CANADIAN INSTITUTE FOR INTERNATIONAL PEACE AND SECURITY

NUCLEAR WEAPONS, COUNTER-FORCE, AND ARMS REDUCTION PROPOSALS: A GUIDE TO INFORMATION SOURCES AND FORCE CALCULATIONS

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Foreword

This working paper brings together several related but somewhat distinct projects undertaken by the research staff of the Institute.

First, a number of individuals suggested that the Institute might assist interested individuals by preparing a guide to sources on nuclear weapons data. Effectively, Section II of this paper responds to that suggestion. While the commentary is likely to be most useful to non-specialists in the area, it might also provide a useful checklist to more experienced observers who are already familiar with the source materials.

Second, the Institute undertook its own assessments of the Soviet and American proposals at Geneva, which were designed primarily as background analyses and detailed descriptions of the respective proposals. Major elements of these analyses are incorporated into the text.

Third, both proposals and, indeed, the strategic debate for several years now, reflect the issue of counter-force capabilities. This paper seeks to identify the counter-force problem and to relate it to the present arms control negotiations. In so doing we have attempted, as simply as possible, to set out the calculations used in counter-force analyses with a view to allowing the non-specialized reader to understand the basis of the technical debate without necessarily becoming familiar with all the equations involved. Indeed, the commentary accompanying the tables is intended to be self-explanatory, so that the steps of the argument can be followed through the text alone.

The paper has been prepared by David Cox in co-operation with Jane Boulden, research assistant at the Institute. Acknowledgement is made to Lawrence Hagen, former Director of Research at the Canadian Centre for Arms Control and Disarmament, for his advice and comment.

We welcome and invite comments on the paper, whether about the value of the analysis for particular audiences, or the substance. Communications should be addressed to David Cox, Director of Research.

I. INTRODUCTION

'Who is ahead?' is perhaps a crude question, but when applied to the strategic arms race, it is the one most often raised. For example, Secretary of Defence Weinberger states that the comparative data found in Soviet Military Power "highlight even more vividly the magnitude and the dimensions of the threatening challenge posed by Soviet force deployments".[1] Even if the other side is not judged to be ahead, it is typical that the need for new strategic weapons systems is explained on the grounds that these systems are needed to counter new developments on the other side, or to maintain the stability of deterrence.

An interesting recent example of this pattern was the use of the term "window of vulnerability" to describe the threat posed by the Soviet SS-18 and SS-19 missiles to the land-based Intercontinental Ballistic Missile (ICBM) force of the United States. Shortly after taking office, President Reagan warned that "a window of vulnerability is opening", and alleged that it would "jeopardise not just our hopes for serious productive arms negotiations, but our hopes for peace and freedom."[2]

In 1983 the Scowcroft Commission, appointed to examine the claim that the Soviets were ahead in ICBMs and to resolve the controversies about the MX missile, refuted the more alarmist views but expressed continued concern about the Soviet strategic built-up. Pointing out that more than half of the Soviet ICBM's had been deployed since the last U.S. ICBM (the Minuteman) was deployed in 1980 the Commission commented:

"The Soviets now probably possess the necessary combination of ICBM numbers, reliability, accuracy and warhead yield to destroy about all of the 1,047 US. ICBM silos using only a portion of their ICBM force. The U.S. ICBM force now deployed cannot inflict similar damage even using the entire force."[3] The Scowcroft Commission recommended, therefore, the

1 Soviet Military Power 1985, DoD, Washington D.C., p.5
2 President Reagan, Press Conference, October, 1981
3 Report of the President's Commission on Strategic Forces (the Scowcroft Commission), Washington, April 1983, p. 4

deployment of the MX as a new and more powerful ICBM.

The purpose of this paper is not to revive these familiar debates. It is, instead, an attempt to provide a guide to understanding some of the basic characteristics of the strategic weapons systems which the superpowers either presently possess or are about to deploy. Understanding these characteristics allows the claims and counter-claims about particular weapons systems to be checked against some basic performance characteristics. Used in context, these characteristics not only provide insight into the old debates, but also criteria by which to judge current negotiating proposals and future developments.

The analysis begins with an account of the public sources which provide the basis for informed analysis of strategic arms control issues. The strategic force balance is then presented, using both simple quantitative indicators and more complex indicators of weapons performance and quality. The counter-force capabilities of American and Soviet strategic weapons systems are then compared in order to complete the context for the analysis of the Soviet and US proposals at Geneva. The conclusion indicates the promising areas for negotiation and the logic of arms control trends in the current strategic environment.

II. The Public Sources Generally Relied Upon

There are three basic sources of information on strategic weapons systems which appear annually:

- The Military Balance, published by the International Institute for Strategic Studies (IISS)
- The Armament and Disarmament Yearbook published by the Stockholm International Peace Research Institute (SIPRI)
- The US Department of Defence Publications, Soviet Military Power (SMP) and the Fiscal Year Reports of the Secretary of Defense to

Congress. The latter lists only American forces; the former, Soviet Military Power, first published in 1981, has become a valuable, if sometimes controversial source on Soviet and American strategic systems.

The Military Balance provides the most detailed listing of any public source. The main section provides charts of nuclear capable delivery vehicles listing the accuracies of the weapons where available. Although comprehensive, the Military Balance sometimes obscures critical information, particularly in its failure to distinguish between the different modifications of Soviet missiles.

SIPRI's 1984 Yearbook was the only annual source to make such distinctions between modifications. However, the 1985 Yearbook failed to continue this practice. The yearbook has exhibited a certain inconsistency from year to year, reflecting its use of different sources and information gathering techniques.

In particular, SIPRI's 1985 data on the strategic nuclear balance departed quite dramatically from the style and format of previous years. For the first time, sources were listed, indicating a heavy reliance on the US Department of Defense (DOD) and the Nuclear Weapons Databook (see below). The emphasis in the data is on warheads and warhead stockpiles, not qualitative factors.

By contrast, the US Department of Defense's Soviet Military Power (SMP), assumes that every Soviet missile is deployed in its most current modification with the largest number of multiple independently targetable re-entry vehicles (MIRVs). This establishes a maximum warhead total. In sum, Soviet Military Power is geared towards emphasizing the size and quantity of the Soviet forces. Questions of accuracy and overall quality are not addressed. The US Department of Defense statistics on American nuclear forces are, of course, the best sources of information on American weapons numbers. Even here, however, they must be carefully used, since they are not always internally consistent. Particularly, they become less and less clear when addressing intermediate range nuclear forces, a difficulty which is in no way confined to DOD publications. Another interesting source can be found in John Collins' Congressional Research Service Reports which document Soviet-US comparisons in every weapon category as far back as 1974.

In 1984 NATO Information Services published NATO and the Warsaw Pact Force Comparison, an update to a first edition published in 1982. The paper concentrates primarily on the two alliances at conventional force levels, addressing strategic and intermediate range nuclear forces in terms of long-range modernisation trends rather than specific totals or counts of existing nuclear forces.

There are few Soviet sources available, and they generally present figures on American forces only. The main Soviet source, Whence the Threat to Peace is a response to Soviet Military Power. Not surprisingly, the Soviets take the opposite approach to the American and focus on the quality of American forces, emphasizing accuracy and the modernization of American strategic systems. However, there is very little detailed information about Soviet forces. Some of this information can be found in statements made by Soviet officials to explain proposals put forward in Geneva. For example, a revealing contrast between American and Soviet counting approaches to the Intermediate-Range Nuclear Forces (INF) balance emerged in the early debates on the nuclear balance in the European theatre. The American count of Soviet forces was four times higher than the Soviet count; the Americans claimed that the Soviet had 3,825 missiles and planes that should be counted in the INF negotiation, the Soviets counted 975.[4] (It should be noted however, that the two sides are much closer on strategic weapons).

In addition to these annual publications, there are a large number of other sources which are valuable for information purposes. These include the CIA

[4] The New York Times November 30, 1981, p. A12

National Intelligence Estimates, which, even in their public form, sometimes offer key insights into the evaluation process. For example, in July 1985 the CIA intelligence estimates altered their previous judgement on the accuracy of the Soviet SS-19 missile, concluding that it was about 100 metres less accurate than had previously been thought.[5] Although largely unnoticed in the public debate, this revision, small though it might appear, has a critical effect on the counter-force capability of the SS-19, as will be demonstrated later in this paper. Apart from the substantive issue, the C.I.A. revision - disputed, incidentally, by its sister organisation the Defense Intelligence Agency - demonstrates the fragility of even the most sophisticated estimates of the counter-force capabilities of most Soviet weapons systems.

