the Soviets are most concerned in their literature with the impact of *any* nuclear weapon on a primarily conventional conflict, consistent with their national military objective of achieving their war aims with conventional forces. Therefore, it

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[4]Savkin, 1972.
[5]Anureyev, 1972.

is the belief of this author that the methodology for the correlation of nuclear forces was first developed with theater nuclear forces in mind, and extended from there to the intercontinental arena.

There is likely one form of the correlation of nuclear forces which is currently used as the standard equation by the military in their strategic exchange analysis, however no single formula has been accepted as the one and only correct interpretation of the correlation of nuclear forces. Work is ongoing in this area. With respect to the form of the equation which is currently used by the General Staff, no one but the General Staff knows what that equation is. What is offered here are some of the most likely alternatives for the correlation of nuclear forces.

Several different forms of the correlation of nuclear forces are found in the Soviet military literature. In its original form, the correlation of nuclear forces is simply a ratio of similar types of weapons of opposing sides, which would be termed a static measure in the West. This is referred to in their literature as a *quantitative* COE. Qualitative differences between weapons systems and between warheads are not taken into account. This is the original correlation of nuclear forces, developed by the early 1960s as an extension of the methodology used for conventional weapons, which compared firepower capabilities: "At first there was a purely quantitative evaluation of the new means of conflict."[6]

A second class of "correlation of nuclear forces" emerged when it was recognized that nuclear weapons were a distinctly new and different type of weapon which could not be adequately captured by simple quantitative counts employed with conventional measures. The same article referenced above which speaks of the "quantitative evaluation" goes on to discuss the new direction taken for evaluating nuclear weapons:

> As we became more acquainted with the properties of the new weapon, with the quantities of its availability, and with the improvements in methods of delivering it to the target, the methods of combat operations became more decisive and original. The purely quantitative considerations, which accompanied the first introduction of the new weapons, began to acquire a more and more clearly expressed qualitative nature.

The move from "quantitative considerations" to a more "qualitative nature" refers to the need to go beyond just counting the number of weapons, to providing some indication of what those weapons could do operationally.[7] This ushered in a new class of COEs, referred

[6]S. Kozlov, 1964.

[7]This quantitative versus qualitative theme that runs through Soviet literature on this topic is very similar to our own classification in the United States of static versus dynamic measures of

to in the Soviet literature as *qualitative* COEs. The Kozlov article suggests two avenues for the incorporation of qualitative factors: "properties of the new weapon" (differences among warheads) and "improvements in methods of delivering it to the target" (differences among launching platforms).

The first qualitative factor to be incorporated into the CNF was the destructive capability of the warhead, with *equivalent TNT* (referred to subsequently as ETNT) as the proxy for damage. According to A. I. Ivanov et al.: "Usually the power of a nuclear weapon is evaluated in accordance with the energy which is liberated during an explosion. This energy is measured in TNT equivalents. . . ."[8]

Therefore, the likely first qualitative CNF was a simple ratio of ETNT for the opposing sides. This measure went one step further than the quantitative CNF by indicating an overall capability of the nuclear forces, in terms of soft-target kill capability. Equivalent TNT, or equivalent megatonnage (EMT), the form of this measure used in the West, is a "soft-target kill" measure because the lethal area of an attacking weapon is proportional to its EMT, and because soft targets are regarded as area targets.[9]

While there are no explicit references to this ETNT as a strategic level COE for nuclear forces in the Soviet literature, there is evidence to suggest it was first used as a measure, before and separately from the Anureyev CNF. First, the use of ETNT as the primary measure for warhead capability (used as a tactical COE) appears to be established as such prior to the Anureyev measure of 1967. Second, whereas the use of planning factors for launchers appears to be a new proposal by Anureyev in 1967, as raised in one of the commentaries, no objections to or special note of the use of ETNT by Anureyev is made. ETNT appeared to be a measure familiar to Soviet military theoreticians.

A third form of the CNF was set forth in a well-known *Military Thought* article by General I. I. Anureyev in June 1967, in which he proposes the inclusion of yet another set of qualitative factors. ETNT captured differences in the capabilities of the warheads. General Anureyev proposed that differences in the weapon launchers now be incorporated into the CNF measure, as well. These parameters, known as planning factors in the West, include such factors as "the probability of non-destruction on the ground" (PLS, or pre-launch

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effectiveness, although they do not exactly equate. Our static measures can include EMT measures, which would be considered qualitative measures by the Soviets.

[8]A. I. Ivanov, et al., 1971.

[9]The EMT of a weapon with yield Y is usually defined as $Y^{2/3}$.

survivability in the West), and "the probability of overcoming enemy defense" (PTP, or probability to penetrate in the West).[10]

This article, the first and only analytic piece known in the West to be devoted to the calculation of the *correlation of forces in terms of nuclear weapons*, is a landmark piece. In it, Anureyev sets forth the task of calculating "the correlation of forces of nuclear weapons on a *strategic* scale." While it is questionable whether the explicit measure he sets forth was ever used, the framework he presents undoubtedly set the standard for future work in this area.

Finally, the third major change proposed in incorporating qualitative factors into the correlation of nuclear forces was that ETNT ceased to be the primary unit for assessing warhead capability. This was driven by the improvement in warhead accuracy, and was predicted in 1972 by Varfolomeyev and Kopytov: "Therefore as launch accuracy is improved it is possible that it will become unnecessary to build missiles with a high TNT equivalent for the destruction of pinpoint targets."[11]

This change in the correlation of nuclear forces likely took place in the mid to late 1970s, when the advent of hard target kill (HTK) capable intercontinental ballistic missiles was approaching (the SS-18 was first deployed in 1975, and the MM3 in 1970). The new qualitative indicator of warhead capability was an explicit damage calculation, which indicated the *destruction potential* of the warhead against targets of specific hardnesses.[12]

In summary, the Soviets first sought to evaluate nuclear weapons in the same manner as conventional ones, using a simple quantitative ratio as the measure for both. The need to move beyond such simple quantitative COEs, toward the incorporation of qualitative parameters, arose from three basic factors. First, there was recognition of the fundamental qualitative differences between conventional and nuclear weapons. Second, it became necessary to delineate between different types of nuclear weapons as their capabilities grew with the deployment of larger warheads. Finally, a more sophisticated interest in the CNF arose at a time when the Soviets first began to deploy a significant strategic nuclear force. Whereas in 1966 the Soviets had a ballistic missile force (relative to the United States) of 411:1496 launchers, in 1970 that ratio had improved to 1672:1710 launchers. In fact, during the period from 1967 to 1980, the United States only introduced two new strategic nuclear weapons systems, the Minuteman 3 and Poseidon C3, whereas the Soviets introduced a total of eight new ballistic missile weapons systems.

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[10]These factors are used as multipliers, with fractional values that degrade the destructive capability of the weapon.

[11]Varfolomeyev and Kopytov, 1970, p. 295.

[12]Vice Admiral V. Babiy and Captain 1st Rank N. Volgin, "On the Problem of Evaluating the Relative Strength of Opposing Forces," *Naval Digest* No. 12, 1980.

Qualitative differences in the weapons were incorporated into the measures in two basic ways. First, differences in the warheads themselves were captured through some expression of the destructive power of those warheads (ETNT) or damage. Second, parameters which described differences in weapon launchers were factored in. The latter group of qualitative parameters, refered to in the West as planning factors, includes such factors as pre-launch survivability and probability to penetrate.

The rest of this section will develop each of these forms of the CNF in detail, providing definition, mathematical form, sample calculations, and a summary of the likelihood of their employment. Sample calculations are all given in terms of the peacetime or "initial" correlation of forces, before any employment of nuclear weapons. Calculations are made across a 30 year period (1958–1988) so that comparisons of the different measures can be made. The examples given here are intended as illustrations. A detailed application of these measures, including scenario development, will be covered in a forthcoming publication.

QUANTITATIVE CNF

As noted above, a "quantitative" correlation of nuclear forces refers to a simple counting of forces. Qualitative differences between weapons systems and between warheads are not taken into account. This is the original correlation of nuclear forces, used as an extension of the methodology used for conventional weapons, which compared firepower capabilities. Kozlov (1964) states, "At first there was a purely quantitative evaluation of the new means of conflict. They basically tried to regard them as some new quantitative expression of the chief factor in armed conflict—firepower."

The representation of this is simply a ratio of the numbers of similar weapons, which could be taken either for the total force, or for different classes of weapons.

$$\frac{\text{Number of friendly warheads}}{\text{Number of enemy warheads}}$$ [13]

Values for the "initial" quantitative correlation of forces from 1958 to 1988 are given in Fig. 3.1. The data are derived from Western sources.[14]

[13]In all correlations, the Soviets list themselves in the numerator and the enemy forces in the denominator.

[14]Soviet force data is take from Thomas B. Cochran, William M. Arkin, Robert S. Norris, and Jeffrey I. Sands, *Nuclear Weapons Databook, Volume IV: Soviet Nuclear Weapons*, Harper and Row, New York, 1989. U.S. force data is compiled from International Institute for Strategic Studies (IISS) Military Balances, with the exception of the bomber loadings, which are taken from the Arkin Databook, Volume 2. Please refer to Appendix B for questions on the data.

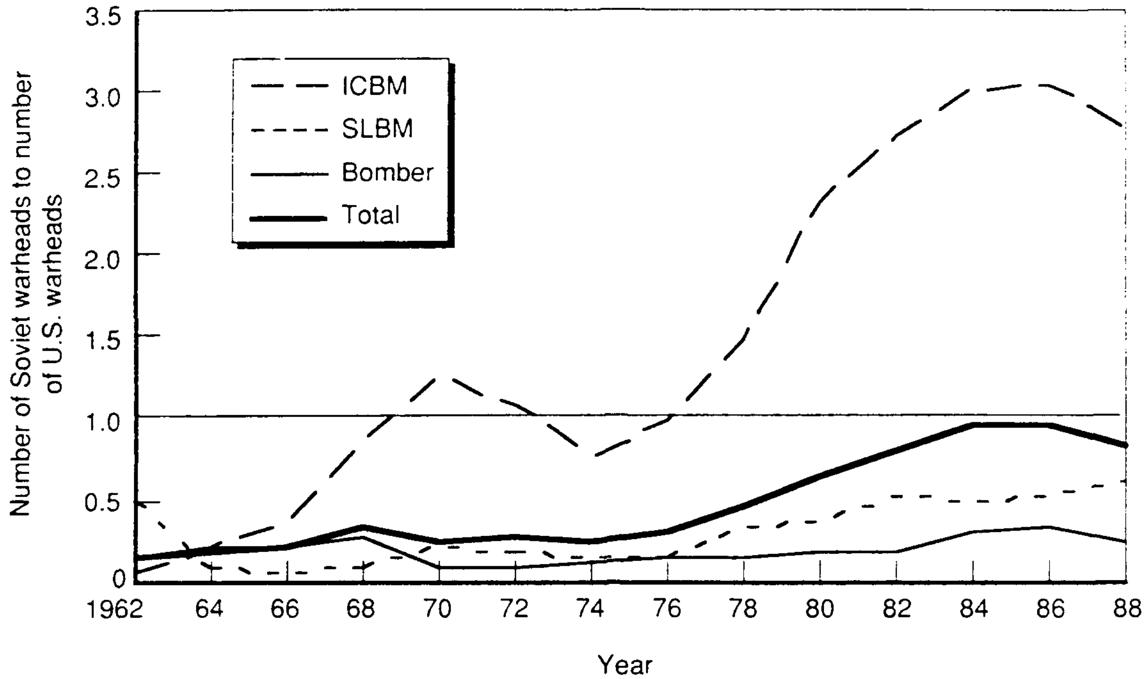

Figure 3.1—Quantitative Correlation of Nuclear Forces, 1962 to 1988 (Preexchange)

During the complete period from 1958 to 1988 the United States has had the advantage in overall quantitative correlation of nuclear forces (QCNF). While the Soviets made significant gains on the United States in the CNF for ballistic missiles in the late 1960s, this was offset by the U.S. MIRV (multiple independent reentry vehicle) program, which began in 1970. The Soviets did gain significantly on the U.S. advantage in CNF beginning in 1976, and parity was essentially achieved in 1984 (10005:10489).

Despite the primitive form of this criterion of effectiveness, it appears to still be used today. While all Soviet experts on this subject agree that this measure does not go far enough in describing the correlation of nuclear forces, virtually all indicate that this measure is in use. A 1980 Soviet *Naval Digest* article[15] implies that this may still be the preferred method of calculating the correlation of nuclear forces. It refers to the World War II method of "evaluating relative strength for individual combat arms," indicating that because of the effectiveness of that measure in World War II, "the *desire* to use the methodology of those times today is natural."

