A New Approach to Arms Control

Glenn A. Kent
with Randall J. DeValk and Edward L. Warner III
The research described in this report was supported by The Ford Foundation under Grant No. 790-0061 and by The Rand Corporation as part of its program of public service.

Library of Congress Cataloging in Publication Data

Kent, Glenn A.
A new approach to arms control.
"Prepared for the Ford Foundation."
"R-3140-FF/RC."
1. Atomic weapons and disarmament. 2. Arms control.
JX1974.7.K385 1984 327.1'74 84-11567
ISBN 0-8330-0575-8

The Rand Publication Series: The Report is the principal publication documenting and transmitting Rand's major research findings and final research results. The Rand Note reports other outputs of sponsored research for general distribution. Publications of The Rand Corporation do not necessarily reflect the opinions or policies of the sponsors of Rand research.

Published by The Rand Corporation
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June 1984

Supported by a grant from
The Ford Foundation

A Series in International
Security and Arms Control
PREFACE

In late 1978, The Ford Foundation provided grants to The Rand Corporation and several university centers for research and training in international security and arms control. At Rand, the grant is supporting a diverse program. In the Rand Graduate Institute, which offers a doctorate in policy analysis, the grant is contributing to student fellowships for dissertation preparation, curriculum development, workshops and tutorials, and a series of visiting lecturers. In Rand's National Security Research Division, the Ford-sponsored projects are designed to extend beyond the immediate needs of government sponsors of research by investigating long-term or emerging problems and by developing and assessing new research methodologies. The grant also is being used to fund the publication of relevant sponsored research that would otherwise not be disseminated to the general public.

All research products are being made available to as wide an audience as possible through publication as unclassified Rand Reports or Notes or in journals. The Rand documents may be obtained directly or may be found in the more than 290 libraries in the United States and 30 other countries that maintain collections of Rand publications.

The present report proposes an approach to arms control that would constrain the total destructive power of each side's strategic force and, at the same time, allow (perhaps even encourage) unilateral measures to increase strategic force survivability. The work was prompted in part by the strong interest of the president of The Rand Corporation and of several congressmen in the approach to arms control to be taken by the United States.

Funded by The Ford Foundation and by The Rand Corporation from its own research funds, the report should interest all those who believe that arms control can play a role in reducing the likelihood of war.

The authors wish to thank their Rand colleagues Thomas A. Brown and Peter J. E. Stan for reviewing the report in draft.
SUMMARY

Because arms control cannot meaningfully reduce the catastrophic destructive capacity of existing U.S. and Soviet nuclear arsenals against people and industrial targets, its main objective must be to reduce the likelihood of war in the first place. The United States must therefore seek agreement with the Soviet Union on the fundamental principle of survival of strategic forces: that both countries seek stability and eschew the capability for a successful first strike.

The likelihood of war can be reduced if both sides agree to constrain counterforce capability and at the same time allow unilateral measures to increase strategic force survivability. That is, each side must agree to constrain its counterforce potential to the level at which the expenditure of forces for a successful attack is so costly that the would-be attacker lacks the incentive to attack in the first place.

The second objective of arms control must be to maintain rough equality of forces, at least in the aggregate. At the same time, an agreement must permit verification and unilateral choice of the details of force structure. Under no circumstances should an agreement inhibit or prohibit measures to enhance survivability.

We propose in this report a two-pronged approach that will achieve stability and prevent a successful attack on the intercontinental ballistic missile (ICBM) forces of either side. The two elements of this approach are to constrain the offensive counterforce capability through arms control and, at the same time, to allow unilateral measures to increase force survivability.

To control counterforce capability, the superpowers must control throwweight. (We show in detail that offensive counterforce capability is directly related to throwweight.) Each side must also understand the relationship between its own measures to enhance survivability and the controls that are to be placed on offensive power.

At present, U.S. and Soviet strategic forces are roughly equal according to one measure and unequal according to two others. The United States and the Soviet Union have approximately 8500 ballistic missile weapons each, according to counting rules of the strategic arms limitation (SALT) treaties. The USSR has the great advantage in missile throwweight, with about 5.3 million kilograms; the United States has only a little over 1.8 million kilograms. The United States has considerably more bomber weapons and slightly more bomber payload (take-off gross weight is the surrogate) if only active forces are counted and much more if all SALT-accountable forces are counted.
The U.S. proposal at the 1983 strategic arms reduction talks (START) and the build-down proposal for constraining the destructive potential of U.S. and Soviet strategic nuclear arsenals provide for an approximately 5 percent annual guaranteed build-down of weapons on ballistic missiles. According to these proposals, the United States and the Soviet Union would reduce their SALT-accountable ballistic missile weapons from the present 8500 to 5000 in eight years. The reduction to 5000 weapons would decrease Soviet throwweight to around 3.2 million kilograms if the reduction in throwweight was proportional to the reduction in weapons; U.S. throwweight would decrease to 1.7 million kilograms.

One form of the U.S. START proposal, called Approach I in this report, seeks to further reduce the Soviet throwweight to around 2.6 million kilograms by stipulating subceilings on the allowed number of certain types of missiles, the total number of weapons allowed on these missiles, and the size of weapons allowed on new missiles. Some U.S. observers consider this approach unrealistic and excessively intrusive in dictating Soviet force structure.

A second U.S. approach places a direct limit of around 2.5 million kilograms on overall throwweight. Although Approach II lacks the intrusiveness of Approach I, many U.S. observers view as unachievable the demand that the Soviets make additional and substantial reductions in throwweight over the reduction from 5.3 million kilograms to the 3.2 million kilograms that would result from a reduction in throwweight proportional to the reduction in weapons from 8500 to 5000.

In both approaches, the reductions of the three principal commodities—ballistic missile weapons, ballistic missile throwweight, and bombers—would be negotiated separately. We propose a third approach: to aggregate the three commodities and negotiate constraints on them collectively.

By aggregating bombers with ballistic missile throwweight, Approach III would constrain strategic forces as a whole and permit freedom to mix between bombers and missile throwweight. Such an aggregation may present a better overall negotiating strategy than an attempt to reach agreement on three separate numbers (warheads, missile throwweight, and bombers), two of which see the United States and the Soviet Union starting at quite unequal positions.

Specifically, an approach based on aggregation could be constructed so as to prevent the Soviets from seeking parity in bombers with the United States if they maintained more throwweight in their missile

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1See letter by Senators Nunn, Cohen, and Percy to the President’s Commission on Strategic Forces, September 9, 1983.
force than that planned by the United States. The penalty would be an incrementally smaller Soviet bomber force, one that ultimately reached few or no bombers. By the same token, the United States could not increase missile throwweight to the level planned by the Soviet Union without reducing its bomber force below the level now planned.

If the United States and the Soviet Union are to seek a trade-off and freedom to mix between throwweight and bombers, they must find a common currency. We propose such a currency: the standard weapon station. This currency expresses the throwweight of missiles in units of 400 kilograms. In effect, we propose to convert kilograms of throwweight to a currency that represents a "standard" weapon on a ballistic missile. With this currency, we can directly and meaningfully compare what is allowed and what is required for successful attack, and we can demonstrate stability.

The number of standard weapon stations charged for each type of ballistic missile delivery vehicle would be the largest of the following four numbers: (1) the declared or agreed to number of weapons on the missile; (2) the maximum number of weapons tested on the missile; (3) the throwweight in kilograms of a missile armed with multiple independently targetable reentry vehicles (MIRVs) divided by 400 (500 for missiles carrying a single weapon); (4) the volume in cubic feet of a MIRVed missile divided by 400 for missiles with solid propellant and by 500 for missiles carrying a single weapon or propelled by liquid fuel.

The number of standard weapon stations charged for each type of bomber would be take-off gross weight in pounds divided by 25,000 if the bomber carries air-launched cruise missiles and by 50,000 if it does not.

Our proposed approach mandates straight-line reductions in (1) SALT-accountable ballistic missile weapons and (2) aggregate potential destructive capacity of all long-range strategic forces—bombers as well as intercontinental and submarine-launched ballistic missiles—as measured in standard weapon stations on counted delivery systems.

Beginning at the present SALT-accountable inventory of 8500 each, the United States and the Soviet Union would reduce ballistic missile weapons 5 percent annually to 5000 by 1992. Within the ceiling of 5000, a subceiling might be established allowing each side up to 3300 ICBM weapons.

The straight-line reduction of ballistic missile weapons might also be overlayed with a build-down driven by modernization. In this case, each side's missile modernization program or an annual percentage reduction, whichever produced the larger cuts, would pace the ballistic missile reductions.
Aggregate potential destructive capacity would also be reduced along a straight line. Each side would start with around 15,000 standard weapon stations (a little more for the Soviet Union and somewhat less for the United States if only the B-52 bombers in the active inventory are counted). The number of standard weapon stations allowed would be reduced along a straight line to 8500 by 1996.

Approach III has a number of advantages. Based on the currency of the standard weapon station, it provides coherence between allowable offensive forces and the effects of survivability measures, permits force reductions without restructuring, offers trade-offs and freedom to mix between bombers and missile throwweight, and sanctions unilateral survivability measures.

This approach is designed specifically to adhere to the underlying principle of promoting the stability of strategic forces and achieving the basic objective of reducing the likelihood of war. We demonstrate in the report that the constraints on potential destructive capacity set forth in this approach assure the long-term viability of such unilateral survivability measures as mobile ICBMs on hardened transporters deployed over a 10,000-square-mile area and a modest number of very hard silos. The cost to the Soviets of attacking these deployments in terms of the number of standard weapon stations allowed is such that they would prefer the preattack position to the postattack position. Thus, they would lack the incentive to attack first and stability would be achieved.
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I. THE BASIC OBJECTIVES OF ARMS CONTROL

The United States and the Soviet Union have searched for over 20 years for an effective and verifiable means of limiting the potential destructive capacity of strategic nuclear weapons. Despite U.S. and Soviet de facto compliance with the SALT I and SALT II treaties, however, the arms race continues.

The number of individual nuclear weapons carried by the strategic ballistic missile forces of each country has increased from some 1500 in 1970 to approximately 8000 today.\(^1\) Given the modernization options available to both sides, the number of weapons deployed on all central strategic systems could readily reach 15,000 for each side and still stay within the limits set by SALT II.

Furthermore, the SALT agreements have done little, if anything, to control the throwweight of ballistic missile forces. Since the SALT I treaty was signed in mid-1972, Soviet ballistic missile throwweight has increased from 3.3 million kilograms to nearly 5.3 million kilograms.

The nearly continuous growth in the number and destructive power of weapons, ironically, has failed to ensure the security of either the United States or the Soviet Union. In fact, many analysts argue that the growth in strategic arsenals has had the opposite effect—that it has made each superpower’s strategic forces more vulnerable to attack by the other side, thereby eroding crisis stability and increasing the likelihood of nuclear war.

This ominous and unnecessary state of affairs has sparked a growing awareness—particularly among U.S. congressional leaders—of the need for the United States and the Soviet Union to control the destructive capacity of nuclear weapons against each other’s strategic forces. Arms control unfortunately offers no real hope for limiting the destructive capacity of these weapons to levels that would significantly reduce the catastrophic effects of their use against populations.