A somewhat different source, also valuable when used discriminatingly, is Aviation Week and Space Technology (AWST). This weekly journal has excellent sources, particularly in the United States Air Force, and from time to time produces detailed accounts of missile accuracies and other developments in both American and Soviet strategic weapons. AWST tends to hyperbole, however, and there is a fine distinction between access to inside sources and the release of information designed to lead the public debate in a desired direction.

Designed primarily for a military readership, the monthly Air Force Magazine contains remarkably detailed expositions of stategic weapons programmes, generally interspersed with more routine articles about the USAF. Air Force Magazine also provides an annual update on American strategic nuclear forces. Like AWST, it is an excellent 'insider' source which must be used with discrimination.

The Nuclear Weapons Data Book, by Thomas B. Cochran, William Arkin and Milton Hoenig, is billed by the authors as "the most comprehensive and authoritative examination of U.S. nuclear weapons". Their claim is

[5]B. Keller, "US Study Finds a Soviet ICBM Is Less of a Threat to Missile Silos" New York Times July 19, 1985, p. 1

justified. Alone amongst the major publications identified here, it lists all its sources, including Congressional Hearings and more than 200 requests under the Freedom of Information Act. The Databook, the first volume of which is on U.S. Nuclear Forces and Capabilities (a Soviet volume is to come), has become an indispensable reference manual, although it does not seek to make annual missile counts comparable to those of the Military Balance.

Why not rely simply on Government statements about nuclear deployments? In the Canadian case, as with other allies of the United States, the answer is that our main insights into the nuclear debate lie in Washington, not Ottawa. The Canadian Government, as a member of NATO, is more or less obliged to accept the figures generated through the NATO process. The independent intelligence capabilities of the smaller allies, Canada included, are extremely limited. In respect of nuclear weapons holdings, therefore, NATO figures are effectively the official American figures.

But these figures too are open to debate, particularly in the United States, where information from competing agencies often finds its way into the public record. By analysing and comparing the various sources it is possible to understand the areas of uncertainty and controversy in the debate about the capabilities and tendencies of strategic weapons systems.

III Basic Factors in the Strategic Force Balance

An effective analysis of the comparative value of strategic nuclear weapons systems involves consideration of a number of variables. These include the following:

- the number of missiles and warheads deployed by both sides
- the yield of the warhead
- the accuracy of the warhead

- the throw-weight of the missile
- the hardness of the target
- the reliability of the delivery system.

In addition to these factors, which are addressed in this paper, there are a number of other variables which are not easily quantified, but are critical to calculations of the force balance. These include the readiness of operational forces, the survivability of command and control centres, the time between launch and target of a delivery system, the ability of offensive weapons to penetrate defences, and defence capabilities. Allowing for these factors generally involves devising complicated scenarios, which are themselves the subject of considerable debate regarding their real-life plausibility. This paper does not address these factors, important though they are, but deals only with the quantifiable variables identified above which provide the most basic aids to an understanding of the strategic debate. Used in combination and in a step-by-step process they can provide useful keys to understanding the superpower competition in nuclear weapons.

Tables 1A and 1B use standard counts of missiles and warheads. The figures cited in the Tables are based on information derived from a variety of sources. Where this information is compatible with the Military Balance, the figures are used without notation, and the Military Balance may be used for reference. Where there are significant differences with the Military Balance, the differences are noted and the actual source used is cited. Where the information was not available in the Military Balance, the source used is cited. Although the indicators used in Tables 1A and 1B are generally familiar, it may still be useful to define the exact meaning of the terms used.

Missiles/Warheads

The number of missiles and warheads possessed by each side are the basic counting variables, sometimes referred to as static indicators. A 'missile' is the actual vehicle launched. Some missiles carry multiple independently targetable reentry vehicles (MIRVs) which means that they carry more than one warhead, each of which can be specifically aimed at a distinct target. The warhead 'rides' the re-entry vehicle to the target; the lethality of the warhead, therefore, depends not only on its size, but also on the accuracy of the re-entry vehicle and the sophistication of its guidance system.

Yield and Equivalent Megatonnage (EMT)

The megatonnage or yield of a warhead provides a measure of its explosive energy yield. Due to the nature of the blast, however, destructive power and the yield of a warhead do not grow proportionately. When an explosion takes place, a great deal of the energy released as blast and shock is concentrated in the centre vertical plane of the explosion, as opposed to expanding equally outwards in the shape of a sphere. As the yield of a weapon increases the energy "lost" to the concentration effect in the centre also increases, but not in a one-to-one relationship to the increase in yield. Equivalent megatonnage (EMT) expressed as $Y^{2/3}$ (Y=yield) reflects this distribution of energy and provides a better measure of overall destructiveness than yield alone.[6] EMT is generally used to measure weapons effects against 'soft' urban and industrial targets. On balance, it can be seen from the table that the lower the yield of a weapon, the relatively greater its destructive efficiency expressed in EMT. Large warheads, therefore, are not necessarily a sign of a greater destructive capability. For example, 2 warheads of 0.5 Mt. have an EMT of 1.26; 4 warheads of 0.25 Mt. have an EMT of 1.59 Mt.. In each case, total yield is 1Mt.

A useful example of the way in which the distinction can be applied is provided by a recent letter to the New York Times by Frank Gaffney, presently the US Deputy Assistant Secretary of Defense. Gaffney wrote:

[6] For further discussion, see Kosta Tsipis, Nuclear Explosion Effects on Missile Silos (Center for International Studies, Massachusetts Institute of Technology, February 1978)

"Improvements in warhead design validated by nuclear testing have made possible an even more dramatic reduction in our explosive power - currently one-fourth what it was at its high point."[7] Mr. Gaffney presumably referred to total yield when he spoke of this reduction; the destructive power of the arsenal has almost certainly increased because the US has many more re-entry vehicles with smaller but more efficient warheads.

Throw-weight

Throw-weight "is the weight of the post-boost vehicle (warheads, guidance systems, penetration aids) over a given range."[8] Missiles with large throw-weights can be converted to carry more warheads of smaller yield. Throw-weight then gives a general indication of the potential for MIRVing. In their current reduction proposal, for example, the US has included a provision that could require the Soviets to reduce their total throw-weight by 50%. This provision reflects the US concern that the large Soviet advantage in throw-weight (particularly on the SS-18's), combined with the increasing accuracy of the re-entry vehicles, gives the Soviet Union an inherent advantage in counter-force capabilities. The contrary argument is that increasing accuracy permits the use of warheads with lower yields, thereby diminishing the significance of throw-weight.

Fuel

Fuel is either liquid (deuterium and tritium) or solid (lithium-6 deuteride). Liquid fuel decays radioactively and must be replaced on an ongoing basis.[9] Liquid fuel must be primed in advance of launch time and the priming of the fuel releases gases which can be detected by satellite as a warning of preparations for launch. Solid fuel is in a constant state of readiness for launch and has a much longer storage life. It is

7 F. Gaffney, "What's Good About U.S. Nuclear Testing" New York Times August 28, 1985 p. 22
8 IISS, The Military Balance 1984-1985 p. 136
9 Cochran, Arkin, Hoening, US Nuclear Forces and Capabilities (Natural Resources Defense Council, 1984). p. 26

essential to use solid fuel with mobile missiles, since liquid fuel is too bulky and flamable to permit mobility.

General Observations about Tables 1A and 1B

Overall, the tables clearly illustrate one of the central difficulties with which arms control negotiators struggle: for a variety of reasons - different targeting priorities, concepts of nuclear deterrence, technological skills, bureaucratic politics - the superpowers have developed their nuclear arsenals in an asymmetrical pattern. In sum, the United States has emphasised a balance of delivery systems such that the "triad" of land-based, sea-based and air launched weapons remains more or less equally important in its parts. The Soviet Union also has the elements of a triad, but much the greater part of its strategic weapons are land based. It is for this reason that proposed cuts in weapons systems which are applied only to one type fall unequally on the two sides. As a consequence, easy debating points may be won by proposing cuts which are, on the surface, eminently reasonable, but in reality have no chance of acceptance because they adversely affect the relative position of the other side. To avoid this dilemma, reduction proposals which allow each side the freedom to choose their own mix of forces, on the way down to an agreed lower level for total delivery systems or warheads, provide much greater potential for fruitful negotiation.