[15]Babiy and Volgin, 1980. This is the most recent article on strategic nuclear COEs.

SIMPLE ETNT CNF

The first qualitative change to the correlation of nuclear forces was the incorporation of differences in the destructive capability of the warheads in the form of *equivalent TNT* (ETNT). These changes were probably incorporated in the early to mid 1960s, prior to the Anureyev measure.

This COE is very similar to our equivalent megatonnage (EMT) measure that was also prevalent in U.S. strategic analysis during the same time period.[16] The two measures differ from each other slightly. While the Soviets raise all yields to the two-thirds power in calculating ETNT, in the United States, yields below one megaton are raised to the two-thirds power, and yields above this are sometimes raised to the one-half power. The explicit form of the Soviet measure is given below.

$$\frac{\text{ETNT(USSR)}}{\text{ETNT(US)}}, \text{ where ETNT} = (\text{warhead yield}^{2/3})$$

This correlation of nuclear forces does not explicitly appear anywhere in the Soviet literature. However, the evidence supporting its usage is fairly strong. As cited earlier in this report, ETNT was a widely accepted COE for warheads. Planning factors, on the other hand, did not appear to be widely accepted prior to the 1967 Anureyev article, as evidenced by the commentaries to that article in 1968. Therefore it seems highly likely that ETNT as a separate measure was employed as the first qualitative CNF.

Values for the initial correlation of nuclear forces in terms of equivalent TNT are given in Fig. 3.2. Once again, it is important to remember that whereas the measures are Soviet, the data are Western.

An examination of this COE across the full 30 year period shows that parity in ballistic missiles was reached in 1967, with overall parity for all strategic nuclear forces achieved in 1972. The arsenals of both sides grew significantly during this period, to over 10,000 weapons on each side. However, it was the Soviets who managed to continue to improve their advantage in the CNF, even after reaching parity, despite the U.S. MIRV program which began in 1970. The Soviets peaked at approximately a 1.8:1 advantage in equivalent TNT (7300 ETNT:4000 ETNT) in 1984, after which their advantage slipped. This

[16]EMT measures are still used today in the West with respect to assessment of soft or area targets or in assessing reserve capability. DE is widely used as a measure which captures more explicit breakouts of damage to specific arrays of targets.

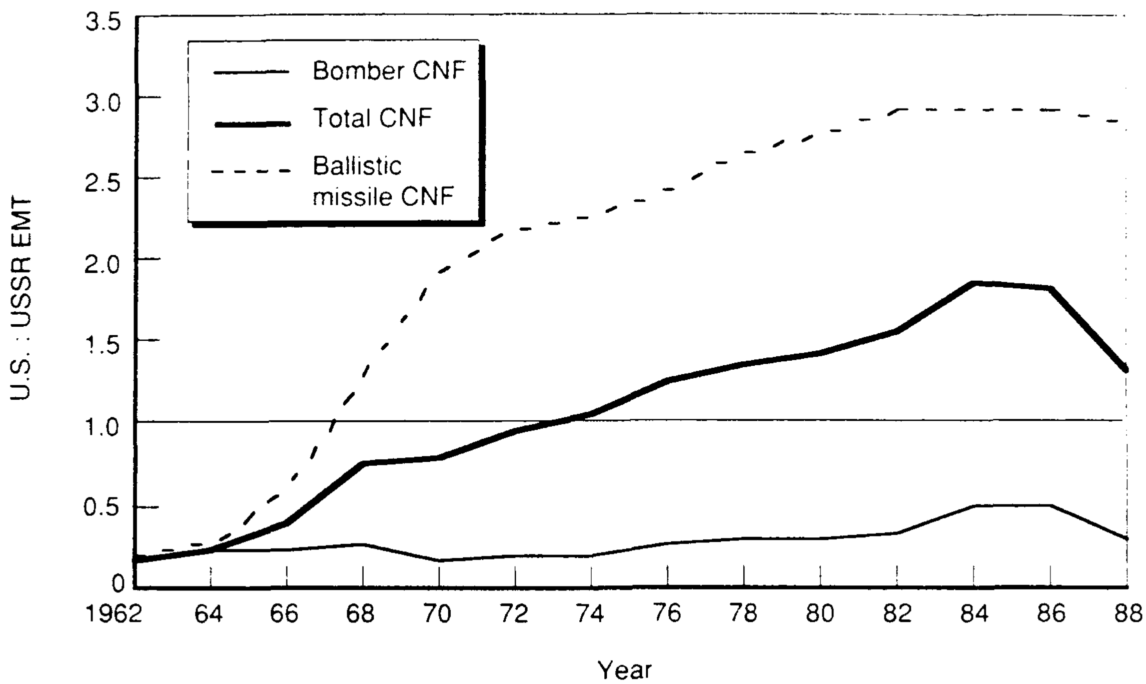

Figure 3.2—Equivalent TNT Correlation of Nuclear Forces, 1962 to 1988

decline in relative capability was due to increases in U.S. strategic nuclear forces, rather than any actual decline in Soviet strategic nuclear forces ETNT.

Comparing the ETNT measure with the simple quantitative CNF, Soviet gains in ETNT relative to the United States are the most dramatic prior to 1970. Subsequent to this their gains drop off. Yet it is during the 1974 to 1984 time period that they are increasing their *numbers* of nuclear weapons (due to the alteration of ICBMs into MIRVs) at a faster rate than the United States. Therefore the average EMT per Soviet weapon is decreasing during this time period. Fig. 3.3 shows this drop in average ETNT for Soviet ICBMs. This is particularly sharp from 1974 to 1980 (from 2.4 to .82 average ETNT per Soviet ICBM warhead), during which time the average ETNT per U.S. ICBM warhead stays fairly constant (approximately 0.6 ETNT per U.S. ICBM warhead).

This clearly raises questions as to the status of ETNT as the primary COE since the early 1970s. If this were the primary criterion of effectiveness, then one would expect the Soviets to build nuclear weapons which maximize their ETNT potential. This appears to be the case through the early 1970s. Following 1974, however, beginning with the deployment of SS-18s, average ETNT for deployed Soviet reentry vehicles (RVs) began to drop.

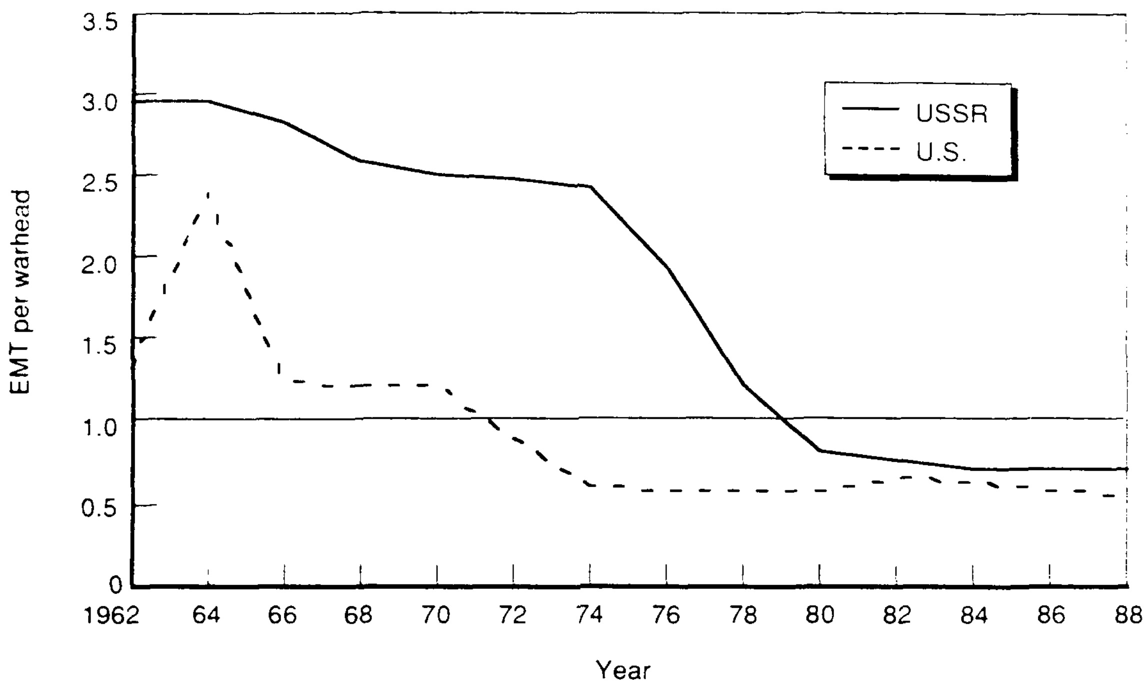

Figure 3.3—Average ICBM ETNT per Year, 1962 to 1988

The differences between the simple quantitative CNF and this basic ENT CNF are considerable. By either measure, the Soviets have improved their standing relative to the United States across the 30 year period, although at different rates. By the late 1980s, the aggregate ETNT measure portrays the Soviets as having a sizeable advantage; the quantitative CNF portrays the United States as having a marginal advantage.

ANUREYEV CNF

The most prominent criterion of effectiveness for nuclear forces and the only one to formally use the term "correlation of forces for nuclear weapons," was proposed by General I. I. Anureyev in a 1967 *Military Thought* article. Whether or not the measure is still used today in the form specified in the article (or for that matter, has ever been used), it sets forth the basic principles and framework which are undoubtedly still followed today.

This measure differs significantly from the previous two measures in the following ways. First, whereas the first two CNFs are what are termed *static* measures in the West,[17] the Anureyev CNF is a *dynamic* measure, which explicitly factors time into the equation:

[17]Static measures are counts taken of forces before any force employment. Dynamic measures, on the other hand, reflect the capabilities of forces during or after conflict.

"Since in the course of military actions the combat capabilities are changing continuously, the correlation of forces is a function of time."[18]

Second, a new class of qualitative factors is taken into account—those which affect launcher performance. The explicit form of this equation is as follows:

$$\lambda = \lambda_o \frac{\sum_i \sqrt[3]{\mu_{in}^2} * V_i * W_i}{\sum_j \sqrt[3]{\mu_{jn}^2} * V_j * W_j}, \text{ where}$$

[1] $\lambda_o = \sqrt[3]{\frac{Q_H^2}{Q_P^2}}$ = the initial COF in nuclear weapons

(Q_H = total TNT equivalent of side H/Soviets)
(Q_P = total TNT equivalent of side P/enemy);

[2] $\mu_{in} = \frac{Q_{in}}{Q_H}$ = portion of TNT equivalent delivered by i-type delivery vehicle of side H (Soviet);

[3] $\mu_{jn} = \frac{Q_{jn}}{Q_P}$ = portion of TNT equivalent delivered by j-type delivery vehicle of side P (Soviet);

[4] V_i = probability of i-type delivery vehicle of side H overcoming enemy defense;

[5] V_j = probability of non-destruction of i-type deliv^ry vehicle of side H on the ground;

[6] W_j, V_j = same values, respectively, for side P.

The first parameter in this equation, the initial correlation of nuclear forces, is simply the ratio of total ETNT for both sides prior to strategic exchange. The Soviets emphasize in

[18]Anureyev, 1967.

their literature that the initial correlation of forces is more important than any subsequent force ratios.[19] According to Tyushkevich (1969), "success in a nuclear missile war on the whole will depend on that correlation of forces which is established prior to its beginning."

The second and third parameters are the portion of TNT equivalent for a particular weapon system or class of weapon systems, summed across all types of weapons systems (i or j) for a particular side. For the sample given in Fig. 3.4 below, we have differentiated 41 different weapon types for the Soviet Union, and 29 different weapon types for the United States (e.g., SS-11, SS-13, etc. See Appendix C).

The remaining two parameters are planning factors for "the probability of overcoming enemy defense" (PTP) and "the probability of non-destruction on the ground" (PLS). Although only two planning factors are incorporated into this measure, in fact they are aggregations of other planning factors. This is particularly true for the PLS factor.