To prevent attacks against its population, the United States, ideally, should pursue a two-tiered strategy of (1) threatening reprisal and (2) denying the enemy his objective if he attacks.\(^2\) In actual practice, the United States threatens retaliation with a countervalue attack, but it lacks the capability for the second tier of the strategy. That is, unable to prevent by posture a successful attack against its cities, now or in

\(^1\)See Appendix A for a breakdown of U.S. and Soviet strategic forces in 1983.

\(^2\)This statement is not meant to imply that the USSR is targeting the U.S. population.
the foreseeable future, the United States deters such attack by threat. This strategy of deterrence depends, of course, on the Soviet perception of the credibility and character of the U.S. response.

With respect to a possible Soviet attack on U.S. strategic nuclear forces, however, the United States can acquire the capability to support a more positive strategy than deterrence by threat alone. It can deploy its strategic forces so that a Soviet attack would itself not succeed. Arms control, by limiting the potential destructive capacity of both sides, can help the United States to achieve this posture.

The principal objective of arms control must be to promote stability and to prevent successful attack. This objective can be achieved if both sides agree to constrain counterforce capability and at the same time allow unilateral measures to increase strategic force survivability. That is, each side must agree to constrain its counterforce potential to the level at which the cost to the attacker in terms of the expenditure of forces for a successful attack is so high relative to the forces allowed by arms control that the would-be attacker lacks the incentive to attack in the first place.

The second objective of arms control must be to maintain rough equality of forces, at least in the aggregate. Force equality remains an important military and political consideration, as neither the United States nor the Soviet Union would agree to an arms control treaty that allowed a disparity in the overall force balance. At the same time, agreements must permit adequate verification and unilateral choice of the details of force structure.

We propose a two-pronged approach that will achieve stability and prevent a successful attack on the intercontinental ballistic missile (ICBM) forces of either side. The two elements of this approach are to constrain the offensive counterforce capability through arms control and, at the same time, to allow unilateral measures to increase force survivability.

To demonstrate this approach, we have devised a currency of arms control to describe—in terms of destructive capacity—both what is allowed in each side's arsenal and what is required for successful attack. With this currency, we can directly and meaningfully compare what is allowed and what is required for successful attack, and we can demonstrate stability.
STABILITY AND PREVENTION OF SUCCESSFUL ATTACK

To control counterforce capability, the superpowers must control throwweight. (Later we will show in detail that offensive counterforce capability relates directly to throwweight.) Each side must also understand the relationship between its own measures to enhance survivability and the controls that are to be placed on offensive power. With this well-defined objective in mind, the two sides have a good prospect of increasing crisis stability and thus making further progress toward the goal of averting war.3

Would the Soviets accept as the basis of arms control a formulation whereby each country would seek to limit the other’s counterforce capability (and in consequence its own) to levels where attacks on the other’s forces could not succeed? One would think so, in light of the alternative. The Soviets must surely want—as much as Americans do—to avoid nuclear war.4

Less-than-secure forces on either side increase the likelihood of war. The side with secure forces may fear that the side with nonsecure forces will adopt a strategy of preemptive attack in deep crisis. That is, the less secure country may seek to do what it can with its forces before losing them.

For example, the less secure side might use its forces against any portion of the enemy’s strategic forces that are not secure or against the other country’s nonsecure land, air, and sea forces. The country with the nonsecure forces might also resort to a strategy of launching under attack. Both scenarios contain the same underlying imperative of “use or lose”—only the timing differs. In both, the chance of false alarm increases the likelihood of nuclear attack.

The acceptance of the proper reciprocal constraints on the offensive power of each country would cap the overall destructive potential of both. It would also improve the predictability of the superpower force postures and enhance the long-term viability of the measures taken by each side to improve the survivability of its offensive retaliatory forces.

When the military threat is bounded, each side will be able to ensure viable, survivable retaliatory capabilities. Strategic force survivability, in turn, will enhance stability and deterrence. The utility of such force planning is clear and predictable. This would not be the case against an unconstrained threat.

3Other efforts to reduce the likelihood of war include the current attempt to establish confidence-building measures.
4While the Soviets may want to avoid nuclear war, they may also view arms control as a way to gain a strategic advantage over the United States. If this is the case, the basis for an arms control agreement disappears.
Constraints that effectively cap strategic offensive power have proved difficult to define. The SALT II agreement, which focused on missile launchers, also restricted the maximum overall size of new missiles (3600 kilograms of throwweight) and the number of reentry vehicles (RVs) per booster (ten). With such constraints, the overall effectiveness of a strategic force is maximized by deploying new ICBMs with 3600 kilograms of throwweight and ten RVs.

The SALT limitation on launchers led to increases in U.S. and Soviet offensive power and the development of missiles up to the allowable standards—the MX by the United States and the SS-X-24 by the Soviet Union. Also, the constraints on the number of delivery vehicles and fixed ICBM launchers operated to inhibit (or prohibit) such survivability measures as the hardening of existing missile silos to make them more resistant to attack and the construction of redundant silos to increase the other side's uncertainty as to the location of the missiles.

If the units of account, or currency, of arms control agreements were weapons rather than launchers, then the way to maximize the overall effectiveness of the force would be to deploy the permitted number of weapons, making each as large as practical or permissible. Thus, if the number of weapons were to be limited, their size would also have to be controlled. Otherwise, the arms race would turn to larger weapons.

ROUGH EQUALITY

That any arms control proposal must result in rough overall equality of forces is universally accepted. The problem lies in negotiating to equality from a beginning of serious inequality. For example, two countries would have difficulty agreeing to ultimately reduce to a capability of less than, say, 1x when Country A started at 1x and Country B started at 3x. Suppose the capability were set at 2x. Country B would be obliged to build down to 2x, but unless Country A intended to build up to 2x (de jure equality), a de facto imbalance would likely result.

The prospects for achieving an equitable agreement are decidedly greater if the forces to be limited are roughly equal. This requirement argues strongly for aggregating commodities so as to reflect the existing parity in destructive capability.
VERIFICATION AND UNILATERALLY DETERMINED FORCE STRUCTURE

The need to fashion arms control agreements so that compliance can be verified is also widely accepted. Although this report does not discuss better means of verification, one particular point merits mention. Largely because of the verification problem, past agreements have counted only missiles near counted (or specified) launchers, as distinct from counting all missiles in the country’s inventory.

Counting only weapons on missiles at or near counted launchers may cause a serious distortion if one country (the USSR) opts for a considerable number of reload missiles, because the reloads would probably not be counted. The availability of a strategic reserve of "decommissioned" missiles that could be launched from austere facilities further complicates the counting problem, as does the advent of small, mobile missiles. The two sides therefore urgently need to explore the possibility of counting all intercontinental and submarine-launched ballistic missiles (ICBMs and SLBMs) in each country's inventory to close this loophole.

A viable arms control proposal would require monitoring, in addition to the number of counted missiles on each side, (1) the number of weapons, (2) the throwweight or volume of each type of ballistic missile, and (3) the offensive potential of bombers (for which a surrogate measure—take-off gross weight—is suggested). These would require no new monitoring capabilities.

As a final objective, arms control proposals should avoid constraints that dictate in detail the force structure of either country. At the same time, an arms control agreement should under no circumstances inhibit or prohibit measures to enhance survivability. Each side should be allowed to decide unilaterally what measures it will take to increase stability.

In summary, arms control cannot meaningfully reduce the catastrophic destructive capacity of existing U.S. and Soviet nuclear arsenals against people and industrial targets. The United States must therefore seek agreement with the Soviet Union on the fundamental principle of averting war and ensuring against incentives for preemptive first strikes. American strategic policymakers are challenged to formulate a negotiable arms control proposal that will reduce prompt counterforce capability through decreases in the number of ballistic missile weapons and the amount of ballistic missile throwweight, permit unilateral survivability measures, provide for verification, and foster deterrence and crisis stability.
II. SIZE AND CHARACTERISTICS OF
THE ARSENALS

The strategic nuclear systems deployed by the United States and the
Soviet Union are usually compared in simplistic terms relating to the
numerical size of the forces but neglecting their characteristics. One
common method counts the total number of delivery systems—ICBMs,
SLBMs, and long-range bombers—available to the two sides. By this
method, the USSR has over 2600 delivery systems and the United
States roughly 2000 (see Appendix A).

Another method assesses U.S. and Soviet strategic forces by count-
ing the number of weapons carried by each side’s strategic delivery sys-
tems. Applying SALT II counting rules to ballistic missiles and
estimating bomber force loadings, U.S. weapons total about 11,400 and
Soviet, about 10,000. Each side has roughly 8500 SALT-accountable
ballistic missile warheads.¹

The United States has only about 2500 of these RVs on ICBMs; the
remaining nearly 6400 are on SLBMs. The Soviets, in contrast, have
about 6400 on land and 2150 at sea. The U.S. edge in total deliverable
weapons stems from its much larger bomber force. The U.S. active
intercontinental bomber force of 265 B-52G/Hs (including 45 B-52G
cruise missile carriers) and 60 FB-111s is estimated to carry over 2900
weapons; Soviet bombers carry approximately 1200 weapons.

However, these two measures—the number of delivery systems and
the number of deliverable weapons—taken separately or together
neglect several important considerations. The method of counting
delivery systems alone fails to differentiate among systems carrying dif-
ferent numbers of separately targetable weapons. For example,
although a Soviet SS-18 missile carries ten warheads and a U.S.
Minuteman II missile carries one, both are considered a single strategic
delivery system. Counting weapons avoids this problem but has the
serious shortcoming of treating large weapons the same as small ones.

Three parameters—the number, yield, and accuracy of the individual
weapons in the force—taken together can capture the essence of the

¹SALT II counting rules assume that all missiles of a given type carry the maximum
number of warheads with which any missile of that type had been tested. For example,
since a C-3 missile was tested with 14 RVs, each C-3 missile is now charged with that
number even though it is commonly believed to carry no more than ten. Thus, the
number of ballistic missile RVs actually deployed by each side is, by most estimates,
around 7500.
destructive power of a strategic force. To get a more complete picture of the current U.S.-Soviet strategic balance, one must also consider—in addition to the number of weapons—their size, their accuracy, their deployment posture with respect to survivability, and the ability of the delivery vehicles to penetrate.

The control of all of these parameters generally lies beyond arms control measures. Estimating the accuracy of Soviet weapons would be difficult enough; monitoring their accuracy to ensure that they were not more accurate than allowed by some arms control provision would be impossible.

The arms control approach that we propose adheres to the basic principle of constraining, to the extent possible, the offensive capability of each side; it focuses particularly on limiting each side's ability to attack the other's strategic forces. At the same time, it suggests an approach that does not inhibit deployments and measures designed to enhance the resistance of strategic forces to attacks by the other side.