Some general characteristics of the strategic weapons systems of the superpowers are readily observable.The range of American weapons systems, with the exception of some SLBM systems, is greater, and the readiness of American systems is likely to be greater (remembering that there are other factors involved which are not indicated in the table) because a significant number of Soviet systems use storeable liquid fuel, and therefore take more time to prepare for launch than missiles using solid fuel. Generally speaking, the Soviet systems have significantly larger throw-weights, and larger yield warheads, but this advantage is partially offset by considering EMT. Here the smaller American warheads are more

Table 1A U.S. Strategic Nuclear Forces

	Range (Km)	Throw-weight (000lb.)	Fuel	Missiles	Warhead/ Missile	MT/ Warhead	EMT/ Warhead	Total Warheads	Total Yield	Total EMT
ICBMs										
Minuteman II	11,300	1.6	sol.	450	1	1.200	1.095	450	540	493
Minuteman III	14,800	1.5	sol.	250[a]	3	0.170	0.307	750	127.5	230
Minuteman III12A	12,900	2.4	sol.	300	3	0.335	0.482	900	301.5	434
Titan II	15,000	8.3	liq.	24[b]	1	9.000	4.327	24	216	104
				(1024)				(2124)	(1185)	(1261)
SLBMs[c]										
Poseidon C3	4,600	3.3	sol.	288	10	0.040	0.117	2880	115	337
Trident C4	7,400	3.0	sol.	360	8	0.100	0.215	2880	288	619
				(648)				(5760)	(403)	(956)
Bombers[d]				(324)[d]						
ALCM	2,500	240 lb	—	1476	1	0.200	0.340	1476	295	502
SRAM	160-220	—	sol.	1444	1	0.170	0.307	1444	246	443
Bombs	—	—	—	722	1	0.600[e]	0.710	722	433	513
								(3642)	(974)	(1458)
Totals				**1,996** (ICBMs, SLBMs, Bombers)				**11,526**	**2,562**	**3,675**

a. Minuteman III silos are now being prepared to receive MX missiles. "Silos Prepped to Take MX" *Defense Week* February 3, 1986, p.6

b. Titan II missiles are being phased out at the rate of about one/month. There were 24 Titan II missiles still deployed as of November 1985. (See "Strategic Nuclear Forces of the United States and the Soviet Union" *Arms Control Association*, November 1985)

c. There are 37 American ballistic missile submarines.
– 7 Trident OHIOs-class submarines with 24 Trident C-4 missiles each (168 missiles)
– 30 Poseidon submarines:
18 Lafayette with 16 Poseidon C-3 missiles each (288 missiles)
12 Ben Franklin with 16 Trident C-4 missiles each (192 missiles)

(Arms Control Association, *Countdown to SALT II*, Nov, 1985, p.41)

Both IISS *The Military Balance* 1985-86 and SIPRI 1985 (published earlier than ACA figures) base their estimates on 36 US submarines and therefore 615 SLBMs with 5,536 warheads. The ACA is including both the new USS Alaska now on sea trials and the recently launched USS Nevada in their total of 7 Trident submarines. (R. Norris *Arms Control Today* Sept. 1985)

The Poseidon submarine has been dismantled by the United States (November 28, 1985) as part of President Reagan's decision to comply with the SALT II ceiling of 1200 MIRVed missiles on land and sea. The newest Trident submarine, the USS Nevada, will begin sea trials in May 1986, at which point the United States will have to dismantle two additional Poseidon submarines to stay within the SALT limit. The USS Andrew Jackson and USS Nathan Hale have been chosen to be dismantled. One of Defense Secretary Weinberger's recommendations to President Reagan concerning responses to alleged Soviet SALT violations (January 1986) was to simply drydock the submarines rather than dismantle them. This would leave them available to be retrofitted and put to sea again at a later date.

As part of a press briefing on the Soviet counter-proposal in Geneva, National Security Adviser Robert McFarlane stated that the US had 37 submarines with "approximately 600 tubes, comprising 5,370 warheads" ("US Official Assesses Soviet Counter-Proposal on Arms Cuts", *New York Times*, October 10, 1985)

d.

167 B-52G	– 98 with	12 ALCM	=	1176 ALCM
	– 69 with	8 SRAM	=	552 SRAM
		4 Bombs	=	276 Bombs
96 B-52H	– 15 with	20 ALCM	=	300 ALCM
	– 81 with	8 SRAM	=	648 SRAM
		4 Bombs	=	324 Bombs
61 FB-111	–	4 SRAM	=	244 SRAM
	–	2 Bombs	=	122 Bombs

Totals: 1476 ALCM
1444 SRAM
722 Bombs
3642

See ACA *Countdown to SALT II* p. 41
Arms Control Reporter 1985 p. 611E3

There are also 307 B-52s in storage. (See ACA *Countdown to SALT II* p.41 and *Foreign Broadcast Information Service – USSR* Nov. 4, 1985, p. AA4)

The IISS, *Military Balance 1985–1986* states that of 241 B-52 bombers, 61 have now been converted to non-nuclear roles (carrying Harpoon weapons). The strategic nuclear bomber force is then made up of 90B-52G and 90B-52H bombers. This may be in order to accommodate the B-1 Bomber.

e. The figure of 0.60 Mt is an *average* of the yields of the various gravity bombs carried by all 3 bomber types. These include:

B-28 – 0.07/0.35/1.10/1.45 Mt
B-43 – 1 Mt
B-57 – 0.005 – 0.010 Mt
B-61 – 0.10 – 0.40 Mt

(Cochran, Arkin, Hoening eds. *US Nuclear Forces and Capabilities*, Cambridge: Ballinger, 1984, pp. 42, 50, 63, 65)

Table 1B Soviet Strategic Nuclear Forces

	Range (Km)	Throw-weight (000lb.)	Fuel	Missiles	Warhead/ Missile	MT/ Warhead	EMT/ Warhead	Total Warheads	Total Yield	Total EMT
ICBMs										
SS-11 Mod 1	10,000	2.0	liq.	50	1	0.95	0.97	50	48	49
Mod 2/3	13,000	2.0	liq.	420	1	1.00	1.00	420	420	420
SS-13 Mod 2	10,000	1.0	sol.	60	1	0.60	0.71	60	36	43
SS-17 Mod 3	10,000	—	liq.	150	4	0.75	0.83	600	450	495
SS-18 Mod 4	11,000	16.7	liq.	308	10	0.50	0.63	3,080	1,540	1,940
SS-19 Mod 3	10,000	8.0	liq.	360	6	0.55	0.67	2,160	1,188	1,450
SS-25	8,500	1.6	sol.	45[a]	1	0.55	0.67	45	25	30
				(1393)				(6,415)	(3,707)	(4,427)
SLBMs[b]										
SS-N-5	1,400	—	—	39	1	1.00	1.00	39	39	39
SS-N-6 Mod 1/2	2,400/3,000	1.5	liq.	336	1	1.00	1.00	336	336	336
SS-N-8 Mod 1/2	7,800/9,100	1.5/8.0	liq.	292	1	0.80	0.86	292	234	252
SS-N-17	3,900	2.5	sol.	12	1	1.00	1.00	12	12	12
SS-N-18 Mod 3	6,500	1.8/2.9[d]	liq.	224	7	0.20	0.34	1,568	314	536
SS-N-20	8,300	5.6	sol.	60	9	0.50	0.63	540	270	340
SS-N-23[c]	7,240	3.36[d]	liq.	16	7	0.25	0.40	112	28	44
				(979)				(2,899)	(1,233)	(1,559)
Bombers										
Bear Tu-95 B/C/G	12,800	—	—	100	2-4	1	1.41	400	400	564
Bear Tu-95 H	12,800			30[e]	8	0.25	0.40	240	60	95
Bison Mya-4	11,200	—	—	45	4	1	1.41	180	180	254
				(175)				(820)	(640)	(913)
Total				**2547**				**10,134**	**5,580**	**6,899**

a. The SS-25 is a single-warhead road-mobile missile now deployed at two converted SS-20 sites (Yurya [an old SS-7 site] and Yashkarola). Fifty SS-11 missiles have been dismantled to accommodate 45 SS-25s. (*Arms Control Reporter* p. 607.8.76, 1985)