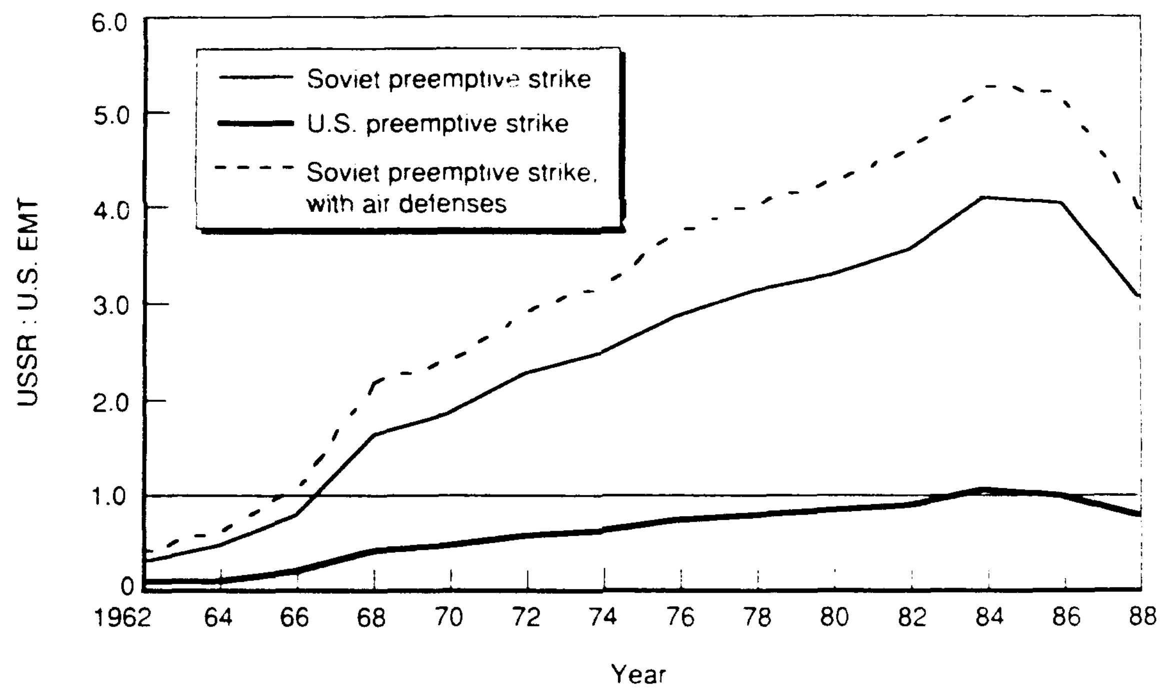

Figure 3.4—Anureyev Correlation of Nuclear Forces, 1962 to 1988

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[19]In the form of the equation given, however, this initial COF cancels out, and the equation reduces to the following:

$$L = \frac{\sum_i Q_{in}^{2/3} \cdot V_i \cdot W_i}{\sum_j Q_{jn}^{2/3} \cdot V_j \cdot W_j}$$

Incorporated into the "probability of non-destruction on the ground" are a wide variety of factors, including:

- Combat readiness
- The degree of automated control of troops and equipment
- The protection and mobility of the carrier launch facilities
- The reconnaissance system
- The characteristics of carrier dispersion.

Obviously, each of these subparameters of the PLS parameter is a complete problem in and of itself, as pointed out by Khabarov et al. in their commentary. While General Anureyev describes some of these parameters, he does not explicitly indicate how they are to be incorporated into the PLS parameter. In practice, the mechanics of their incorporation into the CNF likely falls short of his prescription.

This is also true for the PTP variable. At first, he describes this parameter as "the vulnerability of combat means during flight, during movement on land and at sea," which would seem to include all three legs of the Soviet Triad. In the explicit formula this is then reduced to the "antiair (antimissile) defense of the sides." Finally, in the example given he sets the probability to penetrate ballistic missile defenses at 1.0 and varies the PTP parameter only for the bombers (a more detailed discussion of these parameters can be found in Appendix B on planning factors). In the final analysis PTP is only applied to the bomber leg of the triad, although it was initially prescribed for all forces.

Values for the initial correlation of nuclear forces according to General Anureyev's formula have been calculated and appear in Fig. 3.4.

This figure provides three basic cases. The first two are drawn directly from the Anureyev article, and show the difference that the PLS factor can make in the equation. Force data from Western sources are used, with the exception of planning factors for which illustrative values are assigned. Both sides are assumed to have equal air and ballistic missile defense capability. (Probability to penetrate = .7 for all aircraft and 1.0 for all ballistic missiles.)

The first case is "for a sufficiently unexpected enemy attack," where the prelaunch survivability (PLS) values are .4 for the Soviet Union and .8 for the United States, for all forces. The second case is essentially the reverse, with values of .8 and .4 for the Soviets and United States, respectively. The latter case is consistent with a scenario of Soviet preemption. In this case, the bulk of Soviet forces launch before any U.S. warheads arrive on

Soviet soil, resulting in a high survival rate of Soviet forces. A significant portion of U.S. strategic forces are not able to execute or disperse before the arrival of Soviet warheads, and are therefore vulnerable to attack. In describing how to make the calculations for this correlation of forces model, General Anureyev refers to "the mathematical expectation of the number of carriers overcoming the *enemy* defense." The third step is "a determination of undamaged carriers at the enemy launch facilities which have overcome *our* defense."

The dramatic effects of successful Soviet preemption are shown clearly in the figure. In that case, Soviet superiority in the CNF is overwhelming. Relative to the first two forms of the CNF, where parity was achieved in 1984 (weapons) and 1972 (ETNT), respectively, parity according to the Anureyev CNF is reached in the preemptive scenario by 1966, with continued improvement through the mid 1980s. In the opposite scenario where the United States preempts (PLS factors of .8 for the United States, .4 for the USSR), with little or no warning to the Soviets, parity is not reached until 1984. While the PLS and PTP data are notional, they do not invalidate the basic conclusions one draws from these figures.

The third case given in Fig. 3.4 factors in a difference in the penetration planning factor, specifically differences in air defense effectiveness between the two sides. Soviet air forces are assumed to have a higher penetration rate relative to U.S. air forces because of their superior air defenses. The rates are .9 for the USSR and .7 for the United States. This enhances the Soviet advantage in the CNF even further.

A Critique

While this criterion of effectiveness has received much attention in the United States,[20] it is highly questionable whether it plays a significant role in current Soviet assessments. Soviet articles on the subject subsequent to the Anureyev article[21] have not referred to the Anureyev measure. Instead, references have been made to the basic quantitative correlation of nuclear forces, and to a correlation of nuclear forces which uses an explicit damage equation.[22]

Because of the attention this COE has received, it has come under close scrutiny. One of the most obvious criticisms that can be brought to bear against the Anureyev COE is the use of equivalent TNT (EMT) as the proxy for damage. This was the primary measure used

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[20]Stephan M. Meyer, *Soviet Theater Nuclear Forces*, Adelphi Paper, No. 187–188, International Institute for Strategic Studies (IISS), London, Winter 1983–1984.

[21]With the exception of the direct commentary on the Anureyev piece, which is in the August 1968 *Military Thought* issue.

[22]Babiy and Volgin, 1980.

by both the Soviet Union and the United States at a time when targets were softer and missiles were far less accurate than they are today.

> The problem of optimization of the TNT equivalent of the charge and launch precision involves combined analysis, since the effectiveness in performance of the combat mission is governed by a combination of [them both]. . . . i.e., a 10% decrease in target accuracy can be compensated for by increasing the TNT equivalent of the charge by 30%.[23]

Once weapon accuracy increased to where there was a hard target kill capability (driven in part by the quantitative and qualitative growth in hard targets), ETNT (EMT) became a less appropriate measure.

A second drawback of this CNF is that in the form given, it does not differentiate between a one warhead weapon with a 10 megaton yield and ten warheads with a one megaton yield because it is aggregating over delivery system types (e.g., ICBMs). This difference is clearly appreciated by the Soviets, but not reflected in this measure. Perhaps the most important and accurate criticism has been from Khabarov et al., who originally commented on the article: "The author offers an appropriate formula for determining the correlation of forces in nuclear weapons. At first glance it creates a favorable impression by its simplicity, but after a closer look it is evident that that simplicity is illusory."[24]

Colonel Semeyko's complaint refers primarily to the fact that the operational factors which appear as simple parameters in Anureyev's criteria are themselves complex models which require complex calculations. Their calculation is not specified by Anureyev, and poses further problems in the solution of the CNF.

While its importance today in the form specified in the article is questionable, it is important to point out that the Anureyev article did establish most of the basic arguments that would be repeated in future discussions on criteria of effectiveness. His work was groundbreaking, and set the standard for CNFs to come. Future articles did advocate the incorporation of factors included in Anureyev's lambda, and several principles raised in the equation are more likely elements of any current equation:

- Damage
- The basic form

[23]Varfolomeyev and Kopytov, p. 288.
[24]Khabarov et al., 1968.

- Operational factors
- CNF as a function of time.

DESTRUCTION POTENTIAL (PD) CNF

The destruction potential (hereafter referred to as PD, according to the U.S. analog—probability of destruction) correlation is fundamentally different from previous CNF measures in that the qualitative differences in warheads are no longer taken account of by equivalent TNT, but by explicit damage calculations. Whereas the former (ETNT) is a soft-target or area kill measure, the PD measure is equipped to deal with hardened point targets as well as soft area targets.

Explicit damage equations appear in the Soviet operations research literature throughout the 1970s.[25] However, they are typically mentioned in the context of tactical or operational-tactical calculations for evaluation of the effectiveness of a single missile complex. During this time they did not explicitly appear in what might be called a strategic level COE, across all strategic nuclear forces, for both sides.

A *Naval Digest* article from 1980 discusses the use of the PD CNF at a strategic level. It is defined as a two-sided measure, the correlation of *destruction potentials* for the evaluation of "relative strengths of opposing sides." One of the primary focuses of this article is on the need for a "cumulative evaluation . . . with the application of quantitative methods and with consideration of all factors, including indirect ones, capable of having a substantial effect on the course of armed conflict."[26] The damage form of the correlation provides a "comparative evaluation of relative strength of varied forces and weapons of the sides." Clearly, this is intended as a strategic level MOE for the evaluation of force effectiveness on a broad scale.

The article implies that this form of the CNF was in use at the time of publication (1980), for the article criticizes this measure. While it maintains that damage is the proper form, "there can be nothing arbitrary in determining the type of effectiveness factor. Effectiveness depends on damage inflicted on the enemy,"[27] It is proposed that they need to go beyond simply calculating damage, and explicitly link that damage to the military goals and objectives. A criterion in one of the following two forms is required:

1. Infliction of a minimum level of damage on friendly forces;
2. Infliction of maximum possible damage on the enemy.

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[25]Yu. V. Chuyev, 1971, and Varfolomeyev and Kopytov, 1970.
[26]Babiy and Volgin, 1980.
[27]Ibid.

The expression of warhead capability as damage rather than using ETNT as a damage proxy is a significant change. Whereas ETNT is an appropriate estimate of a weapon's (or force's) ability to inflict damage on soft targets, the PD formulation brings target characteristics explicitly into the equation. The fact that damage is calculated for a particular weapon against a specified target also requires a specific target plan.

The explicit form of the PD correlation is given below.

$$\frac{\text{Destruction potential of side A (Soviets)}}{\text{Destruction potential of side B (enemy)}} = \frac{U(A)}{U(B)}$$

$$U(A) = \sum_{j=1}^{N^{(A)}} n_j(A) \cdot u_j(A); \quad U(B) = \sum_{j=1}^{N^{(B)}} n_j(B) \cdot u_j(B) ,$$

where $N^{(A)}$ is the number of different groups or types of forces, each of which consists of n like units, and $u_j^{(A)}$, $u_j^{(B)}$ are the target destruction potentials by one means of the j-th group for sides A and B, respectively.

The representation of the PD correlation in the article is simplistic and requires some further clarification concerning u, the "target destruction potential," or "mathematical expectation of the number of destructive hits or number of destroyed targets." Earlier in the article, the probability of kill, W, is given as:

$$W = 1 - e^{-u}$$

From another source,[28] the probability of kill, P_k ,, is given as:

$$P_k = 1 - e^{\frac{-(LR)^2}{2\sigma^2}}$$

Therefore

$$-u = -\frac{(LR)^2}{2\sigma^2}$$

$$u = \frac{(LR)^2}{2\sigma^2}, \text{ where LR = lethal radius;}$$

[28]Bruce W. Bennett, *Assessing the Capabilities of Strategic Nuclear Forces: The Limits of Current Methods*, RAND, N-1441-NA, June 1980.

$$\sigma^2 = \left[\frac{\text{CEP}}{1,1714}\right]^2 \text{ for bivariate normal distribution model}$$

The explicit incorporation of target hardness (in the lethal radius parameter) is a new and significant change over the ETNT measures. It requires a much more complex model, which compiles a target base, pairs specific weapons with specific targets, and then performs the calculations. Previously, the measures only incorporated weapons and weapons characteristics. Targets, specifically their number and hardness, were not addressed.

The PD CNF given in the *Naval Digest* article does not explicitly include planning factors in the equation. However, they are discussed generally in the article. The authors state that "different methods for calculating these potentials are proposed, which differ from each other by the techniques of accounting for particular properties of combat operation processes." "Combat operation processes" most likely refer to planning factors such as penetration and reliability.