In the case of ballistic missiles, the destructive potential that a given force can generate relates closely to its total throwweight. This correlation applies particularly to attacks on hard targets and bombardments of area targets. By this measure, the Soviets have a tremendous edge, thanks largely to their development of huge ICBMs. Such systems permit the deployment of many heavy RVs per missile. Today, the Soviet Union has roughly 5.3 million kilograms of ballistic missile throwweight; the United States has around 1.8 million kilograms.

The Soviet advantage in total throwweight can also be seen in the associated throwweight of individual warheads. The average SALT-accountable Soviet ICBM RV has about 1.4 times the associated throwweight of its U.S. counterpart—730 kilograms as compared with 480 kilograms.

Soviet throwweight concerns the United States for several reasons. First, the huge Soviet ICBMs provide the USSR with an opportunity for modernization in reaction to any U.S. deployments. The Soviets could rapidly deploy on existing large missiles many more effective warheads than stipulated by any agreement. A large amount of throwweight would also allow them to deploy sufficient numbers of new weapons designed to counter U.S. survivability measures.

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2See Appendix D for a detailed explanation of the effects of weapon yield and accuracy on the destructive capacity of a strategic force.

3The throwweight associated with a given RV is the total throwweight of a missile divided by the number of RVs on that missile. The average associated throwweight of a country's RVs is the total throwweight of the ballistic missile force divided by the number of RVs. The actual weight of the RV is 55 percent of its total throwweight. The guidance system and the structure and fuel of the postboost control system add the remaining 45 percent of the weight.
For example, if the Soviets had available sufficient throwweight, they could deploy a large number of earth-penetrating weapons equipped with terminal guidance in response to a U.S. deployment of closely spaced hard silos. But a proper constraint on throwweight would make such deployments prohibitively expensive in terms of throwweight. Such weapons are apt to be quite heavy and would, if properly constrained, consume an undue amount of the total throwweight allowed.

A large amount of throwweight also provides the Soviets with an increased capability to successfully attack more hard targets. For the same circular error probable (CEP) and warhead technology, a country with twice the amount of throwweight of another can attack twice the number of hard targets. Finally, the throwweight furnishes the Soviets with a significant capability to barrage attack any U.S. deployment area, including that of future small, mobile missiles.

A relatively direct measure of potential destructive capacity does not exist for bombers. Bomber destructive capacity cannot readily be estimated on the basis of the number of weapons carried, since exact bomber force loadings are hard to determine, subject to change, and impossible to monitor.

A surrogate for measuring a bomber’s offensive potential is its take-off gross weight—the weight of the airplane fully loaded with fuel and weapons. Although not as good a direct measure of destructive potential as throwweight is for a missile, take-off gross weight is subject to verification and provides a useful starting point for a negotiated definition of bomber destructive potential.\(^4\)

The take-off gross weight of the active U.S. bomber force of 265 B-52s and 60 FB-111s is about 136 million pounds. If all SALT-accountable aircraft are counted (including the B-52s in the boneyard at Davis-Monthan Air Force Base), the U.S. total doubles to 283 million pounds. The take-off gross weight of the Soviet bomber force (143 Bear and Bison bombers and 210 Backfires) comes to nearly 115 million pounds.

Accuracy of delivery systems and their warheads, the third parameter for determining the destructive capacity of a strategic force, figures critically in assessing the effectiveness of weapons used for attacks against hard point targets. However, of all the characteristics of strategic nuclear weapons systems, accuracy is one of the most difficult to determine.

\(^4\)See Appendix C for a discussion of how bomber destructive potential is to be counted.
At best, accuracy can only be estimated from the observation of a limited number of tests that are not carried out over the operational trajectories of the delivery system. As a result, any estimate of accuracy is subject to much uncertainty. Verifying Soviet compliance with any constraint on accuracy is generally considered impossible.

Thus, unfortunately, any direct limit on accuracy is not practical. However, there may be a secondary constraint. Improved accuracy generally costs in weight. A weapon with a terminal guidance system and associated sensors and control equipment will weigh more. If the two sides can agree to a sufficiently low limit on throwweight, this limit may at the same time serve to constrain somewhat the number of highly accurate weapons. Furthermore, both sides might also agree that neither will test or deploy weapons that use terminal guidance. Such a ban would be difficult to monitor, unless the agreement banned the testing of maneuvering weapons over land areas.

In summary, U.S. and Soviet strategic forces are roughly equal according to one measure and unequal according to two others. The United States and the USSR have approximately 8500 ballistic missile weapons each according to SALT counting rules. The Soviet Union has the great advantage in missile throwweight, however, with about 5.3 million kilograms, whereas the United States has only a little over 1.8 million kilograms. In contrast, the United States has considerably more bomber weapons and slightly more payload (take-off gross weight is the surrogate) if only active forces are counted and much more if all SALT-accountable forces are counted.
III. STRATEGIC ARMS REDUCTION OPTIONS

All three approaches to constraining the destructive potential of U.S. and Soviet strategic nuclear arsenals examined in this section propose a 5 percent annual guaranteed build-down of weapons on ballistic missiles. According to these proposals, the United States and Soviet Union would reduce their SALT-accountable ballistic missile RVs from 8500 to 5000 in eight years.

The three approaches differ as to (1) the way in which the throwweight of ballistic missiles would be constrained and (2) whether the reductions of the three principal commodities—ballistic missile RVs, ballistic missile throwweight, and bombers—would be negotiated separately or whether they would be aggregated and negotiated collectively. Approaches I and II propose to negotiate the reductions separately; they differ as to the manner in which missile throwweight would be constrained.

APPROACH I

Approach I seeks to control ballistic missile throwweight by stipulating subceilings on the allowed number of certain types of missiles, the number of RVs allowed on certain types of missiles, and the size of RVs allowed on new missiles. In early 1983, the United States based its approach to the strategic arms reduction talks (START) on such constraints. Specifically, this proposal seeks the following four limitations:

1. No more than 5000 RVs on ballistic missiles
2. No more than 2500 of the 5000 RVs on ICBMs
3. No more than 850 (later increased to approximately 1250) ballistic missile launchers armed with multiple independently targetable reentry vehicles (MIRVs)
4. No more than 210 ICBMs of the SS-17, SS-18, and SS-19 classes, including no more than 110 SS-18s.

The United States also considered a fifth limitation:

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1 The term guaranteed (or compulsory) annual build-down was originally used to describe one type of strategic nuclear reductions. It is now used interchangeably with reduction.
5. RVs on new missiles not to weigh more than 225 kilograms.

The practical net result of applying all of these constraints (including the 225-kilogram weight limit on new RVs) would be to reduce the total throwweight of the Soviet ballistic missile force to around 2.6 million kilograms. The theoretical maximum upper limit attainable for Soviet throwweight would be around 2.8 million kilograms; to achieve this level, however, the Soviets would have to upgrade their entire SLBM force to the maximum allowed RV weight (225 kilograms of actual weight or 400 kilograms of associated throwweight).

The limitation of ballistic missile RVs to 5000, without constraints (2) through (5) above, would itself, based on a proportional reduction, decrease Soviet ballistic missile throwweight from around 5.3 million kilograms to around 3.2 million kilograms. The U.S. throwweight, even after the reduction in RVs, would decrease only slightly to a level of 1.7 million kilograms, thanks to the planned modernization of U.S. SLBM forces with larger RVs. The adoption of constraints (2) through (5) in addition to the ceiling of 5000 RVs would nearly halve the Soviet throwweight advantage, reducing it from around 1.5 million kilograms (3.2 million less 1.7 million) to around .9 million kilograms (2.6 million less 1.7 million).

Many U.S. observers believed the above approach to be unrealistic and overly intrusive in dictating the structure of the Soviet ballistic missile forces. Some influential congressmen considered these additional constraints punitive to the Soviets, considering the fact that their present force structure emphasizes large, MIRVed ICBMs.

APPROACH II

Approach II, proposed by the United States as an alternative to Approach I, seeks to constrain strategic potential destructive capacity by limiting overall throwweight. As in Approach I, the ceiling for ballistic missile RVs would be set at 5000. Limiting overall throwweight to 2.5 million kilograms would have the same effect as constraints (2) through (5) of Approach I, but would avoid the intrusiveness of Approach I in dictating in detail the structure of the Soviet forces.

Negotiating 2.5 million kilograms of total throwweight might prove difficult, however. The Soviet Union would start with around 5.3 million kilograms. The reduction to 5000 RVs would induce a proportional drop in Soviet throwweight to around 3.2 million kilograms. Despite the cut to 5000 RVs, U.S. throwweight would decrease only slightly to 1.7 million kilograms, because the United States plans to
modernize its SLBM force with larger warheads. Many U.S. observers view as unachievable the demand that the Soviets make an additional cut in throwweight on top of the proportional 40 percent reduction—from 3.2 million kilograms to some 2.5 million kilograms—while the United States made marginal throwweight reductions.

The problem of reaching agreement on such a number underlines the difficulty of negotiating any currency to de facto parity when the two sides are so far apart in this particular currency at the outset. The absence of U.S. plans to deploy a ballistic missile force with anywhere near 3.2 million kilograms of throwweight adds to the problem.

As in any agreement, the United States and the Soviet Union will have to negotiate numbers that will be critical in determining whether or not there is to be a de facto balance (or imbalance) in some commodity. The amount of overall throwweight to be allowed is a prime example.

Suppose that as a result of the reductions to 5000 RVs, the value of total throwweight to be allowed were set at around the natural Soviet resting point of 3.2 million kilograms. A number like 3.2 million kilograms might be negotiable if the Soviets accepted the 5000 RV constraint in the first place; presumably they would agree to a throwweight level commensurate with the specified number of RVs.

But, could the United States, with less than 2 million kilograms of throwweight, accept for an indefinite period a Soviet throwweight figure of 3.2 million kilograms? Is the extra 1.5 million kilograms of throwweight of political or operational significance? Opinions differ on this point.

This difference in throwweight of around 1.5 million kilograms roughly approximates the throwweight inequality that the unratified SALT II treaty would have created. SALT II allowed the USSR to retain its 308 SS-18 missiles, but prohibited the United States from deploying an equally heavy class of missiles. Instead, both countries were to be allowed a new class of medium 3600-kilogram missiles. Thus, SALT II would have led to a de jure imbalance of approximately 1.4 million kilograms.²

The U.S. Congress strongly criticized this imbalance when it considered the SALT II treaty for ratification. Under the treaty, the United States could not have made up the throwweight difference if it

²This number was derived as follows: The difference in throwweight between the already built Soviet SS-18 and the new missile that SALT II allowed is 4400 kilograms per missile (8000 kilograms minus 3600 kilograms). By virtue of already possessing 308 SS-18s, the Soviets could maintain a throwweight advantage equal to the throwweight difference between the SS-18 and the new missile (4400 kilograms) multiplied by 308, or around 1.4 million kilograms.
had wanted to. Approach II created a de facto imbalance. Either way, the imbalance worked against the United States.