Jane's Defence Weekly January 18, 1986 p.43

Michael Gordon. "CIA Downgrades Estimate of Soviet SS-19" *National Journal* July 20, 1985, p. 1693

A Joint Chiefs of Staff Report said that the Soviets had dismantled 70 SS-11 missiles and deployed 45 SS-25s. M. Gordon "Joint Chiefs Find No Soviet Cheating" *New York Times* Feb. 8, 1986, p.6. A report by AWST suggested some of the empty SS-11 silos are being demolished and buried. *Aviation Week and Space Technology* Oct. 28, 1985, p.22

US Defense Secretary Caspar Weinberger states that the range of the SS-25 is 10,500 km. (*Jane's Defence Weekly*, Nov. 2, 1985 p. 43) CIA estimates (National Intelligence Estimate NIE-11-3-888) suggest that 20 bases are being prepared for the SS-25. Ten missiles will be at each base for a total of 200 missiles. The SS-25 is similar in size to the American Minuteman III and US officials claim its throw-weight gives it the capability to carry three warheads. According to the same CIA estimate, 100 ten warhead SS-24s are also in the process of being deployed at two bases (Plesetsk and Kostrama where it will replace SS-17s). In 1986 the missile will be deployed in silos and will be transferred to a rail-mobile system in 1987.

"Big Soviet Build-up Foreseen" *Defense Week*, June 17, 1985, p. 15
"What You'll Hear on the Threat" *Defense Week*, June 24, 1985, p. 16
"CIA Goes Public on Threat" *Defense Week*, July 1, 1985, p. 14-15

b. SALT limits allow 62 Soviet strategic submarines and 940 SLBM

The USSR currently maintains: – 22 Yankee submarines
– 37 Delta submarines
– 3 Typhoon submarines

IISS, *The Military Balance 1985-1986* lists 15 submarines not counted in the SALT limit of 62 and 39 non-SALT theatre SLBMs that are deployed by the USSR (p.21) Two Delta IV submarines have been launched, one is assumed to be operational and carrying SS-N-23 missiles (*Jane's Defence Weekly* Dec. 7, 1985, ACA *Countdown to SALT II* p. 41)

c. The SS-N-23 is still being flight tested and is deployed on the new Delta IV submarine. The SS-N-23 is reported to be a replacement for the SS-18 SLBM with better accuracy and larger throw-weight. (*Jane's Defence Weekly* December 7, 1985)

See also: IISS *The Military Balance 1985-1986*
Arms Control Association *Countdown to SALT II* November 1985, p. 41

d. J. Sands and R. Norris "A Soviet Trident II?" *Arms Control Today* September 1985, p.7

e. Arms Control Association, *Countdown to SALT II*, November 1985, p. 41 The new Bear H bomber carries 8 AS-15 cruise missiles with a range of 3,000 km.

The USSR has said it has destroyed 15 Bison bombers and converted 15 others to tankers to compensate for the deployment of the Bear H. The Bison that were destroyed were placed in full view at an airfield with their tail sections cut off. (*Arms Control Reporter* p. 607B76, 1985) efficient when translated into EMT, thereby reducing the Soviet advantage and in some measure offsetting the Soviet throw-weight superiority. This point is reinforced when the number of total warheads is considered: the Soviet advantage in throw-weight does not translate into a greater number of warheads; on the contrary, the United States, with less throw-weight but smaller, more efficient warheads, is able to deploy a significantly larger number of warheads.

IV. Counter-Force Capabilities

Tables 2A and 2B illustrate the way in which the basic data in Tables 1A and B can be further developed to provide a more sophisticated indication of the strategic nuclear capabilities of the superpowers. An explanation of the terms used precedes the table in order to help explain the significance of these indicators.

Accuracy and Circular Error Probable (CEP)

The accuracy of a warhead is expressed as a measurement of precision in terms of circular error probable or CEP. If a number of the same type of warheads are fired at a single point, CEP represents the radius of the circle whose centre is the point within which half of the warheads will fall.

Countermilitary Potential (CMP)

CMP (sometimes referred to as lethality) combines the variables of yield and accuracy to provide a way of measuring warhead capability against specific hard targets such as missile silos. This differs from EMT since EMT is primarily a measure of general destructiveness. The CMP equation is derived from the mechanical relationship between yield and accuracy and is expressed in the formula:

$$CMP = \frac{Y^{2/3}}{(CEP)^2}$$ [10]

One of the drawbacks involved in using CMP is that it is not strictly a measure but a numerical expression of potential. Since there are no units of CMP, the equation simply generates a numerical value unique to each combination of yield and accuracy. It can be used most effectively as a general idea of design efficiency. For example, CMP provides a way of qualitatively comparing individual missile systems. To illustrate by reference to CMPs for the Soviet ICBM force, the table indicates that the warheads of the SS-18 are as much as 20 times more efficient than those of the earlier generation SS-11's. The U.S. Mark 12A warhead on the Minuteman III is almost 3 times more efficient than that of the earlier Minuteman III.

Single Shot Kill Probability (SSKP)

This calculation is designed to measure the ability of a single warhead to hit and destroy hardened targets, in particular hardened missile silos. Single Shot Kill Probability is "the probability that a single reliable warhead can be expected to destroy a given target."[11] SSKP is expressed mathematically in the following equation, where it can be seen that the critical variables are yield, CEP and hardness.

$SSKP = 1 - 0.5^{\frac{8.41Y^{2/3}}{H^{.7}(CEP)^2}}$	CEP=circular error probable Y=yield H=hardness

10 D. Ball, "The Future of the Strategic Balance", in (ed. L. Hagen) The Crisis in Western European Security (St. Martin's Press, N.Y., 1982); See also K. Tsipis Arsenal (New York: Simon&Schuster, 1983) pp. 305-308; and IISS The Military Balance 1985-1986, p.179

11 L.E. Davis and W.R. Schilling, "All You Ever Wanted to Know About MIRV and ICBM Calculations But Were Not Cleared to Ask", Journal of Conflict Resolution vol. 17 no.2, June 1973, p. 210

Terminal Kill Probability (TKP)

Terminal Kill Probability takes warhead reliability into account, and is expressed as follows:

TKP=SSKP x OAR (OAR=overall reliability)

Reliability as a statistic is not readily available in any public sources and must be estimated from general knowledge. Because of the difficulties involved in measuring reliability, however, it is safe to assume that even official estimates are only educated guesses. TKP and SSKP can be used in comparing the capabilities of different missile systems. They are obviously essential in assessing the 'silo-busting' capabilities of each side. Before examining some of the data presented in Table 2, it is important to note uncertainties and problems in the use of these variables.

Accuracy

Measurement of CEP is based on the distribution of a number of test firings. The number of test firings carried out is usually not large and their measurement is subject to significant uncertainties. The Military Balance has estimated that the range of error in CEP figures may be as high as ± 50%[12]. Use of CEP further assumes that the conditions and trajectories under test firing and battlefield conditions will be the same, and that the bias is zero. A bias means that the distribution of test firings was significantly to one side of the target.[13] This can occur as a result of a number of conditions or factors during the flight of the missile. Because the conditions affecting the bias are different in each case, and because its occurrence and effects are extremely difficult to measure, for convenience sake it is always assumed to be zero (CEP is then more correctly a measure of precision). While this may be necessary in

12 IISS, "Estimating the Soviet-US Strategic Balance" The Military Balance 1982-1983 p. 139

13 For a discussion of bias, see K. Tsipis, Arsenal (New York: Simon&Schuster, 1983), p. 142

order to facilitate calculations, it leaves open the possibility that missiles fired in anger on untested trajectories might uniformly miss their target.[14]