Further evidence to support the belief that the Soviet military uses the PD CNF is given by a strategic exchange model developed by a civilian group. That model also uses destruction probabilities and provides a detailed target list.[29] However, this corroborating evidence is tenuous. Due to the lack of communication and the lack of information exchanged between the civilian and military sectors in the Soviet Union, these Soviet civilian researchers could have based their model on Western exchange models.

Values for the PD CNF were not calculated for this study, since in addition to the force data, it would have been necessary to compile a target base for both the United States and the Soviet Union. These calculations, the focus of subsequent work under this project, will be presented in a separate publication.

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[29]This model is described in the appendix of ***Strategic Stability Under the Conditions of Radical Nuclear Arms Reductions***, Committee of Soviet Scientists for Peace, Novosti Press Agency, Moscow, Apr. 1987.

4. CONCLUSIONS

SELECTING A MEASURE

This Note has addressed four possible *strategic* level COEs for intercontinental nuclear forces. The quantitative CNF is a simple ratio of numbers of similar types of weapons. The ETNT CNF takes account of qualitative differences in the destructive power of warheads through a ratio of equivalent TNT. The Anureyev CNF provides a full complement of qualitative factors, including both ETNT to account for differences in warheads, and planning factors to account for differences in weapons launchers. Finally, the PD (destruction potential) CNF accounts for qualitative differences in weapons through explicit damage calculations, rather than a TNT proxy (see Fig. 4.1 for a comparison of these CNFs across the years).

The primary question to be answered is which of these forms have the most currency today with the Soviet General Staff. There are three basic choices to be made in answering this question. First, is the CNF used today qualitative or quantitative? Second, if it is qualitative, then how are qualitative factors in the warheads represented—with ETNT or explicit damage equations? Finally, are qualitative differences in launching platforms accounted for by using planning factors?

It is clear from virtually all the sources examined that the quantitative CNF is still used by the Soviet military. Specific reference to this exists as recently as 1980. However, as long ago as 1967, Anureyev pointed out that while this form of the CNF was useful, it is insufficient. Other measures are needed: "[The quantitative CNF] has been used in the military field for a long time and retains its effectiveness for the same types of means today. However, the use of this kind of approach alone in determining the correlation of forces . . . is obviously insufficient."[1]

Therefore, while the quantitative CNF is still used today, it is probably not the primary form of the CNF used by the General Staff. Rather, some form of the qualitative CNF is probably used.

Concerning the representation of qualitative differences in warheads, an explicit damage equation is more likely than ETNT for several reasons. First, ETNT is most appropriate as a measure of effectiveness against soft targets. Targets have become increasingly hardened over the past 20 years.

[1]Anureyev and Tatarchenko, 1967.

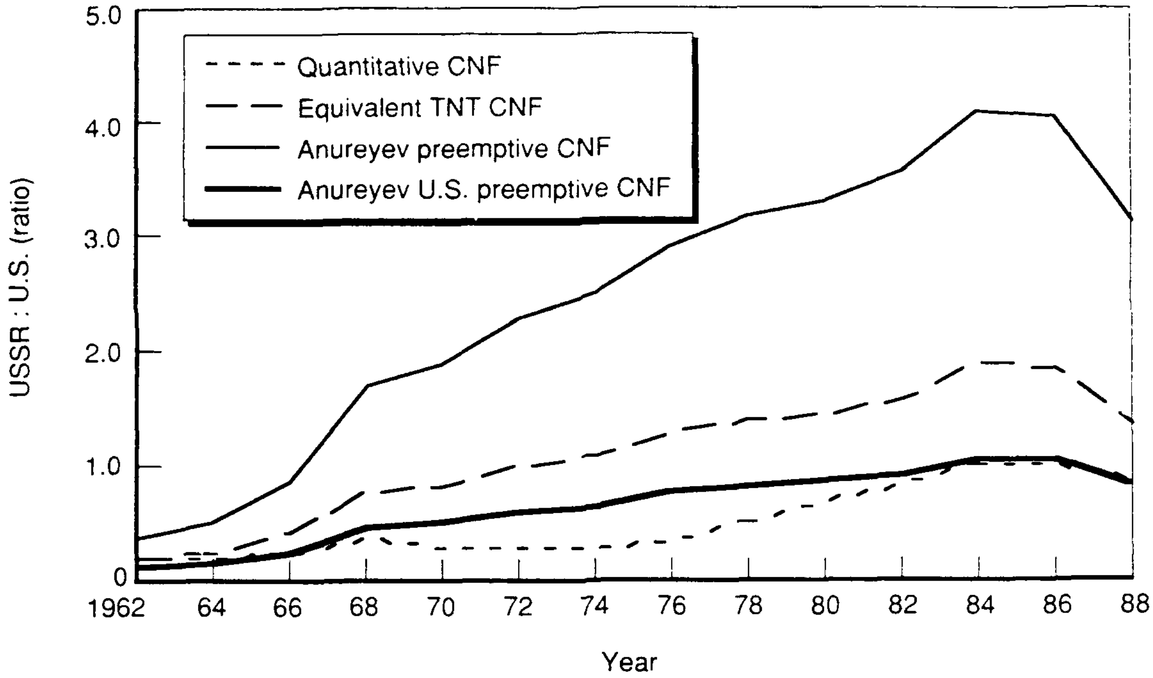

Figure 4.1—Summary of Soviet CNFs, 1962 to 1988

Second, from the mid 1970s to the present, average Soviet ETNT per warhead has been decreasing significantly. This decrease, while the U.S. ETNT per warhead has remained relatively constant, is difficult to reconcile with Soviet use of ETNT as the primary criterion of effectiveness for nuclear weapons. If ETNT were the principal COE one would expect average ETNT per Soviet warhead to increase rather than decrease.

An ETNT measure still remains valid for two cases. First, it is appropriate for use as a reserve force measure, since reserve forces are typically charged for the most part (i.e., except for hard-target restrikes) with targeting countervalue (soft) targets. Second, it is appropriate for measuring capabilities against any subset of soft targets.

The second area of contention is the incorporation of planning factors. At issue are which planning factors would be incorporated into a Soviet measure, or whether they would be incorporated at all. It might be argued that the need to include planning factors would not be very great since the Soviet strategic nuclear force is primarily composed of ICBMs (60 percent of the total force), and the planning factors (PLS, PTP, reliability) for those weapons are equal to or close to one in most cases:[2]

[2]Ivanov et al., 1971.

- **High PTP**: "The high speed and flight altitude ensured the practical invulnerability of a rocket during its flight."
- **High PLS**: "Rockets also have a low vulnerability on their launch sites."
- **High Readiness & Reliability**: "These advantages of rockets, and also the short flight time to a target, the constant readiness for action and high technical reliability have put them in first place among other means of delivery."

However, several issues support a judgment that the Soviets must use launcher planning factors in their strategic nuclear measures of effectiveness. First, a ratio is used in estimating force effectiveness, where the forces of the opposing side are considered as well. Bomber weapons make up a substantial component of the U.S. force, and for these launchers the PLS and PTP factors are less than one. Further, Soviets emphasize in their writings the importance of selecting the proper force mix (ICBMs versus SLBMS versus bombers), and it is the planning factors that differentiate these launchers from one another.

Finally, defenses are a major focus of Soviet efforts. In the words of Anureyev and Tatarchenko (1967), "a most important factor which makes it possible to accomplish the task of changing the correlation of forces in one's own favor is antiair defense (antimissile and antispace)."

Sensitivity analyses of the role of defenses is not possible without the incorporation of the PTP factor into these COEs. Therefore the evidence favors the incorporation of planning factors in Soviet COEs.

One approach to determining which of these CNFs is the primary form would be to examine when the Soviets felt that they had achieved parity. In the past several years, the Soviet military community, including official military personnel, high-ranking political figures, and civilian analysts, have frequently referred to the current state of strategic nuclear parity between the United States and the Soviet Union, with some articles specifically dating the achievement of this state to the early 1970s, for example: "As is known, the global quantitative military-strategic parity between the U.S.S.R. and U.S.A. was established in the early 1970s. . . . This balance was preserved during the 1970s. . . . "[3]

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[3]Committee of Soviet Scientists for Peace Against Nuclear Threat, *Strategic Stability Under the Conditions of Radical Nuclear Arms Reductions*, Novosti Press Agency, Moscow, April 1987, p. 6.

The first three measures fail this test (see Fig. 4.1).[4] The quantitative CNF does not achieve parity until the early 1980s. The ETNT CNF achieves parity in the early 1970s, but is followed by a continued gain by the Soviets in the CNF, which ultimately reaches a 1.8 to 1 advantage. This CNF therefore fails the test of preserving the balance. Finally, the Anureyev measure comes closest, but also seems to fail the test. In any case where the Soviets preempt, the Anureyev measure indicates parity is achieved early (mid 1960s) and the Soviets continue to increase their advantage until the mid 1980s. In the conservative U.S. preemption case, parity is not reached until the 1980s, although with different values for the planning factors this would shift.

Unfortunately data are lacking for the PD CNF, and a determination of the Soviet assessment of this criterion is beyond the scope of this Note. However, the evidence available points to a conclusion that this COE is probably the most important measure used by the General Staff today. This does not imply that the simple quantitative CNF (or other measures) is no longer used. Soviet literature on this subject has referred to the continued use of this basic measure through 1980, although citing the inconsistencies and inadequacies of this COE.

One final note on the measures presented in this Note. The plethora of Soviet statements which decry U.S. military strength, pleading a weaker Soviet military, tend to be summarily dismissed, or at least discounted in the West. However, according to the measures presented in this Note, there is some basis for the Soviet complaints of their (potentially) declining military capability relative to that of the United States. Constant across *all* measures, Soviet strategic nuclear capability relative to that of the United States began to decline in 1984, and dropped precipitously from 1986 to 1988.

FUTURE DIRECTIONS

The Soviet Union has undergone considerable political change since Gorbachev became General Secretary, although the military implications of these changes are far from certain. Still, since COEs measure the ability of forces to implement military doctrine, if that doctrine changes (and many analysts argue that it has), it is plausible that the measures used to gauge the capability of their military forces might change, as well. While it is still too early for any concrete evidence, there are several key factors which could have an impact on Soviet MOEs:

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[4]The calculations for the measures are not proported to be exact. However, the data used should be accurate enough for general comparisons.

- Entrance of civilian researchers into the modeling field;
- Doctrinal changes;
- Development of a more balanced triad;
- Development of Soviet strategic measures along the same lines as Soviet; conventional measures.

Civilian Modeling

In the past several years, a new breed of "new thinking" civilian analysts has turned its attentions toward the modeling of military problems,[5] and challenged the Soviet military in an area that has traditionally been its sovereign domain. Lacking data and operational details, the civilian models have focused on policy questions, such as arms control, rather than operational issues.

The entrance of civilian institutes into the world of modeling poses a significant challenge to the military. In particular, the military may be compelled to go beyond their traditional emphasis on operational issues and to develop models relevant to broader policy issues in order to compete with the civilians. The following example provides some evidence to support the emergence of such a trend.

Recently a series of articles have been published by a former military officer and author in the General Staff publication, *Military Thought*, promoting the use of current Soviet military measures at the conventional arms control talks in Vienna.[6] The application of these measures to the arms control arena is an attempt to answer policy questions with COEs traditionally used by the military to solve operational problems. The Soviet military is clearly trying to use its current models to influence the policy-making process, which may or may not be appropriate.

Doctrinal Changes

The correlation of forces methodology reflects the Soviet military's goal of changing the correlation of forces to its own advantage in order to achieve superiority and eventual victory in a potential conflict. The COEs are used to determine how best to allocate weapons, both in target distribution, and in the timing of the attack, to achieve that victory.[7]

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[5]Previously, Soviet civilian strategic nuclear analysts concentrated more on the study of U.S. strategic nuclear force issues than on the study of their own strategic force.

[6]Vitaliy Tsygichko, *Military Bulletin APN*, June 1988, October 1988, March 1989.

[7]Anureyev, 1967.

Soviet military doctrine in the past several years has emphasized the need to *operationalize* a strategy of defense sufficiency.[8] That is, Gorbachev and his supporters are calling on the military to identify how many and what types of forces are required for defense, short of a first-strike offensive capability. While this defensive doctrine was originally applied principally to theater conventional forces, it has now been defined for strategic nuclear forces, as well:

> Defense sufficiency includes two main components. The first is sufficiency in strategic nuclear forces. This is a level of these forces that ensures military-strategic stability in peacetime and in the event of war ensures guaranteed unacceptable damage to an aggressor in the course of retaliatory actions.[9]

The basic question to be answered is whether a measure developed for an offensive strategy will also be valid for a defensive strategy. The correlation of forces measures are traditionally used in the context of changing the correlation of forces to ones own favor, in order to achieve victory. If the political leadership of the Soviet Union wishes to eschew that goal, will this measure continue to be suitable?