From an operational standpoint, the United States wants a gradual reduction of the overall throwweight of the Soviet ballistic missile forces. Every 1 million kilograms of Soviet throwweight produces a bombardment area against a hardened land transporter on patrol of 4000 to 5000 square nautical miles. This is significant in view of the fact that the total deployment area for a small, mobile ICBM on U.S. military reservations may not be more than double this number.

A force of 2500 RVs of 800 kilograms of throwweight each has 1 million more kilograms of throwweight than a force of 2500 RVs of 400 kilograms. For the same warhead and RV technology, the bombardment area of the force with 800-kilogram RVs (roughly the amount of throwweight associated with RVs found on the Soviet SS-18 ICBM) is double that of the force with 400-kilogram RVs (similar to RVs on the U.S. MX).

Doubling the amount of throwweight doubles the number of silos that can be successfully attacked.3 (Success in this case means achieving a specified damage expectancy.) As a result, the extra throwweight in the exemplar force composed of RVs with 800 kilograms of throwweight would allow the Soviets to successfully attack twice the number of very hard silos. Thus, 1 million kilograms of throwweight could critically threaten the deployment of a modest number of very hard silos.

In summary, while an overall throwweight limit might alleviate the problem of intrusiveness, the problem would remain of whether the United States would want to accept and codify the difference between the level of throwweight that could be negotiated and the level of throwweight planned for U.S. ballistic missiles.

PROBLEMS WITH APPROACHES I AND II

Approaches I and II require that three separate numbers—the total number of ballistic missile RVs, the total ballistic missile throwweight, and the total number (or take-off gross weight) of bombers—must be negotiated. All three numbers should (and undoubtedly will) be negotiated in the context of the same overall agreement. But because these numbers are not aggregated, the greater Soviet ballistic missile throwweight and the larger U.S. bomber force can be neither mixed nor traded off directly.

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3See Appendix D.
Agreeing on a reduction level for the number of ballistic missile RVs should be relatively straightforward. The United States and the Soviet Union would start at rough parity and would reduce by the same amount to the same number. Negotiating reductions in missile throw-weight and bombers, however, would require considerable compromise. The Soviets have a sizable advantage in ballistic missile throwweight; the United States possesses more strategic bombers and bomber weapons.

If a ceiling on ballistic missile throwweight could be negotiated at or around the planned U.S. level (much lower than what the Soviets would retain in a proportional reduction to 5000 RVs) and at the same time the level of bombers could be negotiated at planned U.S. levels (seemingly higher than planned Soviet levels), the United States would have no problem. The Soviets, however, would be unlikely to agree to such numbers, since both are tailored to U.S. strategic plans.

If throwweight and bombers were to be negotiated at or near Soviet planned levels, the United States would face a serious problem. There would be a de facto imbalance in missile throwweight and parity in bomber forces, presumably at a lower level than that desired by the United States.

If missile throwweight were set at a level responsive to Soviet planning and bomber levels were fixed according to U.S. plans, the United States could, if it wanted to, increase its missile throwweight and the USSR could, if it wanted to, increase the number of its bombers. Thus, arms control agreements of this sort would actually give each side incentives to add forces. However, the United States would be less likely to increase missile throwweight to the allowed ceiling (the Soviet level) than the Soviets would be to increase their bomber force to the number allowed (the U.S. level).

Also, such an approach would permit a large amount of throwweight to remain in the Soviet missile force with no incentives for reduction.

Asymmetrical limits that allowed the Soviets more missile throwweight and the United States a larger bomber force would represent a large step in the right direction. Asymmetrical limits would not, however, allow each side the freedom to trade off some of one force element for more of another. Approach III explicitly permits this freedom to mix.

\[4\] U.S. ballistic missile throwweight has remained constant since the early 1970s, and the United States has no plans to deploy a ballistic missile force with a significantly greater amount of throwweight. The Soviets, however, have developed a new strategic bomber— their first since the late 1950s. This has led some observers to conclude that the Soviets may now intend to deploy a larger strategic bomber force.
APPROACH III

In Approach III, we propose to aggregate ballistic missile throwweight with bomber take-off gross weight. Despite some U.S. domestic opposition, such an aggregation may present a better overall negotiating strategy than an attempt to reach agreement on three separate numbers, two of which would see the United States and the Soviet Union starting at quite unequal positions.

Specifically, by aggregating missile throwweight and bomber take-off gross weight, Approach III seeks to prevent the Soviets from attaining parity in bombers with the United States if they maintained more throwweight in their missile force than that planned by the United States. The penalty would be an incrementally smaller Soviet bomber force, one that ultimately reached few or no bombers.

For example, if the Soviets saw fit to retain 3.2 million kilograms of ballistic missile throwweight—their normative position after the reduction to 5000 RVs—the approach would allow them few bombers. Conversely, if the United States insisted on the sizable bomber force now being planned, it would have to forgo any increase in the throwweight of its missile force. Both formulations differ from an approach that would limit missile throwweight according to Soviet plans and bombers according to U.S. plans.

If the United States and the Soviet Union are to seek a trade-off and freedom to mix between missiles and bombers, they must find a common currency. Defining a common currency that still constrains offensive destructive capacity in meaningful ways is the starting point for the third approach. We propose such a currency—the standard weapon station—below.

A Common Currency

A standard weapon station (SWS) is a potential slot on a ballistic missile or on an aircraft where a standard weapon is or may be placed. The use of the standard weapon station concept facilitates the calibration and control of the destructive potential of both ballistic missiles and bombers. (Although only strategic nuclear systems are discussed here, this concept could be applied to intermediate range and tactical nuclear systems as well.)

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5 In a letter to the President’s Commission on Strategic Forces, September 9, 1983, Senators Nunn, Cohen, and Percy suggested an approach based largely on the one proposed here.

6 Standard weapon station and weapon apply to both ballistic missiles and bombers. In the case of missiles, these terms refer to reentry vehicles; in the case of bombers, to gravity bombs or cruise missiles.
The number of standard weapon stations counted for each type of ballistic missile delivery vehicle would be the largest of the following four numbers:\textsuperscript{7}

1. The declared or agreed to number of weapons on the missile
2. The maximum number of weapons tested on the missile
3. The throwweight of a MIRVed missile in kilograms divided by 400 (500 for a single RV missile)
4. The volume of a MIRVed missile in cubic feet divided by 400 for missiles with solid propellant and 500 for a single RV and for missiles with liquid propellant.\textsuperscript{8}

In other words, either missile throwweight or the number of reentry vehicles in that amount of throwweight determines the number of standard weapon stations on a ballistic missile. In a sense, the ballistic missile standard weapon station describes throwweight in units of 400 kilograms. The destructive potential could also be expressed in units of 8000 kilograms or equivalent SS-18s.

We are trying, however, to control total ballistic missile throwweight, not the number of standard weapon stations or the amount of throwweight in each. Thus, total throwweight is the independent variable, and the allowed number of standard weapon stations and the throwweight of each are dependent variables.\textsuperscript{9}

The number of standard weapon stations charged for each type of bomber would be either:

1. Take-off gross weight in pounds divided by 25,000 if the bomber carries air-launched cruise missiles (ALCMs) or

\textsuperscript{7}See Appendix B for a development of the ballistic missile standard weapon station concept. The Reagan Administration considered incorporating in its START proposal an equation for calculating the potential destructive capacity of ballistic missiles. This formulation is similar to the standard weapon station counting rules outlined above. It expressed the destructive capacity of a ballistic missile as the equivalent of the total throwweight of the missile in kilograms divided by 225 (kg/RV) plus the maximum number of weapons declared or tested on the missile.

\textsuperscript{8}A fairly good relationship exists between the volume of a missile and its throwweight. For example, a solid-fueled missile requires approximately 1000 cubic feet of volume to generate 1000 kilograms of throwweight. Liquid-fueled missiles require 1200 cubic feet of volume to generate 1000 kilograms of throwweight.

\textsuperscript{9}We emphasize the point that we are trying to control ballistic missile throwweight. If we fixed the total number of standard weapon stations (rather than throwweight) to be allowed, then throwweight would depend on the constant chosen for the number of standard weapon stations. This approach would make no sense.
Fig. 1—U.S. and Soviet reductions of ballistic missile RVs and potential destructive capacity under Approach III

After 1992, that constraint would become a factor in determining what additional force reductions were required.

This third approach makes no distinction between new missile systems and modifications of existing systems. The SALT RV count would continue to be determined by rules (1) and (2), above—i.e., the largest number of standard weapon stations declared, agreed to, or tested. The potential destructive capacity of ballistic missiles would always be determined by rules (3) and (4) in addition to (1) and (2). We have thus avoided the serious pitfall of having to verify whether a particular missile is new or a permissible variant of an existing one.
ADVANTAGES OF APPROACH III

Provides Coherence Between Allowable Offensive Forces and Effects of Survivability Measures

The compulsory reductions of Approach III were designed to achieve the fundamental objective of stability and deterrence by constraining offensive counterforce capability and, at the same time, allowing each side to adopt any measures it wanted to enhance force survivability. The following examples, using the currency of standard weapon stations to measure both the destructive potential of a given force and the cost of successful attack, illustrate how Approach III would operate.\textsuperscript{12}

1. U.S. ICBMs are presently deployed in 1045 silos. Assume that the Soviets would use 2090 weapons (a two-on-one attack) on these silos to achieve a 90 percent damage expectancy. This equates to around 2090 standard weapon stations using standard-size (400-kilogram) RVs and to more than 2090 standard weapon stations using larger weapons.

2. The United States would be prepared to deploy a small, single-RV missile—Midgetman—on hardened transporters so as to greatly increase the cost to the Soviets of attacking U.S. strategic forces. The Soviets would need 5000 to 6000 standard weapon stations to bombard an area of around 10,000 square miles in which the Midgetman was deployed on hardened transporters.

3. If the United States were to deploy the MX in 300 very hard, closely spaced silos, the cost to the Soviets of attacking this portion of U.S. ICBM force could be as high as 3000 standard weapon stations (approximately ten standard weapon stations per silo) to achieve a 90 percent damage expectancy.

One can see that a successful Soviet attack on a U.S. ICBM force composed of elements 2 and 3 above—100 MX in 300 very hard silos and the Midgetman on hardened transporters deployed on approximately a 10,000 square mile area—would require roughly 8000 to 9000 standard weapon stations. Thus, based on allowed counterforce potential and unilateral measures, the United States could make the total cost to the Soviet Union of attacking only the U.S. ICBM force roughly equal to the total number of 8500 standard weapon stations that the Soviets would be allowed in their entire strategic force of

\textsuperscript{12}The numbers given here are notional. We use them solely to demonstrate how the forces allowed and the cost of attack can be expressed in the same currency, namely, standard weapon stations.
2. Take-off gross weight divided by 50,000 if the bomber does not carry ALCMs.\textsuperscript{10}

**Overall Force Reductions**

The approach that we propose mandates straight-line reductions in two categories: (1) SALT-accountable ballistic missile RVs and (2) aggregate potential destructive capacity of all long-range strategic forces (ICBMs, SLBMs, and bombers) as measured in standard weapon stations on counted delivery systems.