The uncertainty involved in estimating Soviet CEPs is much higher because these estimates are primarily the product of a large number of fragments of information that must be pieced together. This problem was demonstrated recently in the CIA revised estimate (referred to above) of the CEP of the SS-19. The original 1977 estimate had been based on test firings and projected improvements, and the CIA revised this estimate on the basis of new information.[15] Using the same intelligence, the Defense Intelligence Agency maintains the previous estimate, raising the question of how much interpretation goes into threat assessment and how reasonable or consistent those threat assessments are. As one observer noted recently, relying only on CEP "clearly leads to higher assessments of Soviet ICBM accuracy than would be obtained in conflict or could be relied upon by Soviet military planners."[16]

Countermilitary Potential

Because of the nature of the equation (CMP varies inversely with CEP^2) CMP is highly sensitive to missile accuracy. As missiles become more accurate, and CEP decreases, CMP grows by substantially larger and larger amounts. Tsipis notes that CMP has "a maximum numerical value beyond which its magnitude has no physical meaning"[17] This occurs when the CEP of a missile is less than the radius of the crater the explosion creates because at that point the probability of kill of the missile or warhead becomes 1.00 or 100%.[18]

To illustrate the difficulty involved when accuracies approach 100%, both

14 Steve Smith "Problems of Assessing Missile Accuracy" RUSI vol. 130 No. 4 p. 37

15 B. Keller, "US Study Finds a Soviet ICBM Is Less of a Threat to Missile Silos", New York Times July 19, 1985, p. 1

16 Smith, op. cit. p. 39

17 Tsipis, Arsenal p. 307

18 Ibid p. 307

the American short-range missile (SRAM) and the air-launched cruise missile (ALCM) have a yield of 0.20 Mt. The CEP of the ALCM is 0.016 n.m., and that of the SRAM is 0.10 n.m., a difference of 0.084 nautical miles. However, this translates into a substantial difference in terms of CMP. The CMP per warhead of the ALCM is 1336 and that of the SRAM is 34[19]. Changes in estimates of Soviet CEPs, such as the recent CIA revision of the SS-19 CEP, also cause large changes in the CMP[20]. This sensitivity to accuracy means that as technology generates qualitative improvements in missile accuracy, CMP will lose its utility as a value.

Despite these emerging limitations, CMP can still be used as a general guide in comparing overall missile system effectiveness. It is probably not useful in aggregate comparisons to determine which side is ahead or superior. To aggregate separate systems would be to assume that the entire missile force is targeted according to a single doctrine of counter-force targeting. Aggregation is also subject to the distortions created by CMP sensitivity to missile accuracy values. For example, the total American CMP is 2,154,924 of which 1,971,936 (92%) is accounted for by the ALCM.

Overall Reliability

A missile has five stages of operation: launch phase, boost phase, separation, penetration and detonation. The missiles' overall reliability is a composite probability of the different reliabilities of the missile at each individual stage of its flight.[21]

For example, if it is assumed that the reliability of the missile at each

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19 See Table 2A

20 B. Keller "US Study Finds a Soviet ICBM Less of a Threat to Missile Silos" New York Times July 19, 1985, p. 1
The change in the CEP estimate from 1,000 feet (0.164 n.m.) to 1,300 feet (0.214 n.m.) caused a corresponding decrease in CMP/warhead from 23.42 to 15.20 and a decrease in the total CMP of the SS-19 Mod 3 from 50,592 to 32,879. This change represented a 12% decrease in the total CMP of the entire Soviet Strategic nuclear force

21 For a useful brief discussion of the stages of missile flight, see Stephen Weiner, "Systems and Technology", especially pp. 50-54, in ed. A.B. Carter and D.N. Schwartz, Ballistic Missile Defense (Brookings Institution, Washington, D.C., 1984)

stage is 97% (there is a 3% chance it will fail), the overall reliability (OAR) is equal to $(0.97)^5$ which equals 0.86 or 86%.

The value for OAR for the United States used in the accommpanying tables is 80%. This means reliability at each stage of missile operation is assumed to be around 96%. The OAR used for the Soviets in the tables is 70% which assumes a 93% reliability at each stage. (Of course, postulating the same value for each of the five stages is also a simplifying assumption designed to average the probability, not to suggest an actual equal reliability at each stage.) To illustrate the potential for overestimating OAR, the French Ariane commercial booster failed recently for the third time in 15 attempts. A rough calculation of its OAR, assuming that it was used as a military launcher, puts it at around 70%. American commercial satellite launches have a near identical success rate. Since these are launches carefully prepared and checked to the last detail, the OAR for missiles stored in silos over long periods of time and subject only to routine maintenance must be treated with scepticism.

General Observations About Table 2A and 2B

It can be seen from Tables 2A and 2B that speaking generally, in all classes of weapons, the accuracies (CEPs) of American delivery systems are greater than those of the Soviets. Similarly, the SSKP's of American warheads are better than their Soviet counterparts. Granted that American missile reliability is conservatively estimated to be superior to that of the Soviets, the TKPs of the American strategic force are noticeably superior to those of the Soviets. Finally, the counter military potential of each class of warhead, considered as CMP per warhead is clearly in the American favour, but (and here one must recognise the warning given earlier about the dangers of aggregating CMP) the total CMP of ICBMs favours the Soviet Union because the Soviets have a larger number of ICBM warheads (as opposed to the overall total of ballistic missile warheads).

In the case of the Soviet Union, the question raised by American strategists and politicians concerns the reasons for the deployment of the

Table 2A U.S. Strategic Nuclear Force Characteristics

	Total Warheads	CEP	CMP/ Warhead	Total CMP	SSKP (H=2,000)	TKP (OAR=80%)
ICBMs						
Minuteman II	450	0.12[a]	78.42	35,289	0.893	0.71
Minuteman III	750	0.11[a]	25.36	19,021	0.515	0.41
Minuteman III12A	900	0.12	33.49	30,147	0.615	0.49
Titan II	24	0.70	8.83	212	0.223	0.18
				(84,669)		
SLBMs						
Poseidon C3	2880	0.24	2.03	5,846	0.056	0.05
Trident C4	2880	0.12[b]	14.96	43,088	0.347	0.28
				(48,934)		
ALMs						
ALCM	1476	0.016[c]	1,336	1,971,936	1.000	0.80
SRAM	1444	0.10[d]	34.2	49,385	0.623	0.50
				(2,021,017)		
Totals	**10,804** (bombs excluded)			**2,154,924**		

a. The CEPs for the Minuteman missiles are derived from figures in IISS *The Military Balance 1984-1985*, upgraded according to improvements listed in "Long-term Strategic Program Beginning to Show Results" *Aviation Week and Space Technology* April 29, 1985, pp. 84-94

b. The Trident C-4 missile has achieved improved CEPs as a result of the Navy's Improved Accuracy Program

See: W. Arkin "Sleight of Hand with Trident II" *Bulletin of Atomic Scientists*, December 1984, p.6

R. Norris "Counterforce at Sea" *Arms Control Today* September 1985, p. 10

c. Cochran, Arkin, Hoenig (eds), *US Nuclear Forces and Capabilities* Cambridge MA: Ballinger, 1984, p. 177

d. D. Ball "The Future of Strategic Balance" L. Hagen ed. *The Crisis in Western Security* New York: St. Martins Press, 1982, p. 128

Table 2B Soviet Strategic Nuclear Forces

	Total Warheads	CEP	CMP/ Warhead	Total CMP	SSKP (H=2,000)	TKP (OAR=70%)
ICBMs						
SS-11 Mod 1	50	0.75	1.72	172	0.048	0.03
Mod 2	420	0.59	2.87	1,034	0.084	0.06
SS-13 Mod 2	60	1.01	0.70	42	0.020	0.01
SS-17 Mod 3	600	0.19	22.90	13,720	0.479	0.33
SS-18 Mod 4	3,080	0.13	24.60	75,792	0.654	0.46
SS-19 Mod 3	2,160	0.21[a]	15.20	32,879	0.352	0.25
SS-25	45	0.11[b]	55.47	2,496	0.794	0.56
				(126,135)		
SLBMs						
SS-N-5	39	1.49	0.45	18	0.01	0.007
SS-N-6 Mod 1/2	366	0.70	2.04	685	0.06	0.04
SS-N-8 Mod 1/2	292	0.48	3.74	1,092	0.10	0.07
SS-N-17	12	0.80	1.56	19	0.044	0.03
SS-N-18 Mod 3	1,568	0.32	3.34	5,237	0.09	0.06
SS-N-20	540	0.25	10.10	5,454	0.25	0.18
SS-N-23	112	0.32[c]	3.88	434	0.11	0.07
				(12,939)		
Total	**9,314** (bombs excluded)			**139,074**		

a. National Intelligence Estimates quoted in B. Keller "US Study Finds a Soviet ICBM Is Less of a Threat to Missile Silos" *New York Times* July 19, 1985, p.1

b. IISS, *The Military Balance 1985-1986*

c. J. Sands and R. Norris "A Soviet Trident II?" *Arms Control Today* September 1985, p. 7

very large and accurate SS-18 and SS-19s. The characteristics of these MIRVed missiles, deployed in large numbers, have encouraged US Administration spokesmen to believe that they are counter-force weapons to be used against 'time urgent', hardened targets - namely, the U.S. land-based missile force.