Development of a More Balanced Triad.

With the decision to replace the SLBM fleet with MIRVs and, to a lesser extent, modernize Soviet strategic bombers, and given the proposed Strategic Arms Reduction Treaty (START) agreement, the percentage of the Soviet strategic nuclear force dedicated to ICBMs will shrink in the future. Measures have been used by the Soviets for the past 30 years to support procurement and deployment decisions, and those decisions have been that ICBMs are the preferred force type. The classic 1967 *Military Thought* article by General Anureyev discussed the use of the COE developed in that article to support selection of the proper force mix.

Now that the relative portion of ICBMs in the Soviet strategic arsenal is shrinking, there should be some question as to whether those same criteria can now be employed to show that ICBMs should be a smaller portion of the Soviet strategic force. Can measures which once were used to prove that ICBMs were the overwhelmingly preferred force type now be used to show that a more balanced triad is needed?

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[8]It is unclear how much of this new doctrine has been embraced by the Soviet military, and how much has been forced on them by the political leadership.

[9]Army General M. A. Moiseyev in a speech he delivered July 5, 1990, to the 28th CPSU Congress.

Mirroring of Conventional Force Measures

Soviet MOEs for intercontinental nuclear forces have traditionally mirrored measures developed for the theater forces. In recent years, the Soviets seem to have converged on a methodology for the assessment of conventional forces which centers on a standard unit of armament (SUA).[10] This methodology is similar to the Weapons Effectiveness Index Weighted Unit Value (WEI-WUV) system in the United States, which seeks to deal with the problem of evaluating the military capability of units of forces, rather than the counting of individual force types.

In the SUA methodology, a weapon is selected as the standard, and other weapons are *translated* into those standard units. For instance, an MM3 warhead might be adopted as the standard (= 1). Less capable weapons systems would be valued at less than one, more capable systems would have a value greater than one. These values would be assigned to the different weapons systems according to some model which assesses military capability, not dissimilar from the measures described in this Note. ETNT could be used as the basis for assigning values to weapons systems, or damage achieved to a target of a specified hardness.

If the lessons of the past hold true, and the Soviets continue to draw heavily from their theater COE methodology for the development of intercontinental nuclear COEs, then a similar system of SUAs could be used for strategic forces. One reason that the SUA methodology might not be applied to the intercontinental arena is that whereas conventional forces are heterogeneous, strategic forces are basically homogeneous. All strategic nuclear forces measure their success or failure in terms of damage.[11] Conventional forces, on the other hand, have many different missions they are trying to accomplish, and numerous ways to measure the success or failure of those missions as well (e.g., aircraft losses, casualties, force ratios). An SUA methodology is very useful for measuring heterogeneous forces but is not necessary for homogeneous forces. Strategic force developments of the future, both in terms of the development of new weapons systems (e.g., ALCMs and SLCMs) and new employment doctrines for strategic forces (against conventional targets) could, however, make an SUA methodology for strategic forces more compelling.

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[10] Tsygichko, 1989.

[11] It is important to note, however, that the target set against which strategic nuclear weapons are employed is not homogeneous.

Appendix A
HOW TO USE SOVIET CRITERIA OF EFFECTIVENESS IN MODELS

The establishment of Soviet COEs for intercontinental nuclear forces is only one part of the problem of providing a Soviet style assessment of the balance. It is also important to examine how those COEs might be used within a model. Several key features, including what kind of model might house the COE, how that COE might be used within the model, and the application of the strategic nuclear model results to the theater, are discussed briefly below.

The operations research literature in the 1970s suggested that the Soviets have favored relatively simple optimization models. Whether this was due to the Soviet preference for simplicity over detail, or whether they lacked the computer technology and hardware to implement more complex computer models, is unclear. There is some evidence to support the latter conclusion—that the Soviets simply lack necessary hardware, software, and personnel to build large-scale (cutting edge) computer models. One recent publication which discusses the state of military models indicates that the military is lacking in all of these areas.[1]

Anureyev prescribed in 1967 a likely framework for Soviet exchange models. The procedure Anureyev laid out in his criterion is simple but powerful. First, optimize damage to nuclear weapons: "maximum efforts must be directed against the nuclear means of the enemy" (Anureyev 1967). After maximizing damage to enemy nuclear targets, the remaining forces are then optimized for ETNT—a soft or value[2] target measure.

This approach is strikingly similar to an approach for strategic stability in the West. (See Fig. A.1.) In such an approach, weapons of either side would be expended against nuclear targets according to a marginal cost criterion, stopping somewhere along the knee of the curve. That is, as long as the attacker destroys more than one enemy nuclear warhead for every warhead he uses in targeting that enemy force, the attacker will choose to expend

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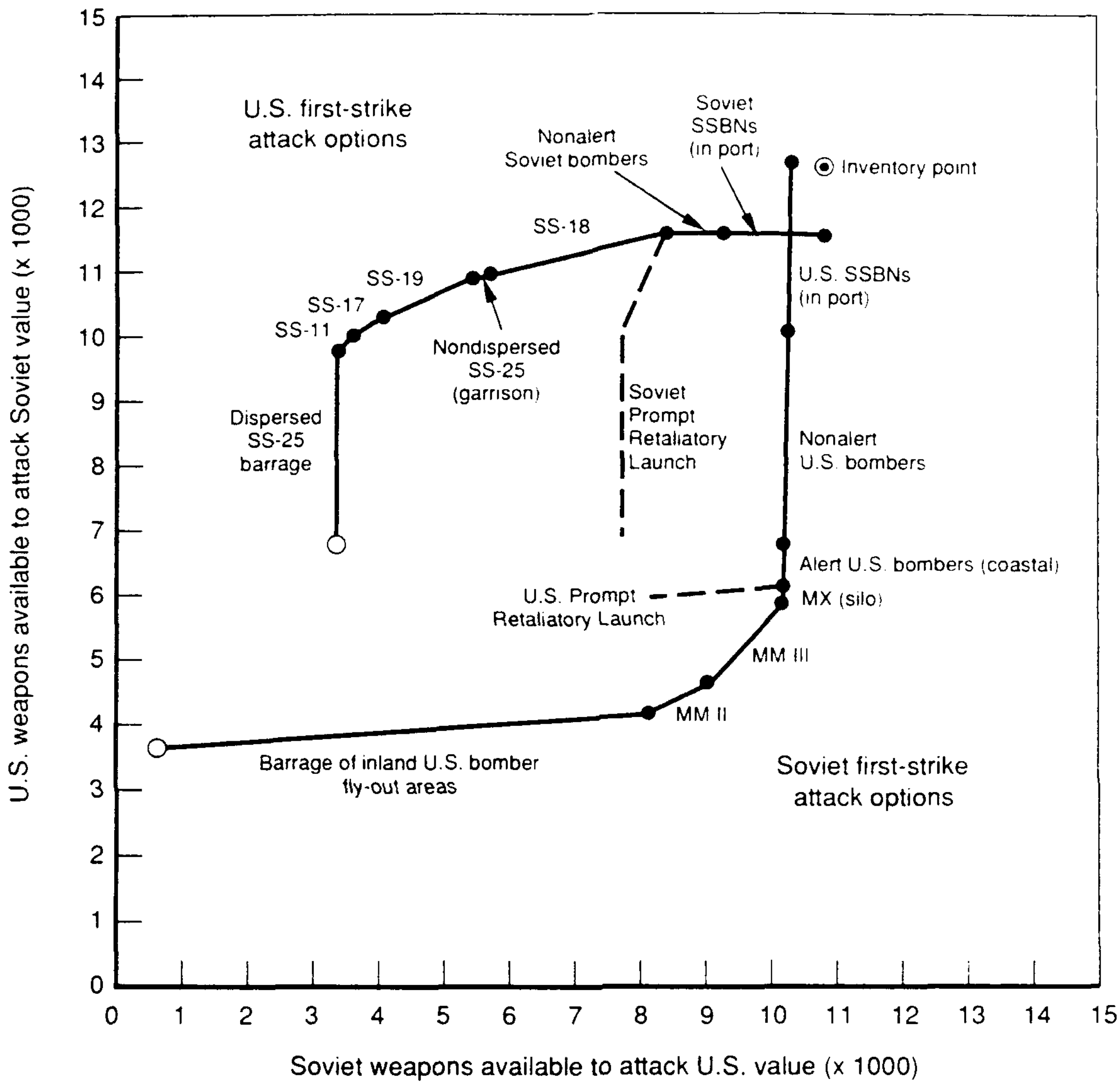
[1]There was a series of articles in *Military Thought* in the late 1980s which discussed what Soviet military analysts consider to be the abominable state of military modeling in the Soviet Union. One of these articles is General Major M.I. Cherednichenko, "A Methodology for the Mathematical Modeling of Operations," *Military Thought*, September 1988.

[2]Value targets are non-military targets, primarily economic and population, but including some administrative centers as well.



SOURCE: Glenn A. Kent and David E. Thaler, *First-Strike Stability: A Methodology for Evaluating Strategic Forces*, RAND, R-3765-AF, August 1989.

Figure A.1—A Two-Sided Drawdown Curve

that warhead.[3] Once that is no longer economical, the attacker might choose to stop,[4] reserving the remaining warheads for use against value targets.

Another piece of evidence suggesting that this modeling approach is used by the Soviets is that this type of cost-effective attack appears in a civilian exchange model which uses what it terms a criterion of cost-to-attack in building its target plan.[5] It is unclear, however, to what extent Soviet civilian military models reflect their own military modeling, or the modeling in the West.[6]

DYNAMIC NATURE OF SOVIET CORRELATION OF FORCES

Soviet military analysts seem to employ the correlation of forces measure in a manner largely adapted from their conventional force correlation of forces COE. A correlation is to be taken *more than once*[7] in the course of a conflict.[8] The goal is not to evaluate what has happened, but to be able to influence what will happen, with the primary objective of changing the correlation of forces to their favor.

In order to determine the times during a conflict when the Soviets would be most likely to calculate the CNF, it is necessary to portray how they think intercontinental nuclear war would unfold and progress. One source portrays this as a two-wave process.[9] (See Fig. A.2.)

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[3]Note that the marginal cost criterion could be based on equivalent megatonnage or damage expectancy tradeoffs rather than warheads.

[4]In the example given, the attacker does not stop according to the economical criterion cited (destruction of at least one enemy warhead for every friendly warhead expended). In this case, there are enough weapons to do some counterforce targeting which does not meet this cost-efficiency criterion, such as the barraging of bomber bases.

[5]Committee of Soviet Scientists for Peace Against the Nuclear Threat, *Strategic Stability Under the Conditions of Radical Nuclear Arms Reductions*, Novosti, Moscow, 1987.

[6]Even in the new era of *glasnost'*, Soviet civilian researchers still have much more access to Western research and military data than to their own.

[7]In much U.S. strategic exchange analysis, damage expectancy (DE) is calculated once at the end the exchange. Although it is a dynamic measure in the sense that we are *using* the weapon and measuring its effect, the *way* in which we use the measure is static; we simply look at the postexchange outcome.

[8]The 1967 Anureyev *Military Thought* article refers to calculating the COF more than once "to compute the COF after any particular stage of combat actions" (p. 162 of the translation), and "having determined the correlation of forces after the first nuclear strike." (p. 163, translation). Also, Varfolomeyev and Kopytov (1970) state that "when strategic missiles are used the number of mutual nuclear missile strikes of the sides is limited to three or four" (p. 318 of the translation). It is ambiguous in both cases whether these references are to intercontinental or theater nuclear forces. In the Varfolomeyev and Kopytov reference, however, while *strategic* does not necessarily refer to *intercontinental*, the same passage refers to the antiballistic missile (ABM) system, which would indicate that this case could apply to the intercontinental arena.

[9]K. V. Tarakanov, *Mathematics and Armed Combat*, Voyenizdat, Moscow, 1974, p. 295 of translation.