Beginning at the present SALT-accountable inventory of 8500 each, the United States and the Soviet Union would reduce ballistic missile RVs 5 percent annually to 5000 by 1992 (see Fig. 1). Within the ceiling of 5000, a subceiling could be established allowing each side up to 3500 ICBM RVs.

This straight-line reduction of ballistic missile RVs could also be overlayed with a build-down driven by ICBM and SLBM modernization. In this case, each side’s missile modernization program or an annual percentage reduction, whichever produced the larger cuts, would pace the ballistic missile reductions.\textsuperscript{11}

The potential destructive capacity of all strategic forces (ICBMs, SLBMs, and bombers) starts at around 16,000 standard weapon stations for each side (a little less for the United States if only active bombers are included) and decreases to 8500 by 1996. The difference between the two reduction lines is, in effect, the number of bomber weapon stations each country would be allowed.

At the end of the reduction period for potential destructive capacity, each side would be allowed 3500 standard weapon stations for its bomber force if the standard weapon station count for ballistic missile weapons did not exceed 5000. However, if either country deployed the allowed 5000 ballistic missile RVs, it could have the 3500 bomber standard weapon stations only if its ballistic missile RVs did not exceed 400 kilograms. If either country retained any heavy RVs in the 5000 deployed, it would have to sacrifice some portion of its 3500 allotted bomber standard weapon stations.

The ballistic missile reduction line would pace the reduction until 1992, when both sides would have built down to the ceiling of 5000 RVs. In other words, if a country made the necessary yearly reductions in ballistic missile RVs, it would have to make no additional force reductions to satisfy the potential destructive capacity constraint.

\textsuperscript{10}See Appendix C for further discussion of bomber standard weapon stations.

\textsuperscript{11}Appendix E compares straight-line and modernization-induced reductions.
ICBMs, SLBMs, and bombers. This relationship is illustrated in Fig. 2.

The important point is not the numbers themselves, but rather the demonstration of the coherence between arms control constraints and the cost of attacking, both expressed in terms of standard weapon stations. The coherence suggests that with the proper arms control, certain U.S. survivability measures appear quite viable, thus serving stability and reducing the likelihood of a nuclear war.

![Diagram showing relationship between cost to attack United States (thousand SWs) and cost to United States to deploy (dollars).]

- **A**: 1000 RVs on 100 MX in 100 Minuteman silos
  700 RVs on 700 MM (D) in 700 MM silos
- **B**: 1000 RVs on 100 MX in 300 very hard silos
  700 RVs on 700 MM (D) in 700 MM silos
- **C**: 1000 RVs on 100 MX in 100 MM silos
  700 RVs on 700 hardened transporters in deployment area of 10,000 sq mi
- **D**: 1000 RVs on 100 MX in 300 very hard silos
  700 RVs on 700 hardened transporters in deployment area of 10,000 sq mi

Fig. 2—Relationship between U.S. ICBM survivability measures and cost to USSR of attacking U.S. ICBM force
Allows Force Reductions Without Restructuring

The United States and the Soviet Union could meet the ceilings on both ballistic missile RVs and standard weapon stations simply by reducing their existing forces. Neither side would be obliged to deploy new systems to achieve the maximum number of RVs and standard weapon stations allowed.

Offers Trade-off and Freedom to Mix Between Bombers and Missile Throwweight

While Approach III affords each country the freedom to mix strategic force elements, this freedom operates essentially in only one direction for each. The Soviets could reduce missile throwweight to have more bombers; the United States could reduce its bomber force to increase ballistic missile throwweight.

At the end of the reduction period in 1996, the destructive potential constraint of 8500 standard weapon stations would compel both the United States and the Soviet Union to trade off the number of bombers against ballistic missile throwweight. To avoid severe constraints on their bomber force, the Soviets would have to decide what portion of the heavy RVs in their present ICBM force to retain. If they decided to retain the 3.2 million kilograms of throwweight remaining after the reduction to 5000 RVs, under Approach III they would be limited to at most a minimal bomber force.

The United States would have to choose between fulfilling current bomber force plans and increasing the present level of its ballistic missile throwweight. It would be allowed a full bomber force only if its ballistic missile throwweight did not exceed the current level (1.8 million kilograms) or slightly less. In other words, a full bomber force would cost the United States 1.4 million kilograms of ballistic missile throwweight (3.2 million minus 1.8 million). Figure 3 illustrates this bomber-throwweight trade-off.

This proposal provides incentives for a gradual reduction of missile throwweight to a level substantially below that of the present Soviet force. The theoretical upper limit for Soviet throwweight under Approach III is 3.4 million kilograms—more than 40 percent below the current level. Soviet throwweight could reach 3.4 million kilograms only if the Soviet strategic forces were to consist entirely of ballistic missile RVs of standard size or larger. (Some force modernization would be required to achieve the 3.4 million kilograms, since the
Fig. 3—Trade-off between allowable bombers and missile throwweight under Approach III

weapons on the newer Soviet MIRVed SLBMs are considerably smaller than the 400 kilograms standard.)

An overall limit on total throwweight would, in effect, allow averaging RVs with small throwweight and RVs with large throwweight. The concept of standard weapon stations, however, does not permit the small throwweight associated with small RVs to be averaged with the greater throwweight of large RVs. If the Soviets were to deploy ballistic missile RVs smaller than the standard, each weapon would still count as one standard weapon station. Soviet throwweight would thus be forced below 3.4 million kilograms.

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Given the current forces, the USSR could achieve an absolute upper limit of throwweight of around 3.2 million kilograms by reductions alone. This figure is based on a Soviet ballistic missile force consisting of 3300 SS-18 and SS-19 ICBM RVs with 2.6 million kilograms of throwweight and 1700 SLBM RVs with .6 million kilograms of throwweight. This force accounts for roughly 8200 standard weapon stations, leaving the Soviets only 300 stations for bombers.

Approach III provides incentives for the Soviets to reduce missile throwweight, and to do so downstream. That is, they may at a later time give up some missile throwweight so as to enhance their bomber force. Asymmetrical limits would not allow this freedom to mix.

Permits Adequate Verification

Approach III would break no new ground with respect to verification. While it introduces a new currency—standard weapon stations—it would demand no new monitoring capabilities. This approach would require monitoring:

1. The number of counted missiles and bombers on each side\textsuperscript{14}
2. The number of weapons tested (or simulated) on each type of ballistic missile
3. The throwweight and/or volume of each type of ballistic missile
4. The take-off gross weight of each type of bomber.

The number of standard weapon stations charged for each type of missile would be about the same whether figured by the throwweight rule or by the volume rule. Accordingly, the volume rule could serve as a backstop for the throwweight rule, or the throwweight rule could be dropped and the volume rule used instead.

Counting only volume would greatly simplify the problem of verification. For example, each side might agree to declare the maximum diameter and length of each stage and the resulting total volume. From time to time, each side could also agree to display each type of missile outside its canister, so as to be visible for overhead photography. In this way, the volume of each type of missile could be verified without ambiguity. The cooperative display of missiles might seem less intrusive than the requirement of no encryption of telemetry in order to verify throwweight.

\textsuperscript{14}As noted above, the verification problem may result in counting only missiles near counted or specified launchers, unless monitoring capabilities allow for confidence in keeping track of all missiles in each side's inventory.
Approach III would not require the determination or verification of whether a given missile was new or an allowed variant of an existing missile. This distinction would not be needed, because a missile would always be counted according to its inherent destructive capacity. Again, such an approach would simplify the verification process by eliminating an area of potential controversy. By these counting rules, new missiles could provide little increase in destructive capacity over allowed variants of existing missiles.

With regard to bombers, Approach III would require a determination of the overall number of bombers, the number of those associated with air-launched cruise missiles (the SALT II treaty specifies counting rules and the cooperative provision of observable differences to identify such bombers), and the size of the various classes of bombers (expressed in terms of take-off gross weight). Although a new requirement, take-off gross weight could be obtained within reasonable limits by overhead observation, based on such measurements as wing area and the overall projected area of the bomber.15

Sanctions Unilateral Survivability Measures

Finally, by not constraining the allowed number of missiles and associated launchers, Approach III would encourage the development and deployment of a small, single-RV ICBM on a hardened transporter continuously patrolling an extensive area. Furthermore, an arms control agreement based on Approach III would explicitly permit the deployment of the MX in redundant silos at new, as well as existing, launch complexes and at whatever spacing is appropriate to complicate a Soviet attack.

From a technical standpoint, increasing the allowable throwweight associated with a small, single-RV ICBM from 400 kilograms to 500 kilograms would further encourage the fielding of such systems. The higher divisor of 500 kilograms would ensure payload flexibility on a single-RV missile without making the missile count as more than one standard weapon station in the destructive potential accounting. (Some relief for single-RV missiles is appropriate because the weight of the guidance system is amortized over one RV rather than over several, as is the case with MIRVed missiles.)

15Alternatively, instead of being concerned with the actual take-off gross weight of a bomber, an agreement could specify the accountable take-off gross weight to be assigned a particular aircraft. Accountable take-off gross weight would be determined by a wing area or total projected area.
Under Approach III and all other current approaches, the United States would probably have to reduce the number of its silos. To avoid such cuts, it might de-MIRV some of the Minuteman III missiles and thus deploy one RV per existing silo.
IV. CONCLUDING REMARKS

The United States and the Soviet Union have one common, overriding interest: to avoid nuclear war. As a large step toward achieving this objective, they must agree to the fundamental principle that both will eschew a first-strike capability and that each will undertake to reduce its counterforce potential so that unilateral survivability measures by both sides are viable and predictable. Without such an agreement, the basis for meaningful arms control is lacking. With such an agreement, the United States and the Soviet Union share common ground on which to negotiate an arms control treaty.

If the United States and the Soviet Union agree to this principle, then it follows on a technical basis that they must constrain missile throwweight. If the Soviets refuse to constrain throwweight, the United States can (and should) argue that they violate the basic objectives and principles and that there is no basis for further negotiation.

Once it has been decided to control throwweight, the problem is reduced to how to do so. Approach III, as proposed above, demonstrates a meaningful way of reducing offensive destructive capacity to levels that enhance stability, using a new arms control currency: the standard weapon station. This same currency can also describe the utility of unilateral force survivability measures. The approach would achieve stability by correlating the cost of attack and the destructive potential allowed.

The standard weapon station approach would control throwweight in blocks of 400 kilograms. It would also control the number of RVs by stipulating that an RV always counts as at least one standard weapon station, regardless of how small it may be. (This stipulation would constrain the United States more than the Soviet Union, since the United States presently has many more small RVs than the USSR.)

Some impugn the negotiability of the standard weapon station concept and, in particular, the divisor of 400. Would the Soviets seek to increase the value of the divisor? Perhaps. But this question suggests the illogic of starting negotiations on numbers. The United States and the Soviet Union must in the first place establish a firm foundation of basic objectives and underlying principles.

Only after they have agreed on objectives and principles should the two countries begin to negotiate specific numbers to constrain counterforce destructive potential. The first number to negotiate is the ballistic missile throwweight that will trigger an added constraint on the
allowed bomber forces. Once this level is set, the numerical value of the divisor does not affect throwweight; it affects only the units of account—i.e., the number of standard weapon stations.