In considering this claim, it might be noted first that although the Soviets have deployed a number of land-based ICBM types of different modifications, only three of them (the SS-17, 18 and 19s) have a CMP and SSKP good enough to make then useful against a certain level of hardened targets. It might be useful also to compare them with the Minuteman, which is an older missile than the SS-17, the SS-18 mod 4 and the SS-19. The table demonstrates that in a comparison of the Minuteman III Mark 12A and the SS-18 mod 4, the Minuteman has a better CEP, CMP per warhead, SSKP and TKP than the SS-18 used against targets with the same hardness. However, the SS-18 warhead is not markedly less efficient than the Minuteman, and there are many more of them (3080 SS-18 warheads compared with 900 Minuteman III warheads and 2124 <u>total</u> American ICBM warheads.)

It is this combination of numbers and accuracy which has led the present American Administration, for example, to claim that the Soviets have the capability to completely eliminate the American ICBM force. The argument is that, in such a case, the President would be placed in a position where his only effective method of retaliation would be against Soviet cities and population. Even after the Americans had carried out the retaliatory strike, the Soviets would still have the ability to counter-retaliate against American cities. Having lost the effective counterforce element of his power and knowing that a second strike would surely bring widespread destruction to American cities and population, the argument runs, the President would be forced to eschew retaliation of any kind, and accept an effective surrender.[22]

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[22] For example, the Scowcroft Commission (<u>op</u>. <u>cit</u>., p. 6) commented: "A one-sided strategic condition in which the Soviet Union could effectively destroy the whole range of strategic targets in the United States, but we could not effectively destroy a similar range of targets in the Soviet Union, would be extremely unstable over the long run."

Counter-Force Calculations

Using the figures and calculations from the charts, the utility of the SS-18's in this scenario can be examined. In all the calculations below, the following assumptions are made:

a) the hardness of missile silos for both the US and the Soviet Union is 2,000 psi

b) the Overall Reliability (OAR) for the US is estimated to be 80%, and for the Soviet Union 70%

c) The CEP and yields are the values identified in the Tables 2A and 2B

d) There are 1,000 American ICBM targets

e) The Soviet targets consist of the counterforce capable SS-17s, SS-18s and SS-19s, which constitute 818 targets

In the first instance, we can examine the relatively simple case in which the Soviets use 1,000 SS-18 warheads (100 missiles) to attack 1,000 American targets

Example 1

SS-18 SSKP	= 0.654
TKP	= SSKPx OAR
	= 0.654 x 0.70
	= 46%
Probability of survival of targets	= 54%

In sum, 46% of 1,000 warheads or 460 warheads could be expected to hit and destroy their targets. Clearly, this would leave the Americans with a substantial Minuteman counter-force capability still intact.

The second and more complex case begins with the recognition, illustrated above, that single warhead targeting offers a poor TKP; in this second case, - the one normally assumed to be the most plausible attack scenario, - two warheads are allocated to to each hard silo target.

If the Soviets used 1,000 SS-18 warheads and 1,000 SS-19 warheads against the American ICBM forces, the following calculation indicates the outcome.

Example 2

Probability of survival of the targets	$= (1-TKP_1)(1-TKP_2)$
From Table 2B TKP SS-19=0.25	
TKP SS-18=0.46	
	$= (1-0.46)(1-0.25)$
	$= 0.41$
	$= 41\%$

In sum, 41% of the targets could be expected to survive.

Alternatively, one may assume that two SS-18 warheads are targeted on each American ICBM:

Example 3

Probability of survival of targets	$= (1-TKP_1)(1-TKP_2)$
(TKP SS-18=0.46)	$= (1-0.46)(1-0.46)$
	$= (0.54)(0.54)$
	$= 0.30$
	$= 30\%$

Double targeting the SS-18, therefore reduces the survival rate but not dramatically. It can be argued, of course, that the Soviets have enough counterforce capable ICBM warheads to use three or four warheads per target. However, adding more than two warheads to a target mathematically means that each additional warhead will only increase the probability of destroying the target by smaller and smaller increments. In addition, the actual physical effects of the explosion of the first two warheads create an environment in which it is less likely that further incoming warheads would function effectively. Two warheads per target, therefore, is generally regarded as the most efficient allocation of warheads.

In the above two cases, the Soviets would use 2,000 of 6,540 ICBM warheads or 31% of their ICBM warheads to destroy 51% in the first case and 58% in the second case of the American ICBMs.

Considered from a slightly different perspective, American ICBM warheads constitute 18% of the total American warheads, while the Soviet ICBM warheads make up 67% of all Soviet warheads. This means that the Soviets would use 20.5% of their total warhead force to destroy 7-8% of the total American warhead force.

Although it is impossible here to explore all the implications of this scenario and of the possible circumstances in which it might take place, the advantage of quantifying the exchange in terms of the variables used in the Tables is clear. It is not evident that this exchange - which trades SS-18 and 19s for Minutemen before the Americans have responded at all - is in the Soviet advantage. Nor is it evident that the strike would paralyse the will of the US President, for, as demonstrated above, after such an exchange the U.S. would be left with a significant number of counter-force missiles and warheads. At this point, however, the analysis cannot be taken further without reference to other factors, particularly command and control, which have been excluded from this paper.

The question must also be asked the other way round: could the U.S. launch an effective counter-force strike against the land-based ICBM forces of the Soviet Union?

In this case, it is assumed for the purpose of illustration that the US used 819 Minuteman III Mark 12A warheads (273 missiles) against the 818 Soviet targets. As in the Soviet case, we begin by counting the effect of single warhead targeting.

Example 4

Minuteman III12A SSKP	= 0.615
OAR	= 0.80
TKP	= (0.615)(0.80)
	= 0.49
	= 49%
Probability of Survival of Targets	= 51%

In sum 49% or 401 of 819 warheads could be expected to hit and destroy their targets.

To double target the Soviet missiles, the Americans might use the Minuteman III and Minuteman III 12A warheads which total 1650, against the 818 Soviet targets.

Example 5*

Probability of survival of the targets	$= (1\text{-TKP}_1)(1\text{-TKP}_2)$
TKP Minuteman III = 0.41	= (1-0.41)(1-0.49)
TKP Minuteman III12A = 0.49	= (0.59)(0.51)
	= 0.30
	= 30%

According to this scenario the U.S. would use 78% of its ICBM warheads, and all of its MIRVed ICBMs, or 14% of its total warheads to destroy 70% of Soviet counterforce ICBMs or 44% of Soviet warheads. The analysis can be taken one step further by introducing the Minuteman II which has achieved a substantially higher CMP, SSKP and TKP, because of recent improvements in accuracy.