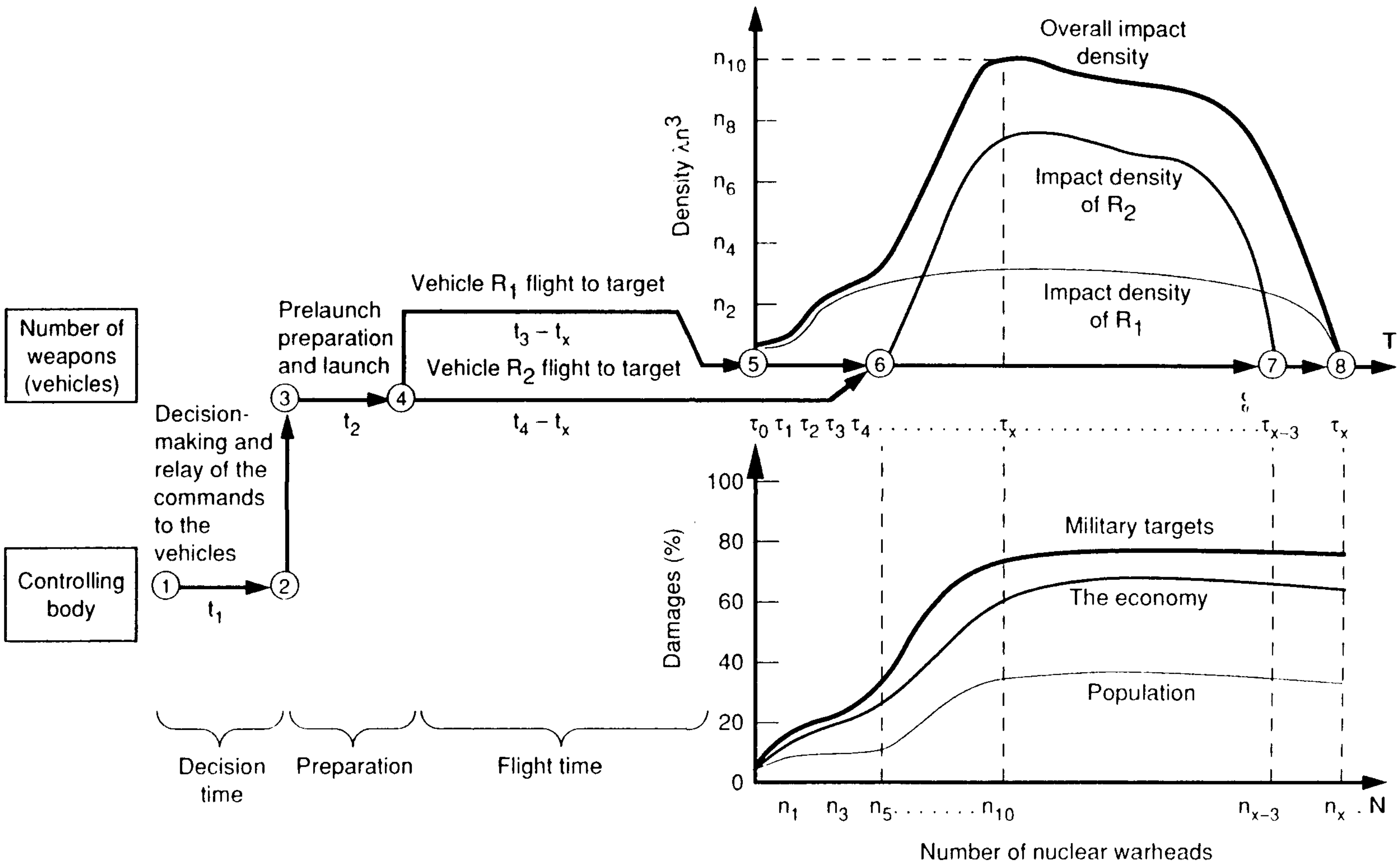

Figure A.2—Strategic Exchange

In this scenario, side A has initiated the use of nuclear weapons (although not explicitly stated, in the scenario it appears clear that side A is the United States and side B is the Soviet Union). While side B is the retaliator, it manages to execute most of its weapons prior to impact by the weapons of side A. This suggests either the receipt by side B of strategic warning in time to launch on warning or an attempted preemption based on some other evidence. Not all of side B's forces execute in the first wave or strike. Whether they choose not to execute, or are unable to execute at the time of the first wave is unclear. Some of side B's forces therefore ride out and survive an attack, and are then executed in a second wave against side A.

The scenario above lays out three possible times for the calculation of the correlation of nuclear forces:

- The initial correlation of forces, prior to execution by either side;
- The correlation of forces some time between the first and second launches (logically after side A's warheads have impacted on side B, and vice versa);
- The correlation of forces sometime after the second launch (and logically after the final impact of any warheads) which would then be a measure of the reserve force.

INTEGRATION OF THEATER WITH STRATEGIC

In the United States, military models tend to separate the strategic component of war from the conventional component. Strategic exchanges are run in isolation of the theater battle, and the two are analyzed separately. If a game or model is run with both the nuclear and conventional components, once nuclear weapons have been employed, the conventional military component is quickly forgotten, as if irrelevant in the presence of nuclear weapons.

In the Soviet writings, there is not a distinction between strategic nuclear and theater conventional conflict. There is not only an interaction between these two, but that interaction runs both ways. The first concern of the Soviets with regard to nuclear weapons and the one that has received the most attention in their literature, is the impact of nuclear weapons on the conventional war:[10]

> Above all, we should never overlook that the losses which can be conflicted by the nuclear weapon are capable of altering basically the ratio in the forces and

[10]D. Samorukov and L. Semeyko, "The Increase of Efforts in Nuclear Warfare Operations," *Military Thought*, October 1968.

means of the opposing sides, even without an additional introduction of other forces and weapons.

From the other point of view, it is also clear that they expect attrition of [theater] nuclear weapons during the conventional phase of the conflict:[11]

> The fact is that under these conditions the command echelons would have to direct the efforts of their troops primarily toward changing the correlation of forces in nuclear resources by destroying those possessed by the enemy. *This is necessary in order to insure beforehand one's own superiority in nuclear weapons and thus create the most favorable conditions in case the enemy attempts to use nuclear weapons.*

There is no evidence that the Soviet strategic exchange models incorporate conventional force employment in them. On the contrary, recent publications describe the fact that models are fairly compartmentalized.[12] However, they do stress the importance of providing a link between their strategic nuclear models and conventional force models. That link is typically manifested through an accounting of damage. Soviet sources[13] provide formulae for the translation of the destructive capability of a weapon (equivalent TNT) into kills of a specific type of target. (For instance, 100 ETNT might equate to 200 tanks killed.) In all such samples provided in the literature, the translation is from nuclear weapons to theater conventional force targets killed.

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[11]Tyushkevich, 1969.
[12]Cherednichenko, 1988.
[13]Varfolomeyev and Kopytov, 1970. Babiy and Volgin,1980.

Appendix B

CORRELATION OF NUCLEAR FORCE PLANNING FACTORS

One of the two classes of qualitative factors to be incorporated into Soviet intercontinental COEs are the planning factors which delineate differences in launching platforms. Concerning such factors, there is some question as to which factors would be included in the Soviet measures, and whether they are included at all. This section will examine briefly some of those parameters.

The case can be made that through the 1960s there was little need to incorporate planning factors into Soviet measures of the outcome of a strategic exchange. Not only was the Soviet force composed primarily of ICBMs, but the Soviets seemed convinced that ballistic missiles would be the primary players in a nuclear war: "In a nuclear missile war, if one should be unleashed by the imperialists, the main means of destruction will be nuclear warheads, and the main means of delivering them to their targets will be rockets."[1] The value for virtually all of these planning factors for an ICBM is close to 1.[2]

However, beginning with the Anureyev article in 1967, the issue of their incorporation into a strategic level MOE is raised. The evidence supporting their use seems strong, since it is those parameters which provide much of the justification for the acquisition of one leg of the triad over another. While the Anureyev article is the only one to discuss these parameters explicitly in the context of the CNF, other sources have focused on one or more of these planning factors in the context of separate or individual models for these factors.

The following is a discussion of the parameters as they appear in the literature. A description of the individual parameters is given, rather than any analysis on which of these parameters form a complete set since there is often an overlap between these components in the literature. For instance, the probability to penetrate is an explicit, separable parameter in the Anureyev CNF. In other sources, it is a component of readiness and reliability.

In his article, General Anureyev sets forth the key components of the correlation of nuclear forces measure:

> Thus the COF in nuclear weapons depends on such important parameters as:
>
> 1. initial correlation of forces in such weapons
> 2. distribution of nuclear weapons among the various branches of the armed forces

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[1] Ivanov et al., 1971, p. vii.
[2] [illegible]

3. effectiveness of the antiair (antimissile) defense of the sides
4. the tactical-technical characteristics of the nuclear weapons delivery vehicles
5. protection and mobility of the nuclear means of the sides
6. the combat readiness of the nuclear means of the sides
7. the systems for control of the troops and combat means
8. reconnaissance
9. the plan of nuclear strikes (distribution of nuclear means over enemy targets).

These parameters are incorporated into Anureyev's model in the following way. The first three are represented explicitly. Parameters 5 through 8 compose the PLS parameter. We will use this same framework in reviewing these planning factors.

VULNERABILITY OF COMBAT MEANS AT LAUNCH (PRELAUNCH SURVIVABILITY)

This variable is an extremely complex combination of a great number of factors which themselves have complex calculations, including:

- Combat readiness
- The degree of automated control of troops and equipment
- The protection and mobility of the carrier launch facilities
- The reconnaissance system
- The characteristics of carrier dispersion.

While all of these are in and of themselves important parameters, comprising complex supporting models, this section looks at the first three. These have been recurrent themes in the Soviet literature, which have received considerable attention recently.

Combat readiness is defined as "the interval of time from the moment the launch signal is received to the moment the carrier leaves the launcher."[3] (The units are therefore time; the translation of these units into a probability is not explicitly given by Anureyev.) The inclusion of readiness in the PLS factor is due to the relationship drawn between the combat readiness and prelaunch survivability of the weapon system. The higher the combat readiness (that is, the shorter the time to prepare the weapons for launch), the smaller the probability of carrier destruction at launch.

Automated Troop Control is defined as the *time* to gather information, process it, make the decision, and transmit that decision back to the people and forces who will execute that

[3]This precise definition is given in Anureyev (1967), although similar definitions are provided in numerous other sources, including Varfolomeyev and Kopytov (1970).

decision.[4] (Once again, the units for this are time). Another source by the same author[5] yields basically the same definition:

$$T(\text{control}) = T(1) + T(2) = T(3)$$

where $T(1)$ = time to gather and receive information
$T(2)$ = time to process information
$T(3)$ = time to transmit decision/information

This equation represents what is called the *control cycle time*. Associated with these times are norms which must be met. Specifically, the control cycle time (T[control]) must be less than the *critical time*, a preestablished norm. Numerical values for T(1), T(2), T(3) and the time to execute the decision appear to be derived from exercise data. Troop performance for each of these components is monitored and calculated to insure that the critical time is met.[6] It is interesting that General Anureyev sets forth here a proposal that became one of the most important areas of improving operational performance for the Soviets over the next twenty years—the task of automating troop control:

> Thus the introduction of automated systems of control in troop units, and primarily in the strategic nuclear forces, makes it possible to reduce the time on the control cycle, and consequently, to increase the correlation of forces after the nuclear strike to our advantage.

This is included in the PLS parameter because "we note that it will be the same as the influence of combat readiness time: the more time spent on the control cycle (gathering information, processing it, making a decision, and transmitting it to the executors), the greater the probability of the carrier's being destroyed at launch and the lower the correlation of forces." [7]

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[4]Anureyev, 1967.
[5]Anureyev and Tatarchenko, 1967.
[6]Anureyev and Tatarchenko, 1967, Chapter 1, p. 12.
[7]Anureyev and Tatarchenko, 1967.

RELIABILITY

The combat reliability of a missile complex is defined as the probability that the warhead will reach the target area at the required moment of time with the aid of the missile complex and that the detonation will occur:[8]

P(mc) = P(v) * P(m) * P(ABM), where

P(v) = probability that the missile complex will be ready within the established time after receiving the command to launch the missiles and will not be destroyed by the enemy (reliability of the technological and test equipment of the launch installation);

P(m) = conditional probability (when P(v) = 1) of successful launch of a missile, delivery of the warhead to the target area with the permissible dispersion and proper functioning of the bomb (missile reliability criterion);

P(ABM) = conditional probability (when P(v) * P(m) =1) that the warhead will penetrate the enemy's ABM system (depends on the degree of saturation of the examined group of targets with ABM defense, and also on warhead parameters.

This formulation of reliability is more accurately a full model of the execution of ballistic missiles. The first component, P(v), is a combination of the control prelaunch survivability (PLS) parameters in Anureyev's equation, and in Western equations. The final element, P(ABM), is the penetration parameter (PTP). It is the middle parameter, P(m), which is what we consider in the West to be the reliability factor, and what would likely be the reliability factor in the Anureyev equation. This includes both platform reliability, for launch and flight to target, as well as warhead reliability in detonation on target.

Further information on the composition of this parameter from the Soviet perspective is given in an article by Tsybul'ko.[9] This article includes one additional factor in reliability which is often omitted in Western estimates, or at least given little attention. In addition to

[8]Varfolomeyev and Kopytov, 1970; the missile example can be generalized to launcher reliability and warhead reliability.