Approach III would force a trade-off and, more important, allow freedom to mix between a large amount of missile throwweight (in which the Soviet Union has the present advantage) and a substantial bomber force (in which the United States has the advantage). The linkage of force elements in Approach III would probably provide greater opportunities for an acceptable outcome than attempts to negotiate separate, and perhaps asymmetrical, limits on ballistic missile RVs, ballistic missile throwweight, and bombers.

Approach III offers the prospect of improving ICBM survivability by constraining the total potential destructive power of each side’s strategic force while allowing (and perhaps encouraging) unilateral efforts to increase strategic force survivability. If the counterforce threat is successfully constrained and both sides take appropriate measures to enhance force survivability, stability can be achieved and deterrence served.
Appendix A

U.S. AND SOVIET STRATEGIC FORCES, MID-1983


In these tables, the standard weapon station value for ballistic missiles, based on the counting method described in this report, is the largest of the following three numbers: (1) the declared number of weapons on the missile; (2) the maximum number of weapons tested on the missile; (3) the throwweight of the missile in kilograms divided by 400 for MIRVed missiles and 500 for single-RV missiles.

The standard weapon station value for bombers is the take-off gross weight in pounds divided by 25,000 for ALCM carriers and 50,000 for aircraft that do not carry ALCMs. The number of bombers and the standard weapon station figures for bombers are based on announced U.S. plans to ultimately equip 104 B-52Gs and all 95 B-52Hs to carry ALCMs. These bomber figures, although subject to change, are consistent with the U.S. START position tabled in 1983. As of late 1983, 45 B-52Gs had been converted to carry ALCMs.
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<td>8313</td>
<td></td>
</tr>
</tbody>
</table>
Table A.1—continued

<table>
<thead>
<tr>
<th></th>
<th>Take-off Gross Weight (thousand pounds)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>per Bomber</td>
<td>Total</td>
</tr>
<tr>
<td>Bombers (active)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B-52G with ALCMs</td>
<td>104</td>
<td>488</td>
</tr>
<tr>
<td>B-52G</td>
<td>66</td>
<td>488</td>
</tr>
<tr>
<td>B-52H with ALCMs</td>
<td>95</td>
<td>488</td>
</tr>
<tr>
<td>FB-111A</td>
<td>60</td>
<td>115</td>
</tr>
<tr>
<td>Total</td>
<td>325</td>
<td>135260</td>
</tr>
<tr>
<td>Total missiles and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>active bombers</td>
<td>1938</td>
<td></td>
</tr>
<tr>
<td>Retired B-52s (SALT-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>accountable)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total bombers</td>
<td>308</td>
<td>488</td>
</tr>
<tr>
<td>Total missiles and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>bombers</td>
<td>2246</td>
<td>285560</td>
</tr>
</tbody>
</table>

*The number of standard weapon stations declared or tested exceeds the value obtained by applying the missile throwweight or bomber take-off gross weight counting rules.

*The U.S. submarine force consists of 31 Poseidon submarines, of which 19 are equipped with C-3a and 12 with C-4a, and 3 Trident submarines equipped with C-4a.

NOTE: Boxed numbers represent starting points for Approach III build-down, depicted in Fig. 1, above.
Table A.2

Soviet Strategic Forces, Mid-1983

<table>
<thead>
<tr>
<th>Force</th>
<th>Number</th>
<th>Missile Throwweight (thousand kg)</th>
<th>Actual or Estimated Weapon</th>
<th>SALT Weapons per Missile</th>
<th>Standard Weapon Stations per Missile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICBMs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS-11</td>
<td>550</td>
<td>.9</td>
<td>495</td>
<td>1</td>
<td>550</td>
</tr>
<tr>
<td>SS-13</td>
<td>60</td>
<td>.5</td>
<td>30</td>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td>SS-17</td>
<td>150</td>
<td>2.7</td>
<td>405</td>
<td>4</td>
<td>600</td>
</tr>
<tr>
<td>SS-18</td>
<td>308</td>
<td>8.0</td>
<td>2464</td>
<td>10</td>
<td>3080</td>
</tr>
<tr>
<td>SS-19</td>
<td>330</td>
<td>3.6</td>
<td>1188</td>
<td>6</td>
<td>1280</td>
</tr>
<tr>
<td>Total</td>
<td>1398</td>
<td></td>
<td>4582</td>
<td>5700</td>
<td>6270</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SLBMs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS N-6</td>
<td>384</td>
<td>.7</td>
<td>269</td>
<td>1</td>
<td>384</td>
</tr>
<tr>
<td>SS-N-8</td>
<td>292</td>
<td>.7</td>
<td>204</td>
<td>1</td>
<td>292</td>
</tr>
<tr>
<td>SS-N-18</td>
<td>224</td>
<td>1.0</td>
<td>224</td>
<td>7</td>
<td>1568</td>
</tr>
<tr>
<td>Total</td>
<td>900</td>
<td></td>
<td>697</td>
<td>1800</td>
<td>2244</td>
</tr>
<tr>
<td>Total ballistic missiles</td>
<td>2298</td>
<td></td>
<td>5279</td>
<td>7500</td>
<td>8514</td>
</tr>
</tbody>
</table>

*Note: Values in italics are considered as reliable and those in regular type are less reliable.*

*a* Based on other evidence.

*b* Includes SLBMs.
Table A.2—continued

<table>
<thead>
<tr>
<th>Bombers</th>
<th>Take-off Gross Weight (thousand pounds)</th>
<th>per Bomber</th>
<th>Total</th>
<th>per Bomber</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tu-95 Bear</td>
<td></td>
<td>100</td>
<td>414</td>
<td>41400</td>
<td>8.3</td>
</tr>
<tr>
<td>Mya-4 Bison</td>
<td></td>
<td>43</td>
<td>350</td>
<td>15050</td>
<td>7.0</td>
</tr>
<tr>
<td>Tu-22M Backfire</td>
<td></td>
<td>210</td>
<td>277</td>
<td>58170</td>
<td>5.5</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>353</td>
<td>114620</td>
<td>1200</td>
<td></td>
</tr>
<tr>
<td>Total missiles and bombers</td>
<td>2651</td>
<td>8700</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

aThe number of standard weapon stations declared or tested exceeds the value obtained by applying the missile throwweight or bomber take-off gross-weight counting rules.

bThe Soviet submarine fleet consists of 14 Delta III submarines, each equipped with 16 SS-N-18s; 4 Delta IIs, each with 16 SS-N-8s; 18 Delta Is, each with 12 SS-N-8s; 1 Hotel III with 6 SS-N-8s; 1 Golf III with 6 SS-N-8s; and 24 Yankee I submarines, each with 16 SS-N-6s.

NOTE: Boxed numbers represent starting points for Approach III build-down, depicted in Fig. 1, above.
Appendix B

THE DESTRUCTIVE CAPACITY OF MISSILES

FIVE COUNTING METHODS

The inherent destructive capacity of a missile is largely determined by a combination of the number and size of weapons that the missile carries. Some analysts have expressed this relationship as

\[ \text{Destructive capacity of a missile} = nt^x, \]

where \( n \) is the number of weapons on a missile and \( t \) is the throwweight associated with each weapon (i.e., the total throwweight of the missile divided by the number of RVs that it carries).

The value of the exponent is a function of the type of target being attacked. For attacks on soft point targets, the value of \( x \) is near zero, since on the margin, increased yield (or associated throwweight) of the RV is not useful. The above formula then becomes

\[ nt^0, \]

and thus \( n \) is the only factor.

For bombarding areas and attacking very hard point targets, the exponent \( x \) approaches a value of 1. The destructive capacity formula is then

\[ nt^1, \]

which is, by definition, the total throwweight of the missile. Thus, missile throwweight is the critical factor in determining a missile's effectiveness in attacking hard targets or bombarding an area (see Appendix D).

With the above thoughts in mind, we examine below several methods that have been used to count the destructive capacity of missiles in arms control.
Method A: A Missile Is a Missile

By this method, a U.S. Minuteman III ICBM with three light RVs is mandated to have the same destructive capacity as a Soviet SS-18 ICBM with ten heavy RVs. The Soviets would doubtless favor such a method because their ICBMs are much larger than those of the United States. As a justification for using such a method, the Soviets might argue that each side has the freedom to develop whatever size missiles it chooses and that the United States has created its own problem by developing smaller missiles.

The United States, however, has belatedly come to regard as unacceptable any method that ignores the fact that missiles come in different sizes and carry different numbers of RVs with different weights. Thus, counting missiles would not, in itself, provide an effective means of limiting the destructive capability to levels that would increase stability.

Method B: An RV Is an RV

This method determines the destructive capacity of a missile by the number of weapons that it carries. The method assumes that a weapon is a weapon, or RV is an RV, regardless of the throwweight associated with that weapon or RV.

This method is more to the mark than Method A. By this method, one U.S. Minuteman III has approximately one-third the destructive capacity of a Soviet SS-18. But RVs, like missiles, come in different sizes, and Method B ignores this difference.

Since Soviet ballistic missile RVs are typically larger than U.S. RVs, this method of counting would put the United States at a disadvantage. If only RVs were constrained, the Soviets could maintain a large counterforce destructive capacity. Such a formulation would not adequately constrain the potential destructive capability of a missile force. A constraint only on the number of RVs would allow, and invite, each side to deploy larger RVs in new systems.

Method C: Missile Throwweight Is Missile Throwweight

According to this method, the total throwweight of a given missile alone determines the destructive capacity of that missile. This means that missile forces with the same aggregate throwweight are mandated to have the same total destructive capacity, regardless of the number of RVs that each side has.
This method has considerable merit, since as we said above, throwweight is the prime factor in determining the potential counterforce capability. However, since the United States typically has more RVs for a given amount of throwweight, counting only throwweight would operate to the advantage of the United States, and the Soviets would therefore be unlikely to accept it.

If forced to choose, one would surely select Method C (throwweight) over Method B (RVs), based on the assessment that counterforce destructive potential more closely parallels throwweight regardless of RVs than RVs regardless of throwweight. But neither method is totally satisfactory. For a given number of RVs, the Soviets have more throwweight. For a given amount of throwweight, the United States has more RVs.

A limit on both throwweight and RVs seems the only possible way out of this dilemma. Given the current U.S. and Soviet force structures, however, it is impossible to set RV and throwweight limits that can be met by both sides through reductions alone. The United States would run out of RV count before reaching the throwweight limit. The Soviets would run out of throwweight before reaching the allowed number of RVs. A counting system that considers both throwweight and RVs seems the most appropriate method.

**Method D: Missile Throwweight Equals the Number of Weapons Times the Throwweight of Each Weapon to Some Exponent Other Than Zero or One**

Method B amounts to measuring the destructive capacity of a missile by $nt^0$. Method C is equivalent to measuring the destructive capacity of a missile by $nt^1$. By definition, the number of RVs on the missile times the throwweight associated with each RV must equal the total throwweight ($T$) of that missile.