A hypothetical scenario incorporating the Minuteman II might then be as follows:

- 450 Minuteman II warheads (450 missiles) targeted against 450 SS-17 and SS-18 silos

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* For purposes of simplicity the equation assumes equal numbers of Minuteman III and Minuteman III 12A warheads. Strictly speaking, the probability of survival would be marginally less than that indicated here

- 370 Minuteman III warheads (124 missiles) targeted against 360 SS-19 silos, and 10 remaining SS-18s
- 820 Minuteman III12A warheads (274 missiles) targeted on all the SS-17, SS-18 and SS-19 silos

The probability of survival of the 450 SS-17 and SS-18 silos can then be expressed as follows:

Example 6

Probability of Survival (Minuteman II and III12A)	$= (1\text{-TKP}_1)(1\text{TKP}_2)$
	$= (1-0.71)(1-0.49)$
	$= (0.29)(0.51)$
	$= 0.15$
	$= 15\%$

The probability of survival of the 370 remaining silos (SS-19's + 10 SS-18's) is then:

Example 7

Probability of Survival (Minuteman III and III12A)	$= (1\text{-TKP}_1)(1\text{-TKP}_2)$
	$= (1-0.41)(1-0.49)$
	$= (0.59)(0.51)$
	$= 0.30$
	$= 30\%$

In this scenario, therefore, use of 77% of American ICBM warheads would inflict massive damage on the Soviet counterforce capable ICBMs, but the percentage of silos remaining suggests that about 180 would survive, as would the older, less capable SS-11 and 13 missiles. At this point it is reasonable to include some planned American deployments in order to indicate the effect of the American modernization programme on counter-force capabilities.

First, present Congressional restraints limit the deployment of the MX missiles to 50, although there is an important caveat which states that further deployment will be considered if a satisfactory alternative basing mode for the MX is devised.[23] Calculations indicate that despite their accuracy and firepower 50 MX would have only a marginal effect on the counter-force capability of the US. The situation changes considerably, however, if 100 MX were deployed, as illustrated below in Example 9 and 11.

Second, the US plans to deploy the Trident II SLBM (also called the Trident D-5) in late 1989.[24] The Trident D-5 makes a qualitative change in the nature of the SLBM force, since its remarkable accuracy (it has a CEP of 100 metres) makes it a powerful counter-force weapon. The calculations in Examples 10, 11 and 12 indicate the effect of the D-5 when introduced into a counter-force scenario.

In example 8, for illustrative purposes it is assumed that 100 MX missiles with 10 warheads each (1,000 warheads) are single targeted against 1,000 Soviet missile silos,

Example 8

MX CEP	= 0.066
MX SSKP	= 0.95 (H=2,000 psi)
OAR	= 0.80
TKP	= (0.95)(0.80)
	= 0.76
	= 76%
Probability of Survival=	24%

76% or 760 of the MX warheads could be expected to hit and destroy their targets.

23 See "Senate Armed Services Committee Votes for 21 Further MX Missiles" New York Times April 3, 1985; S.V. Roberts, "Senate's Chiefs and President in MX Accord" New York Times May 24, 1985

24 J.B. Schultz "Ballistic Missile Guidance" Defense Electronics, September 1984, p. 58; C. Mohr "US. Nuclear Forces: Arsenal Will Be Stronger But Strategy Wont't Change" New York Times July 6, 1985

In Example 9, the MX is now double targeted with the Minuteman III12A: 822 Minuteman warheads (274 missiles) and 820 MX warheads (82 missiles) used against the 818 Soviet counterforce ICBM targets

Example 9

$$\begin{aligned} \text{Probability of survival of targets} &= (1-TKP_1)(1-TKP_2) \\ &= (1-0.76)(1-0.49) \\ &= (0.24)(0.51) \\ &= 12\% \end{aligned}$$

This significant increase in the counter-force capabilities of the US is further emphasized when the Trident D-5 is considered.

Example 10

$$\begin{aligned} \text{D-5CEP} &= 0.06 \\ SSKP &= 0.98 \ (H=2{,}000 \text{ psi}) \\ TKP &= SSKP \times OAR \\ &= 0.78 \\ &= 78\% \end{aligned}$$

In Example 11, 824 Trident D-5 warheads and 820 MX warheads (103 Trident D-5 missiles with 8 warheads each, 82 MX with 10 warheads each) are double targeted against the 818 counterforce Soviet ICBM targets:

Example 11

$$\begin{aligned} \text{Probability of survival of targets} &= (1-TKP_1)(1-TKP_2) \\ &= (1-0.78)(1-0.76) \\ &= (0.22)(0.24) \\ &= 0.05 \\ &= 5\% \end{aligned}$$

In Example 12, 1640 Trident D-5 warheads (205 missiles) are double targeted against 818 Soviet ICBM targets:

Example 12

$$
\begin{aligned}
\text{Probability of Survival} &= (1\text{-TKP})(1\text{-TKP}) \\
&\quad (1-0.78)(1-0.78) \\
&= (0.22)(0.22) \\
&= 0.05 \\
&= 5\%
\end{aligned}
$$

At this point it must be accepted that, with a capability to destroy all but 5% of the Soviet ICBM force, an American planner would also target, in a simultaneous strike, all Soviet aircraft and strategic submarines. If the purpose were a disarming, first-strike counter-force attack, it is evident that this additional targeting would take place. Since aircraft and submarine bases cannot in their nature be hardened other than in certain limited ways, this additional targeting, both for the Soviets and the Americans, could be easily accomplished using a small fraction of their remaining forces, including those significantly less accurate than the forces cited in the calculations above.

However, calculations of damage to strategic aircraft and submarines are so problematic that they cannot easily be merged with the relatively accurate (or at least methodologically consistent) analyses of counter-force targeting on silos.

The explanation for this is basically two-fold. First, it is difficult to obtain information about the range of factors involved in targeting submarine pens and airfields. These include such diverse considerations as the serviceability of aircraft, dispersal plans, including arming and fuelling, the percentage of aircraft on quick reaction alert, the percentage of submarines at sea, the vulnerability of submarines and pens to overpressure, and so on. In these circumstances, the assumptions made about hardness and operational readiness need to be detailed and explicit. Second, counter-force attacks on aircraft and submarines are entirely 'scenario dependent'. In other words, the assumptions made about the political circumstances of crisis (one month of tension, one week of escalating threats, etc.) greatly influence survivability. In sum, it is not possible to incorporate such calculations without identifying detailed and complex scenarios.

In regard to the calculations made above, however, the summary conclusion is that the deployment of the MX missile to the number currently under discussion would not give the United States a counter-force capability, but if the number deployed increased to around 100, then the survivability of Soviet ICBM's is severely reduced.

Furthermore, the deployment of the Trident D-5 will bring the United States much closer to a disarming counter-force capability, assuming no change in present Soviet force deployments.

Of course, at this point in the analysis this last assumption must be qualified, since these last calculations anticipate imminent American deployments without counter-acting Soviet deployments. There is not enough information at the moment to fully assess the effect of the Soviet SS-24 and SS-25. As counter-force weapons, they are not likely to improve on the performance of the SS-18[25], but their deployment in a mobile mode, as indicated below, complicates the counter-force calculation.

Analysing the vulnerability of mobile missiles involves a set of technical calculations which are not, as such, set out in this paper. Nevertheless, the vulnerability of the mobile missile can be set out in general terms.

Mobile missiles are necessarily limited to a finite area (much more so in

25 See for example, Michael R. Gordon "CIA Downgrades Estimate of Soviet SS-19" National Journal July 20, 1985, p. 1693. In regard to the SS-24, Gordon comments: "...Administration experts say that - based on the observation of tests conducted so far - the SS-24 has not yet achieved the accuracy of the SS-18, and judging from the size of its warheads it will not have the combination of accuracy and yield necessary for a high-confidence first-strike capability."

the case of the United States than that of the USSR), and are therefore susceptible to attack. Although it may be possible within certain limits to "track" mobile missiles, and therefore to aim at specific targets, targeting mobiles is generally considered to require the barrage of the area of deployment. Various patterns of barrage are possible, but the two most frequently discussed, as illustrated in diagram 1, are an overlapping pattern and a side-by-side (cookie-cutter) pattern.

Since a mobile missile can be hardened only to a limited extent (around 40 p.s.i. is typical), CEP is less important than the "circle of destruction" created by the attacking warhead. It follows, therefore, that less accurate, older missiles could be used in counter-force strikes against mobile missiles. Nevertheless, the problems of the attacker are considerable. The overlapping pattern necessary for maximum effectiveness requires twice as many warheads as the less effective side-by-side barrage, and may in any case raise the issue of fratricide. Perhaps more importantly, if the mobile missiles are single warhead, the number of missiles required to destroy a given number of mobiles (the cost to attack) invariably favours the defender over the attacker. It follows, therefore, that a mobile force is not only in itself an obstacle to counter-force attacks, but it also supports the immobile element of the defender's forces since the attacker must now expend a significantly large element of his offensive forces in order to attack all elements of the opposing land-based missiles. In sum, recent studies[26] suggest, as indicated in diagram 2, that the cost to attack ratio consistently favours the mobile missile, a conclusion which gains significance if the case of the single-warhead mobile missile is considered in the context of the superpower arms control proposals which establish lower overall warhead ceilings.