[9]Tsybul'ko, 1972.

technical reliability, or the reliability of the weapon system itself, human reliability is also mentioned as a major factor. The fact is cited that at that time 40 percent of all failures in missile tests occurred due to the fault of personnel.

Probability to Penetrate. It is interesting that Anureyev's initial list of planning factors list entails a much broader concept, specifically "the vulnerability of combat means during flight, *during movement on land and at sea*. In later references, however, he reduces this essentially to just the first of these, the combat means during flight, "the effectiveness of the antiair (antimissile) defense." It is unclear whether the three were listed for analytical symmetry, or because he intended to include these in the equation. While the vulnerability at sea would refer to antisubmarine warfare (ASW), the vulnerability on land is unclear, aside from the fact that it must refer to theater mobile missiles.

Appendix C

U.S. AND SOVIET STRATEGIC NUCLEAR FORCE DATA, 1958 TO 1988

The data in Appendix C were derived from U.S. sources. Soviet force data were primarily extracted from Thomas B. Cochran, William B. Arkin, Robert S. Norris, Jeffrey I. Sands, *Nuclear Weapons Databook, Vol. IV, Soviet Nuclear Weapons*, Harper and Row, New York, 1989. U.S. data were extracted primarily from *IISS Military Balances* for years 1969 through 1989. Supplementary U.S. force data were taken from Thomas B. Cochran, William B. Arkin, and Milton M. Hoenig, *Nuclear Weapons Databook, Vol. I, U.S. Nuclear Forces and Capabilities,* Harper and Row, 1984. The author's use of the data does not confirm its accuracy; it is used as a representation of data that Soviet planners would have found easily in the open literature and might have utilized in their analyses—the subject of this work.

U.S. Strategic Nuclear Forces Weapons Characteristics

	MIRV	YIELD (MT)	IOC	DAY	GEN	PTP1	PLS/GEN SOV PRE	PLS/GEN U.S. 1ST	PTP2
ICBMS				1	1	1	0.4	0.8	1
MM1	1	1.00	1962	1	1	1	0.4	0.8	1
TITAN2	1	9.00	1962	1	1	1	0.4	0.8	1
MM2	1	1.20	1966	1	1	1	0.4	0.8	1
MM3	3	0.17	1970	1	1	1	0.4	0.8	1
MM3A	3	0.34	1980	1	1	1	0.4	0.8	1
MX/SILO	10	0.35	1987	1	1	1	0.4	0.8	1
MX/RAIL	10	0.35	9999	1	1	1	0.4	0.8	1
SICBM	3	0.00	9999	1	1	1	0.4	0.8	1
SLBMS				0.35	0.65	1	0.4	0.8	1
POL A2	1	0.80	1962	0.35	0.65	1	0.4	0.8	1
POL A3	3	0.20	1964	0.35	0.65	1	0.4	0.8	1
POS C3	10	0.05	1971	0.35	0.65	1	0.4	0.8	1
POS C4	8	0.10	1980	0.35	0.65	1	0.4	0.8	1
TRI C4	8	0.10	9999	0.35	0.75	1	0.4	0.8	1
TRI D5L	10	0.00		0.35	0.75	1	0.4	0.8	1
TRI D5H	10	0.00		0.35	0.75	1	0.4	0.8	1
LRA BRS				0.3	1	0.7	0.4	0.8	0.7
FB11/GR	2	1.00				0.7	0.4	0.8	0.7
FB111/SR	4	0.20	1969	0.3	1	0.7	0.4	0.8	0.7
B52D/GR	4	1.00		0.3	1	0.7	0.4	0.8	0.7
B52D/SR	0	0.20	1956	0.3	1	0.7	0.4	0.8	0.7
B52D/CM	0	0.20	1956	0.3	1	0.7	0.4	0.8	0.7
B52G/GR	4	1.00		0.3	1	0.7	0.4	0.8	0.7
B52G/SR	4	0.20	1959	0.3	1	0.7	0.4	0.8	0.7
B52G/CM	12	0.20	1959	0.3	1	0.7	0.4	0.8	0.7
B52H/GR	4	1.00		0.3	1	0.7	0.4	0.8	0.7
B52H/SR	4	0.20	1962	0.3	1	0.7	0.4	0.8	0.7
B52H/CM	0	0.20	1962	0.3	1	0.7	0.4	0.8	0.7
B1B GR	12	1.00	1987	0.3	1	0.7	0.4	0.8	0.7
B1B SR	12	0.20		0.3	1	0.7	0.4	0.8	0.7
B1B CM	0	0.20	1987	0.3	1	0.7	0.4	0.8	0.7

Soviet Strategic Nuclear Forces Weapons Characteristics

	MIRV	RANGE	YIELD MT	IOC	DAY	GEN	PTP1	PLS/GEN SOV PRE	PLS/GEN U.S. 1ST	PTP2
ICBMS					1	1	1	0.8	0.4	1
IC-WHDS										
SS-6	1		5.00		1	1	1	0.8	0.4	1
SS-7	1		5.00	1961	1	1	1	0.8	0.4	1
SS-8	1		5.00	1963	1	1	1	0.8	0.4	1
SS-9	1		20.00	1965	1	1	1	0.8	0.4	1
SS-11	1	10000	1.00	1966	1	1	1	0.8	0.4	1
SS-13	1	10000	0.75	1968	1	1	1	0.8	0.4	1
SS-17m1,3	4	10000	0.75	1975	1	1	1	0.8	0.4	1
SS-17m2	1		3.50		1	1	1	0.8	0.4	1
SS-19m1,3	6	10000	0.55	1979	1	1	1	0.8	0.4	1
SS-19m2	1		5.00		1	1	1	0.8	0.4	1
SS-18m1,3	1	10000	18.00	1975	1	1	1	0.8	0.4	1
SS-18m2	8		0.75		1	1	1	0.8	0.4	1
SS-18m4	10		0.55	1979	1	1	1	0.8	0.4	1
SS-24/FIX	10		0.55		1	1	1	0.8	0.4	1
SS-24/MOB	10		0.55	1987	1	1	1	0.8	0.4	1
SS-25/FIX	1		0.55		1	1	1	0.8	0.4	1
SS-25/MOB	1		0.55	1985	1	1	1	0.8	0.4	1
SLBMS					0.15	0.6	1	0.8	0.4	1
SSN4	1		1.00	1961	0.15	0.6	1	0.8	0.4	1
SSN5	1		1.00	1964	0.15	0.6	1	0.8	0.4	1
SSN6	1		1.00	1969	0.15	0.6	1	0.8	0.4	1
SSN8	1		1.50	1972	0.15	0.6	1	0.8	0.4	1
SSN17	1		0.50	1977	0.15	0.6	1	0.8	0.4	1
SSN18	7		0.50	1978	0.15	0.6	1	0.8	0.4	1
SSN20	10		0.10	1981	0.15	0.6	1	0.8	0.4	1
SSN23	4		0.10	1985	0.15	0.6	1	0.8	0.4	1
LRA BRS					0	1	0.7	0.8	0.4	0.9
BISON GR	4		1.00	1956	0	1	0.7	0.8	0.4	0.9
BEARA GR	2		1.00	1956	0	1	0.7	0.8	0.4	0.9
BEARA CM	0		0.00	1956	0	1	0.7	0.8	0.4	0.9
BEARC GR	4		1.00	1962	0	1	0.7	0.8	0.4	0.9
BEARC CM	0		0.00	1962	0	1	0.7	0.8	0.4	0.9
BEARC GR	0		0.00	1962	0	1	0.7	0.8	0.4	0.9
BEARC CM	1		1.50	1962	0	1	0.7	0.8	0.4	0.9
BEARG G	4		1.00	1984	0	1	0.7	0.8	0.4	0.9
BEARG C	2		1.00	1984	0	1	0.7	0.8	0.4	0.9
BEARH GR	0		0.00	1984	0	1	0.7	0.8	0.4	0.9
BEARH CM	8		0.25	1984	0	1	0.7	0.8	0.4	0.9
BACKF G	2		1.00	1974	0	1	0.7	0.8	0.4	0.9
BACKF C	0		0.00	1974	0	1	0.7	0.8	0.4	0.9
BLKJK G			1.00	1988	0	1	0.7	0.8	0.4	0.9
BLKJK S				1988						
BLKJK C				1988						

U.S. Strategic Nuclear Weapons (Launchers) 1958-1988

	1958	1960	1962	1964	1966	1968	1970	1972	1974	1976	1978	1980	1982	1984	1986	1988
ICBMS	0	0	544	834	904	1054	1054	1054	1054	1054	1054	1054	1052	1037	1010	1000
MM1	0	0	490	490	490	490	490	300	21	0	0	0	0	0	0	0
TITAN2	0	0	54	344	54	54	54	54	54	54	54	54	52	37	10	0
MM2	0	0	0	0	360	500	500	500	450	450	450	450	450	450	450	450
MM3	0	0	0	0	0	10	10	200	529	550	550	550	250	250	250	227
MM3A	0	0	0	0	0	0	0	0	0	0	0	0	300	300	300	300
MX/SILO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23
MX/RAIL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SICBM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLBMS			144	416	592	656	656	656	656	656	656	656	520	592	640	638
POL A2	0	0	144	208	208	208	208	128	0	0	0	0	0	0	0	0
POL A3	0	0	0	208	384	448	448	368	304	160	160	160	0	0	0	0
POS C3	0	0	0	0	0	0	0	160	352	496	496	448	304	304	256	254
POS C4	0	0	0	0	0	0	0	0	0	0	0	48	192	192	192	0
TRI C4	0	0	0	0	0	0	0	0	0	0	0	0	24	96	192	384
TRI D5L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRI D5H	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LRA BRS			630	630	630	545	540	457	441	382	382	381	376	297	254	423
FB11/GR	0	0	0	0	0	0	35	67	66	66	66	65	60	56	55	61
FB111/SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B52D/GR	0	0	630	630	630	545	250	150	120	75	75	75	75	0	0	98
B52D/SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B52D/CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B52G/GR	0	0	0	0	0	0	255	240	180	151	151	151	151	151	90	69
B52G/SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B52G/CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B52H/GR	0	0	0	0	0	0	0	0	75	90	90	90	90	90	90	96
B52H/SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B52H/CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B1B GR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	99
B1B SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B1B CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1958	1960	1962	1964	1966	1968	1970	1972	1974	1976	1978	1980	1982	1984	1986	1988

Soviet Strategic Nuclear Weapons (Launchers) 1958-1988

	1958	1960	1962	1964	1966	1968	1970	1972	1974	1976	1978	1980	1982	1984	1986	1988
ICBMS	4	4	30	180	333	909	1361	1547	1587	1559	1398	1378	1388	1398	1398	1394
SS-6	4	4	4	4	4	4	0	0	0	0	0	0	0	0	0	0
SS-7	0	0	26	153	186	186	186	186	186	138	0	0	0	0	0	0
SS-8	0	0	0	23	23	23	23	23	23	23	0	0	0	0	0	0
SS-9	0	0	0	0	30	156	252	288	288	252	132	0	0	0	0	0
SS-11	0	0	0	0	90	540	840	990	1030	910	750	640	550	520	448	420
SS-13	0	0	0	0	0	0	60	60	60	60	60	60	60	60	60	60
SS-17m1,3	0	0	0	0	0	0	0	0	0	20	80	130	140	150	150	130
SS-17m2	0	0	0	0	0	0	0	0	0	20	20	0	0	0	0	0
SS-19m1,3	0	0	0	0	0	0	0	0	0	100	120	200	320	360	360	350
SS-19m2	0	0	0	0	0	0	0	0	0	0	60	40	10	0	0	0
SS-18m1,3	0	0	0	0	0	0	0	0	0	36	36	26	16	0	0	0
SS-18m2	0	0	0	0	0	0	0	0	0	0	140	162	92	0	0	0
SS-18m4	0	0	0	0	0	0	0	0	0	0	0	120	200	308	308	308
SS 24/FIX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SS-24/MOB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SS-25/FIX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SS-25/MOB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72	126
SLBMS	6	30	72	72	78	138	311	497	679	849	1001	989	989	981	947	978
SSN4	6	30	66	66	66	48	42	21	21	15	9	0	0	0	0	0
SSN5	0	0	6	6	12	42	45	60	60	60	60	57	57	45	39	36
SSN6	0	0	0	0	0	48	224	416	512	548	500	468	384	368	288	256
SSN8	0	0	0	0	0	0	0	0	86	226	292	292	292	292	292	286
SSN17	0	0	0	0	0	0	0	0	0	0	12	12	12	12	12	12
SSN18	0	0	0	0	0	0	0	0	0	0	128	160	224	224	224	224
SSN20	0	0	0	0	0	0	0	0	0	0	0	0	20	40	60	100
SSN23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	64
LRA BRS	50	104	133	173	159	159	157	157	157	187	207	232	247	290	300	338
BISON GR	40	56	58	58	54	54	52	52	52	52	52	52	52	45	15	0
BEARA GR	10	48	75	85	45	30	30	30	30	30	30	30	30	30	30	20
BEARA CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BEARC GR	0	0	0	30	60	75	75	75	75	75	75	75	75	65	45	30
BEARC CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BEARC GR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BEARC CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BEARG G	0	0	0	0	0	0	0	0	0	0	0	0	0	10	30	45
BEARG C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BEARH GR	0	0	0	0	0	0	0	0	0	0	0	0	0	10	40	65
BEARH CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BACKF G	0	0	0	0	0	0	0	0	0	30	50	75	90	130	140	178
BACKF C	0	0	0	0	0	0	0	0	0	0	0	0	[illegible]	0	0	0
BLKJK G	0	0	0	0	0	0	0	0	0	0	0	0	[illegible]	0	0	0
BLKJK S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLKJK C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