Method D strikes a balance between methods B and C by giving the exponent of $t$ a value that is greater than zero but less than one. A scale factor of one-half satisfies this criterion and represents a reasonable trade-off between the number and weight of RVs. Since, by definition, $n \times t = T$, obviously $nt^{1/2} = (n \times T)^{1/2}$.

This method suffices in evaluating existing forces, but not in constraining counterforce destructive capacity. By deploying a smaller number of larger RVs, a country could attain more total throwweight without increasing the number of units of account. This, unfortunately, provides an incentive to deploy increasingly larger RVs. This loophole could be blocked by setting an upper limit on the size of new RVs to be deployed.
Method E: The Destructive Capacity of a Missile Is Determined by RVs When RVs Are Small and by Throwweight When RVs Are Large

This counting method stipulates that the destructive capacity value assigned to a missile is the larger of the following two numbers:

1. The number of weapons, either declared or tested
2. The throwweight of the missile in kilograms divided by some chosen constant.

Assume for the moment that this constant (K) is 400. A missile like the MX has, by SALT II provisions, 3600 kilograms of throwweight. By the throwweight rule (2), the MX count is 3600 divided by 400 = 9. But the number of RVs on the MX has been announced as 10. In this case, therefore, the missile is counted according to the number of RVs as 10 standard weapon stations, because it carries more RVs per amount of throwweight than specified by the standard of one RV per 400 kilograms of associated throwweight.

Now examine a missile like the Soviet SS-18. Assume that the throwweight of this missile is around 8000 kilograms. According to the throwweight rule, the missile has a count of 8000 divided by 400 = 20 standard weapon stations. This is larger than the announced number of RV stations, namely 10. In this case, the destructive capacity of the missile is determined by its throwweight, because more throwweight is associated with each RV than specified by the standard of 400 kilograms of throwweight per RV.

So, by Method E, the destructive capacity of a missile, as measured in standard weapon stations, is based on the number of RVs when the throwweight associated with each RV is below the standard and on throwweight when the RV throwweight is above the standard. By charging on the basis of throwweight for RVs above a certain standard weight, Method E, in effect, forestalls a breakout through fractionation. But most important, it directly constrains counterforce potential in a way that is both meaningful and without loopholes.

Under the counting rules set forth here, the overall counterforce potential of a country's missile force would be at or near the maximum if it were to deploy RVs of 400 kilograms of associated throwweight. Within a given number of allowed standard weapon stations, no other size RVs would allow either a larger number of RVs or more actual throwweight.

The question remains of whether such an RV would come close to representing the most efficient use of allowed throwweight in generating counterforce potential to bombard deployment areas of mobile
ICBMs and to destroy hard targets. The answer depends largely on warhead and guidance technology. Assuming an efficient use in the mid-1990s of allowed throwweight, we find with respect to U.S. technology that, on an empirical basis, $n y^{2/3}$ (where $n$ is the number of weapons and $y$ is weapon yield) approaches the maximum within a given amount of throwweight when RVs weighing 200 kilograms (and thus having an associated throwweight of 400 kilograms) are used.\footnote{The term $n y^{2/3}$ is discussed in Appendix D.} Within a given constraint of throwweight, a country deploying larger RVs must deploy fewer of them.

In sum, the currency of a 400-kilogram standard weapon station would unambiguously constrain the counterforce potential of missile forces. For missiles with weapons having more than 400 kilograms of associated throwweight each, the missile would be charged according to throwweight. For small RVs, useful against soft point targets, proliferation would be constrained by counting missiles according to the number of RVs when the number of RVs per 400 kilograms of throwweight exceeded one.

The United States plans to use RVs carrying a little less than 400 kilograms of throwweight on its new MX missile. Each MK-12 warhead on the Minuteman III has around 350 kilograms of throwweight; the MX will carry RVs with 360 kilograms of throwweight. RVs for a new Soviet MIRVed missile are estimated to be in the same weight range.\footnote{Based on characteristics of Soviet missiles described in Modernizing U.S. Strategic Offensive Forces: The Administration’s Program and Alternatives, Congressional Budget Office, May 1985, p. 90.} Furthermore, the combined average of U.S. and Soviet throwweight associated with each ballistic missile RV is 413 kilograms (1835 plus 8513 divided by 8513 plus 8514). Thus, the weight of RVs to be used in new U.S. and Soviet missiles also supports the use of 400 kilograms of associated throwweight per RV as the standard.

The United States has also given serious consideration to limiting the weight of any new RVs on either side to 225 kilograms. (See the above discussion of Approach I and nested constraints to control throwweight.) An RV with 400 kilograms of associated throwweight would have an actual weight of around 225 kilograms. (The actual RV payload of a missile constitutes roughly 55 percent of the missile’s total throwweight.) Accordingly, the 225-kilogram limit on actual weight of Approach I and the 400-kilogram counting rule of this method start from the same base.
### Table B.1
Comparison of Three U.S. Missiles with Soviet SS-18 Using Various Counting Methods

<table>
<thead>
<tr>
<th>Missile</th>
<th>Number of RVs</th>
<th>Throw-weight (kg)</th>
<th>Method A</th>
<th>Method B</th>
<th>Method C</th>
<th>Method D</th>
<th>Method E</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS-18</td>
<td>10</td>
<td>8000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>MM III</td>
<td>3</td>
<td>1000</td>
<td>1.0</td>
<td>3.3</td>
<td>8.0</td>
<td>5.2</td>
<td>6.7</td>
</tr>
<tr>
<td>C-4</td>
<td>8</td>
<td>1300</td>
<td>1.0</td>
<td>1.25</td>
<td>6.2</td>
<td>2.8</td>
<td>2.5</td>
</tr>
<tr>
<td>MX</td>
<td>10</td>
<td>3600</td>
<td>1.0</td>
<td>1.0</td>
<td>2.2</td>
<td>1.5</td>
<td>2.0</td>
</tr>
</tbody>
</table>

**Method A:** Counts missiles (like SALT)  
**Method B:** Counts RVs ($n^0$)  
**Method C:** Counts missile throwweight ($nt^1$)  
**Method D:** Counts RVs and missile throwweight ($nt^{1/2}$)  
**Method E:** Counts either RVs or missile throwweight (larger of $n$ or $T/400$)

**NOTE:**  
$n = $ number of RVs per missile  
$t = $ throwweight of each RV on a missile  
$T = nt = $ total throwweight of missile  

Unacceptable to U.S.  
Unacceptable to USSR  
May be acceptable to both
COMPARISON OF METHODS

Table B.1 compares several U.S. missiles with the Soviet SS-18, using the different counting methods described above. For each U.S. missile, the value shown in the table is the ratio of the destructive potential count of the SS-18 divided by the same count of the respective U.S. missile.

The Soviets might object to Method E, pointing out that such a method penalized them uniquely. In the U.S. force, most present RVs and no currently planned RVs are larger than the 400-kilogram standard. Instead of treating all RVs alike, Method E may seem to charge the Soviets for possessing overweight RVs.

It is far more logical to state the problem as follows. We are striving to limit counterforce capability and thus are focusing on throwweight. However, instead of treating throwweight simply as throwweight, Method E places an additional charge on missiles with more than one RV per 400 kilograms of throwweight. Since the United States has more missiles where the number of RVs per given amount of throwweight exceeds the standard, this method uniquely penalizes the United States. In fact, if the divisor K were 400, all planned U.S. ballistic missile throwweight would be counted extra and none of the throwweight in existing Soviet ICBMs would incur an extra charge. None of the present Soviet ICBMs has more than one RV per 400 kilograms of throwweight.

As shown in Table B.1, the worth of missiles relative to the SS-18 is about the same for methods D \((nt^{1/2})\) and E (RVs or throwweight). Methods D and E are the only counting approaches that merit attention, since they take into account the number of RVs and the throwweight associated with each. We selected Method E because, if one focuses on counterforce capability (throwweight), Method D contains a loophole that allows a side to gain an advantage by deploying missiles with large RVs.

According to the formula \(nt^{1/2}\), doubling the size of an RV doubles throwweight, but increases Method D's units of account by only 1.414 (the square root of 2). This loophole could be blocked by stipulating that new weapons may not exceed a certain throwweight. However, this stipulation would only partially block the loophole and would introduce the extremely worrisome problem of verification as to what is new and what is an allowed modification of an existing missile.

Method E does not contain this loophole. According to this method, doubling missile throwweight doubles the number of standard weapon stations charged. The charge is on each missile. This prevents averag-
ing, that is, applying the lack of throwweight on small RVs against overages on large RVs.

With the standard weapon station counting rule, a missile is always, in effect, charged one standard weapon station for each 400 kilograms of throwweight or for each RV, regardless of the size of the RV. Also, the use of the currency of standard weapon stations seems more straightforward than dealing with the term \( n^{1/2} \), particularly if convertibility between missile and bomber weapons is sought.

Although the above discussion might seem to imply that an extra charge would be levied against RVs larger than some set standard, it would be more to the point to say that an additional charge would be made for more than one RV per 400 kilograms of throwweight. Each side could add RVs to a missile without changing the number of standard weapon stations charged as long as it did not go beyond the standard of no more than one RV, on the average, per \( \leq 00 \) kilograms.

Neither side would have any incentive to fractionate below that standard. Fractionation to RVs with significantly less than 400 kilograms of associated throwweight would mean a considerable loss in the total counterforce potential of that missile. Nevertheless, a charge should be placed against such fractionation, because the side that fractionated would have an advantage in soft target kill within a given amount of throwweight and could use the saving in throwweight on heavier RVs designed to attack hard targets.

To summarize:

- **Method A** (a missile is a missile) dramatically understates the destructive potential of larger missiles relative to smaller missiles and provides no meaningful constraint to the counterforce potential of ballistic missile forces.
- **Method B** (an RV is an RV) understates somewhat the worth of an SS-18 relative to other missiles. For example, the MX counts the same as the SS-18, even though each of the ten RVs on an SS-18 are over twice as heavy as the ten RVs on the MX. It does not take into account the amount of throwweight in a given number of RVs and leaves a loophole of deploying heavy RVs. Thus, it does not represent a viable method of constraining counterforce potential.
- **Method C** (an overall constraint on throwweight) controls the counterforce potential of both sides but does not constrain the number of RVs in a given amount of throwweight. It leaves the loopholes of fractionation and averaging.
- **Method D** suffices for evaluating existing forces but leaves a loophole in constraining counterforce potential.
- Method E unambiguously constrains counterforce potential and fractionation and adequately evaluates existing forces.
Appendix C

THE DESTRUCTIVE CAPACITY OF BOMBERS

To trade off the number of bombers against the number and throwweight of missiles, we again use the concept of standard weapon stations. We assign the number of stations to a bomber of a given type on the basis of reasonableness, rather than on the basis of strict analytical formulations.

We have similar choices with respect to bombers that we had with respect to missiles. The proposition that “a bomber is a bomber” would not be a bad approach. All heavy bombers are about the same size, and if only heavy bombers were counted, that approach would be quite even-handed. But if smaller bombers, such as the Soviet Backfire and U.S. FB-111, were included, then some distinction as to size would have to be made.

We propose take-off gross weight (TOGW) as a surrogate for size. This approach corresponds to the use of throwweight for missiles. However, bomber weapons cannot be counted in the same way as missile weapons, because it is not considered possible to determine and verify the actual number of weapons tested and carried on a bomber. We can distinguish only between bombers that have been outfitted to carry air-launched cruise missiles (ALCMs) and those that have not.

Bombers weighing approximately 500,000 pounds (B-52s, for example) and equipped with cruise missiles typically carry around 20 weapons.¹ Bombers weighing around 500,000 pounds and not equipped with ALCMs typically carry fewer than ten weapons. Accordingly, destructive potential of bombers is counted as follows:

1. For ALCM-equipped bombers, the number of standard weapon stations is the TOGW in pounds divided by 25,000.
2. For bombers not equipped with ALCMs, the number of SWS is the TOGW in pounds divided by 50,000.

¹Article V of the SALT II treaty in effect equated ALCM-equipped bombers with MIRVed ballistic missiles by setting a sublimit on both. The value of the bombers remained ambiguous, however, because the treaty failed to specify the size of the MIRVed missiles—the Soviet SS-18 with ten heavy RVs or the U.S. Minuteman III with three much smaller warheads.
By this formula, a B-52 equipped with ALCMs counts as 20 standard weapon stations and without ALCMs as 10 weapon stations. Some would argue that these values are too high, based on two factors: First, bombers, unlike ballistic missiles, are slow and nonthreatening in a first strike. Second, bombers, particularly U.S. bombers, must face unconstrained defenses. Some would go so far as to stipulate that all heavy bombers (including ALCM carriers) should count as only ten standard weapon stations.

These arguments have some validity. However, assigning such a value to all bombers does not seem to pass the test of reasonableness. The Soviets could argue that in the case of ICBMs, which constitute the bulk of the Soviet force, the number of standard weapon stations charged would always exceed the number of actual weapons. For example, a Soviet SS-18, because of its huge throwweight, would be charged 20 standard weapon stations, although SALT II states that this missile is to carry no more than 10 weapons. At the same time, bombers, which predominate in the U.S. force, would each count as 10 standard weapon stations, although the United States stated in SALT II that B-52s equipped with ALCMs might actually carry as many as 20 weapons.

In sum, there are valid reasons for placing a lower value on bombers than does the counting method used here. However, such a discount, if negotiable, would not necessarily be in the U.S. interest.

If bombers counted too little relative to missiles, then the Soviets would not have to give up much throwweight in the missile force to obtain a sizable bomber force. The U.S. interest requires a trade-off with greater leverage. This proposal already contains a loophole with respect to bombers; namely, it places no constraint on the actual number of weapons that a bomber can carry.

However bombers are counted, the important item is the total number of standard weapon stations allowed and the number of ballistic missile RVs allowed. This difference must be adjusted to accommodate the desired size of the bomber force. Once the rules for counting bombers have been agreed on, the total number of permitted standard weapon stations can be adjusted accordingly.
Appendix D

EFFECT OF RV WEIGHT AND THROWWEIGHT ON BOMBARDMENT AREA AND HARD-TARGET KILL

The term $n^{2/3}$ appears in the formula for determining the bombardment area of ($n$) number of RVs of ($y$) yield each. The same term appears in the formula for damage expectancy against hard targets, such as silos.¹

The yield of weapons weighing from 200 to 400 kilograms (400 to 800 kilograms of associated throwweight) varies approximately with the weight of the weapon to the $3/2$ power. That is, if the weight of a weapon is doubled, the yield more than doubles, increasing by a factor approaching 2.8.

These two statements together mean that the overall effectiveness of a force is directly proportional to $nt$ (number of RVs times the throwweight associated with each RV) or the total throwweight ($T$) of the missile. (The exponent $2/3$ multiplied by the exponent $3/2$ gives an exponent of one.) Since, by definition, $nt$ is the total throwweight of a missile, this means that the throwweight of a missile by and large dictates the inherent bombardment-area and hard-target kill of that missile.

BOMBARDMENT AREA

A weapon weighing about 225 kilograms (400 kilograms of associated throwweight) will have a bombardment area against a hardened transporter of between 1.5 and 2 square nautical miles, depending on the technology of the RV and the hardness of the transporter. These figures are calculated as follows: Assume that a weapon weighing 225 kilograms has a yield of 300 kilotons. Then the radius-to-effect of that weapon against a transporter hardened to withstand 30 pounds per

¹The formula for damage expectancy against silos is given in the subsection on Hard Targets in this appendix.
square inch of peak dynamic pressure is .7 nautical miles.\textsuperscript{2} The bombardment area of this weapon, then, is 1.5 square nautical miles and approaches 2 square nautical miles if the transporter is slightly less hard.

If an RV with 400 kilograms of associated throwweight is taken as the standard, then, by definition, 1 million kilograms of throwweight equals 2500 standard weapon stations. Thus, 1 million kilograms of throwweight provides a bombardment area with an upper limit of 4000 to 5000 square miles, independent of the actual number of RVs involved. This is based on the premise that the bombardment area approaches the maximum, within a given constraint of total throwweight, when RVs of around 400 kilograms of throwweight are employed.

This calculation, viewed in another manner, tells us that

- 2500 RVs of standard weight could bombard an area of around 5000 square miles.
- 2500 RVs of twice the standard weight (800 kilograms throwweight each) could bombard an area twice as large, or 10,000 square miles.
- Each additional 1 million kilograms of throwweight, even with the same number of RVs, could increase the bombardment area by as much as 5000 square miles.

This increase in the bombardment area takes on added meaning when one notes that the total area on U.S. military reservations available for the deployment of small U.S. missiles on hardened transporters may not be much more than 10,000 square miles. Therefore, for every 1-million-kilogram increment of Soviet ballistic missile throwweight, the United States must add 4000 to 5000 square miles to the deployment area so as to maintain the same degree of survivability. Without a meaningful constraint on throwweight, we cannot predict the long-term viability of such a survivability measure.

**HARD TARGETS**

The formula for the damage expectancy ($D$) of RVs against a hard target is

$$D = 1 - .5 \left( ny^{2/3} \frac{r}{C} \right)^2,$$

\textsuperscript{2}This figure is derived from *The Effects of Nuclear Weapons*, U.S. Department of Defense and U.S. Department of Energy, 1977, pp. 116-117.
where the term in brackets is the exponent of .5

\( n \) is the number of RVs
\( y \) is the yield of each RV in megatons
\( r \) is the radius-to-effect of a one-megaton RV against the target
\( C \) is the circular error probable (CEP) of the RV.

Since \( ny^{2/3} \) is proportional to \( nt \), we see again that the counterforce potential of a missile relates directly to the throwweight of the missile. With the same warhead technology, an RV of twice the throwweight will generally affect the damage expectancy as follows. If the damage expectancy of a single small RV is .50, then an RV of twice the throwweight will have a damage expectancy of around .75. The damage expectancy of .75 could also be achieved by two RVs of the smaller size. Thus, as a general rule, doubling the throwweight reduces the survivability of the original percentage surviving to the square power. If the original survivability is .50, then doubling the throwweight reduces the survivability to .25.

From this calculus, it follows that a force with RVs of twice the throwweight can attack twice as many hard targets at a specified damage expectancy. A ballistic missile force with 2 million kilograms of throwweight can successfully attack (attain a specified damage expectancy against) twice as many hard targets as a force that contains 1 million kilograms of throwweight. In fact, the cost of successfully attacking a hard target can be described directly in terms of throwweight, SS-18 equivalents, MX equivalents, or standard weapon stations.

We can calculate the throwweight required to achieve a specified damage expectancy against a hard target, using the following inputs: the weight of the RV being evaluated; (2) the radius-to-effect on the target (a function of the weapon’s yield and the hardness of the target); (3) the CEP of the attacking weapon; and (4) the probability of arrival of the weapon. The output can be described as well in standard weapon stations as in throwweight.

The Soviet response to a U.S. deployment of missiles in very hard silos, closely spaced, might be to design and deploy weapons on their missiles capable of penetrating the earth. The Soviets could also provide these weapons with terminal guidance, thereby reducing CEP to near zero. Such weapons, however, would occupy a considerable amount of throwweight (or number of standard weapon stations).

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3This figure is derived from the above formula for RV damage expectancy against a hard target. If \((1 - .5^2) = .5\), then \((1 - .5^{2r}) = .75\).
Suppose the equivalent of ten standard weapon stations were needed to successfully attack these closely spaced very hard silos. Then it follows that one million kilograms of throwweight (which contains 2500 standard weapon stations) could successfully attack 250 hard silos. This would be significant if a country were contemplating modest deployments of, say, 300 to 500 such silos.

In summary, a limit on throwweight is needed to constrain the counterforce potential of ballistic missile forces. The concept of standard weapon stations allows one to directly link the effects of survivability measures to arms control measures. This arms control approach limits the destructive potential while permitting survivability measures designed to increase the cost of a successful attack. Both the destructive potential and the cost of attack can be expressed in the same currency: standard weapon stations. By constraining the attack potential and initiating unilateral survivability measures, the correlation of the cost to attack and what is allowed is such that both sides will lack the incentive to attack in the first place.
Appendix E

COMPARISON OF STRAIGHT-LINE AND MODERNIZATION-INDUCED BALLISTIC MISSILE BUILD-DOWN

Reductions in ballistic missile weapons can be achieved in several different ways. This report sets forth the straight-line reduction approach, whereby both the United States and the Soviet Union would reduce their SALT-accountable inventories of ballistic missile RVs to 5000 at a fixed annual rate approaching 5 percent.

Straight-line reduction can be overlayed with a build-down driven by ICBM and SLBM modernization programs. Under the modernization-induced build-down, each side would be required to destroy one or more old weapons for each new weapon deployed as it modernized its forces.

Figure E.1 compares the reductions in the number of U.S. ballistic missile weapons that could be achieved by straight-line and by modernization-induced build-down over an eight-year period. The modernization-induced build-down assumes the ballistic missile force modernization program displayed in Table E.1.

The modernization-induced build-down assumes an SLBM modernization reduction of 3:2; i.e., for every two new RVs deployed on MIRVed SLBMs, three old SLBM RVs would have to be destroyed. Two ratios—2:1 and 3:1—are assumed for ICBM modernization, implying that for every new RV deployed on a MIRVed ICBM, two RVs in the first case and three RVs in the second case would have to be destroyed.1 Figure E.1 shows that, based on present plans for modernization, a straight-line reduction would produce larger aggregate decreases in ballistic missile RVs than modernization-induced reductions.

1 Similar ICBM and SLBM reduction ratios were proposed by Senator William S. Cohen. See The Washington Post, January 3, 1983.
Fig. E.1—Comparison of straight-line and modernization-induced build-down of U.S. ballistic missile force, 1984-1992

Table E.1

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