U.S. Strategic Nuclear Weapons (Total EMT) 1958-1988

	1958	1960	1962	1964	1966	1968	1970	1972	1974	1976	1978	1980	1982	1984	1986	1988
ICBMS	0	0	725	1989	1132	1299	1299	1283	1249	1247	1247	1247	1401	1335	1218	1267
MM1	0	0	490	490	490	490	490	300	21	0	0	0	0	0	0	0
TITAN2	0	0	235	1499	235	235	235	235	235	235	235	235	227	161	44	0
MM2	0	0	0	0	407	565	565	565	508	508	508	508	508	508	508	508
MM3	0	0	0	0	0	9	9	183	484	503	503	503	229	229	229	208
MM3A	0	0	0	0	0	0	0	0	0	0	0	0	437	437	437	437
MX/SILO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	114
MX/RAIL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SICBM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLBMS	0	0	124	391	571	636	636	701	783	830	830	847	778	901	1001	998
POL A2	0	0	124	179	179	179	179	110	0	0	0	0	0	0	0	0
POL A3	0	0	0	212	392	457	457	376	310	163	163	163	0	0	0	0
POS C3	0	0	0	0	0	0	0	215	473	666	666	602	408	408	344	341
POS C4	0	0	0	0	0	0	0	0	0	0	0	82	328	328	328	0
TRI C4	0	0	0	0	0	0	0	0	0	0	0	0	41	164	328	657
TRI D5L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRI D5H	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LRA BRS			2520	2520	2520	2180	3525	3091	2804	2430	2430	2427	2410	1733	1823	3355
FB11/GR	0	0	0	0	0	0	70	134	132	132	132	130	120	112	110	122
FB111/SR	0	0	0	0	0	0	48	91	90	90	90	88	82	76	75	83
B52D/GR	0	0	2520	2520	2520	2180	1000	600	480	300	300	300	300	0	0	392
B52D/SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B52D/CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B52G/GR	0	0	0	0	0	0	1020	960	720	604	604	604	604	604	360	276
B52G/SR	0	0	0	0	0	0	347	327	245	205	205	205	205	116	122	94
B52G/CM	0	0	0	0	0	0	1041	980	735	616	616	616	616	343	367	282
B52H/GR	0	0	0	0	0	0	0	0	300	360	360	360	360	360	360	384
B52H/SR	0	0	0	0	0	0	0	0	102	122	122	122	122	122	122	131
B52H/CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B1B GR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	228	1188
B1B SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	78	404
B1B CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Soviet Strategic Nuclear Weapons (Total EMT) 1958-1988

	1958	1960	1962	1964	1966	1968	1970	1972	1974	1976	1978	1980	1982	1984	1986	1988
ICBMS	12	12	88	529	939	2327	3379	3797	3837	4072	3924	4093	4435	4575	4551	4453
SS 6	12	12	12	12	12	12	0	0	0	0	0	0	0	0	0	0
SS-7	0	0	76	450	547	547	547	547	547	406	0	0	0	0	0	0
SS-8	0	0	0	68	68	68	68	68	68	68	0	0	0	0	0	0
SS-9	0	0	0	0	223	1161	1875	2143	2143	1875	982	0	0	0	0	0
SS-11	0	0	0	0	90	540	840	990	1030	910	750	640	550	520	448	420
SS-13	0	0	0	0	0	0	49	49	49	49	49	49	49	49	49	49
SS-17m1,3	0	0	0	0	0	0	0	0	0	66	264	429	462	495	495	429
SS-17m2	0	0	0	0	0	0	0	0	0	46	46	0	0	0	0	0
SS-19m1,3	0	0	0	0	0	0	0	0	0	402	482	804	1286	1447	1447	1407
SS-19m2	0	0	0	0	0	0	0	0	0	0	176	118	29	0	0	0
SS-18m1,3	0	0	0	0	0	0	0	0	0	250	250	180	111	0	0	0
SS-18m2	0	0	0	0	0	0	0	0	0	0	924	1069	607	0	0	0
SS-18m4	0	0	0	0	0	0	0	0	0	0	0	804	1340	2063	2063	2063
SS-24/FIX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SS-24/MOB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SS-25/FIX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SS-25/MOB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	84
SLBMS	6	30	72	72	78	138	311	497	706	920	1523	1620	1860	1875	1859	1929
SSN4	6	30	66	66	66	48	42	21	21	15	9	0	0	0	0	0
SSN5	0	0	6	6	12	42	45	60	60	60	60	57	57	45	39	36
SSN6	0	0	0	0	0	48	224	416	512	548	500	468	384	368	288	256
SSN8	0	0	0	0	0	0	0	0	113	297	383	383	383	383	383	375
SSN17	0	0	0	0	0	0	0	0	0	0	8	8	8	8	8	8
SSN18	0	0	0	0	0	0	0	0	0	0	563	704	985	985	985	985
SSN20	0	0	0	0	0	0	0	0	0	0	0	0	43	86	128	214
SSN23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	55
LRA BRS	180	320	382	522	546	576	568	568	568	628	668	718	748	852	886	991
BISON GR	160	224	232	232	216	216	208	208	208	208	208	208	208	180	60	0
BEARA GR	20	96	150	170	90	60	60	60	60	60	60	60	60	60	60	40
BEARA CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BEARC GR	0	0	0	120	240	300	300	300	300	300	300	300	300	260	180	120
BEARC CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BEARC GR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BEARC CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BEARG G	0	0	0	0	0	0	0	0	0	0	0	0	0	40	120	180
BEARG C	0	0	0	0	0	0	0	0	0	0	0	0	0	20	60	90
BEARH GR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BEARH CM	0	0	0	0	0	0	0	0	0	0	0	0	0	32	126	205
BACKF G	0	0	0	0	0	0	0	0	0	60	100	150	180	260	280	356
BACKF C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLKJK G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLKJK S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLKJK C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

U.S Strategic Nuclear Weapons (Warheads) 1958 1988

	1958	1960	1962	1964	1966	1968	1970	1972	1974	1976	1978	1980	1982	1984	1986	1988
ICBMS	0	0	544	834	904	1074	1074	1454	2112	2154	2154	2154	2152	2137	2110	2261
MM1	0	0	490	490	490	490	490	300	21	0	0	0	0	0	0	0
TITAN2	0	0	54	344	54	54	54	54	54	54	54	54	52	37	10	0
MM2	0	0	0	0	360	500	500	500	450	450	450	450	450	450	450	450
MM3	0	0	0	0	0	30	30	600	1587	1650	1650	1650	750	750	750	681
MM3A	0	0	0	0	0	0	0	0	0	0	0	0	900	900	900	900
MX/SILO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	230
MX/RAIL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SICBM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SLBMS			144	832	1360	1552	1552	2832	4432	5440	5440	5344	4768	5344	5632	5612
POL A2	0	0	144	208	208	208	208	128	0	0	0	0	0	0	0	0
POL A3	0	0	0	624	1152	1344	1344	1104	912	480	480	480	0	0	0	0
POS C3	0	0	0	0	0	0	0	1600	3520	4960	4960	4480	3040	3040	2560	2540
POS C4	0	0	0	0	0	0	0	0	0	0	0	384	1536	1536	1536	0
TRI C4	0	0	0	0	0	0	0	0	0	0	0	0	192	768	1536	3072
TRI D5L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TRI D5H	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LRA BRS			2520	2520	2520	2180	6310	5802	5076	4436	4436	4430	4400	3008	3306	5282
FB11/GR	0	0	0	0	0	0	70	134	132	132	132	130	120	112	110	122
FB111/SR	0	0	0	0	0	0	140	268	264	264	264	260	240	224	220	244
B52D/GR	0	0	2520	2520	2520	2180	1000	600	480	300	300	300	300	0	0	392
B52D/SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B52D/CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B52G/GR	0	0	0	0	0	0	1020	960	720	604	604	604	604	604	360	276
B52G/SR	0	0	0	0	0	0	1020	960	720	604	604	604	604	340	360	276
B52G/CM	0	0	0	0	0	0	3060	2880	2160	1812	1812	1812	1812	1008	1080	828
B52H/GR	0	0	0	0	0	0	0	0	300	360	360	360	360	360	360	384
B52H/SR	0	0	0	0	0	0	0	0	300	360	360	360	360	360	360	384
B52H/CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B1B GR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	228	1188
B1B SR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	228	1188
B1B CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Soviet Strategic Nuclear Weapons (Warheads) 1958-1988

	1958	1960	1962	1964	1966	1968	1970	1972	1974	1976	1978	1980	1982	1984	1986	1988
ICBMS	4	4	30	180	333	909	1361	1547	1587	2119	3218	4982	5852	6420	6420	6306
SS-6	4	4	4	4	4	4	0	0	0	0	0	0	0	0	0	0
SS-7	0	0	26	153	186	186	186	186	186	138	0	0	0	0	0	0
SS-8	0	0	0	23	23	23	23	23	23	23	0	0	0	0	0	0
SS-9	0	0	0	0	30	156	252	288	288	252	132	0	0	0	0	0
SS-11	0	0	0	0	90	540	840	990	1030	910	750	640	550	520	448	420
SS-13	0	0	0	0	0	0	60	60	60	60	60	60	60	60	60	60
SS-17m1,3	0	0	0	0	0	0	0	0	0	80	320	520	560	600	600	520
SS-17m2	0	0	0	0	0	0	0	0	0	20	20	0	0	0	0	0
SS-19m1,3	0	0	0	0	0	0	0	0	0	600	720	1200	1920	2160	2160	2100
SS-19m2	0	0	0	0	0	0	0	0	0	0	60	40	10	0	0	0
SS-18m1,3	0	0	0	0	0	0	0	0	0	36	36	26	16	0	0	0
SS-18m2	0	0	0	0	0	0	0	0	0	0	1120	1296	736	0	0	0
SS-18m4	0	0	0	0	0	0	0	0	0	0	0	1200	2000	3080	3080	3080
SS-24/FIX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SS-24/MOB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SS-25/FIX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SS-25/MOB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72	126
SLBMS	6	30	72	72	78	138	311	497	679	849	1769	1949	2513	2685	2927	3414
SSN4	6	30	66	66	66	48	42	21	21	15	9	0	0	0	0	0
SSN5	0	0	6	6	12	42	45	60	60	60	60	57	57	45	39	36
SSN6	0	0	0	0	0	48	224	416	512	548	500	468	384	368	288	256
SSN8	0	0	0	0	0	0	0	0	86	226	292	292	292	292	292	286
SSN17	0	0	0	0	0	0	0	0	0	0	12	12	12	12	12	12
SSN18	0	0	0	0	0	0	0	0	0	0	896	1120	1568	1568	1568	1568
SSN20	0	0	0	0	0	0	0	0	0	0	0	0	200	400	600	1000
SSN23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	128	256
LRA BRS	180	320	382	522	546	576	568	568	568	628	668	718	748	900	1080	1306
BISON GR	160	224	232	232	216	216	208	208	208	208	208	208	208	180	60	0
BEARA GR	20	96	150	170	90	60	60	60	60	60	60	60	60	60	60	40
BEARA CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BEARC GR	0	0	0	120	240	300	300	300	300	300	300	300	300	260	180	120
BEARC CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BEARC GR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BEARC CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BEARG G	0	0	0	0	0	0	0	0	0	0	0	0	0	40	120	180
BEARG C	0	0	0	0	0	0	0	0	0	0	0	0	0	20	60	90
BEARH GR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BEARH CM	0	0	0	0	0	0	0	0	0	0	0	0	0	80	320	520
BACKF G	0	0	0	0	0	0	0	0	0	60	100	150	180	260	280	356
BACKF C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLKJK G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLKJK S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BLKJK C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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