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[26] A. Hobson, unpublished Small ICBM Study. June 1985
A. Hobson, <u>ICBM Vulnerability, Small Missiles, and Arms Control</u>. Paper submitted to American Physical Society, May 1, 1986
L. Finchand A. Tinajero, <u>Cost to Attack: Measuring How Strategic Forces Affect US Security</u> CRS Report No. 85-64F, March 20, 1985

Diagram 1

Side-by-side Pattern | Overlapping Pattern

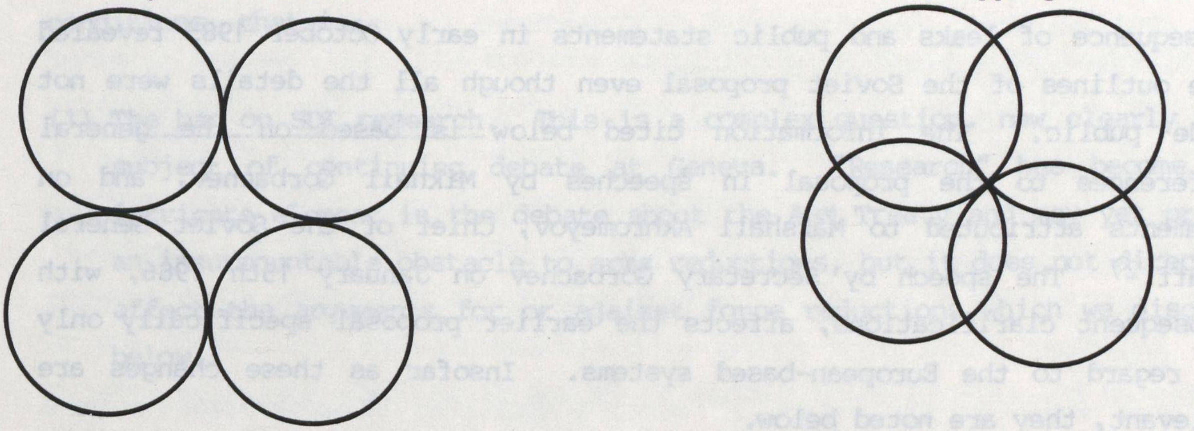
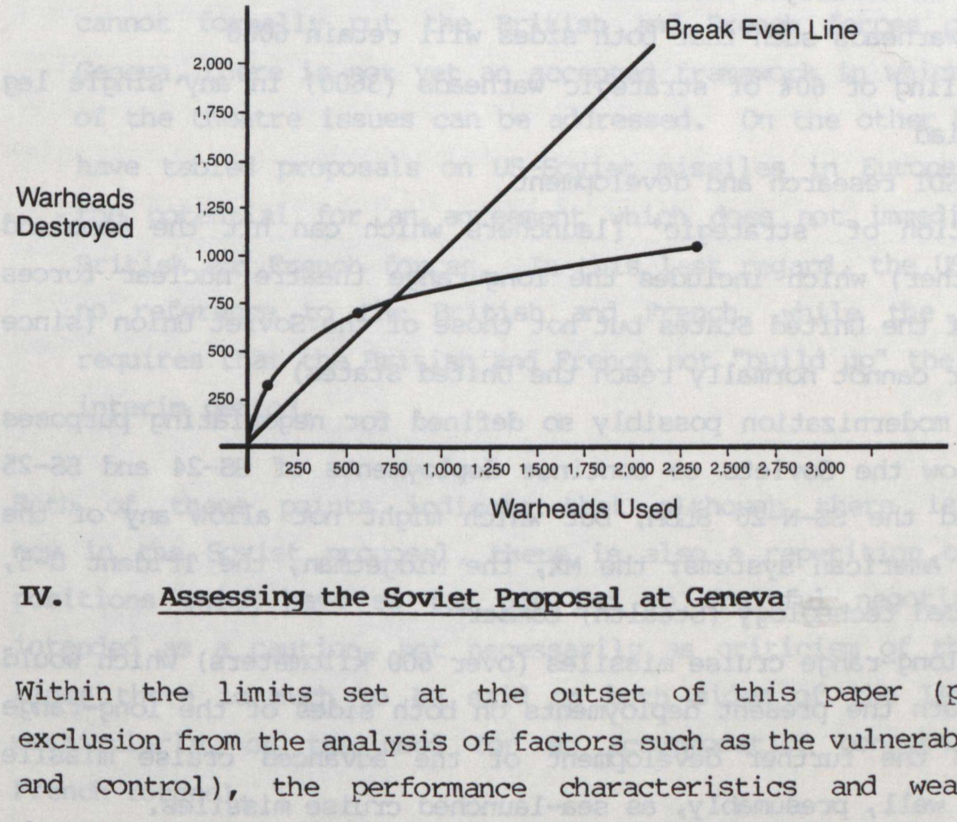


Diagram 2

Cost to Attack - Incoming SS-18 and SS-24 warheads targeted against American ICBM forces according to force levels postulated in Tables 6 and 7.



IV. Assessing the Soviet Proposal at Geneva *

Within the limits set at the outset of this paper (particularly the exclusion from the analysis of factors such as the vulnerability of command and control), the performance characteristics and weapons efficiency described above can be used to assess the substance of arms control proposals. To illustrate the application, we now turn respectively to the Soviet proposal of October 1985, and the US counter-proposal of November 1985.

*The following details of the Soviet and American proposals incorporate the changes made public as of March 1st, 1986.

A sequence of leaks and public statements in early October 1985 revealed the outlines of the Soviet proposal even though all the details were not made public. The information cited below is based on the general references to the proposal in speeches by Mikhail Gorbachev, and on comments attributed to Marshall Akhromeyov, Chief of the Soviet General Staff.[27] The speech by Secretary Gorbachev on January 15th 1986, with subsequent clarifications, affects the earlier proposal specifically only in regard to the European-based systems. Insofar as these changes are relevant, they are noted below.

Although the terms have differed somewhat from one source to another, the main outline appears to be as follows:

- a 50% cut in strategic launchers on both sides
- a cut in warheads such that both sides will retain 6000
- a sub-ceiling of 60% of strategic warheads (3600) in any single leg of the triad
- a ban on SDI research and development
- a definition of 'strategic' (launchers which can hit the homeland of the other) which includes the long-range theatre nuclear forces (LRTNF) of the United States but not those of the Soviet Union (since the latter cannot normally reach the United States)
- a ban on modernization possibly so defined for negotiating purposes as to allow the Soviets to continue deployments of SS-24 and SS-25 ICBMs, and the SS-N-20 SLBM, but which might not allow any of the following American systems: the MX, the Midgetman, the Trident D-5, the advanced technology (Stealth) bomber
- a ban on long-range cruise missiles (over 600 kilometers) which would prevent both the present deployments on both sides of the long-range ALCMs and the further development of the advanced cruise missile (ACM), as well, presumably, as sea-launched cruise missiles.

In the following analysis we by-pass two of the most critical of these

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[27] "Soviet Official's Response to Arms Questions" New York Times October 18, 1985, p. 14

conditions, that is:

(1) The ban on SDI research. This is a complex question, now clearly the subject of continuing debate at Geneva. "Research" has become an intricate element in the debate about the ABM Treaty and may yet prove an insurmountable obstacle to arms reductions, but it does not directly affect the arguments for or against force reductions which we discuss below.

(2) The question of British and French nuclear forces. Somewhat differing proposals have emerged on this, but the following is clear. The British and French have been invited to discuss their forces with the Soviets, but the Soviets are not necessarily seeking to negotiate European reductions in a separate framework. Since the Americans cannot formally put the British and French forces on the table in Geneva, there is not yet an accepted framework in which the full range of the theatre issues can be addressed. On the other hand, both sides have tabled proposals on US-Soviet missiles in Europe which indicate the potential for an agreement which does not immediately encompass British and French forces. In this last regard, the US proposal makes no reference to the British and French, while the Soviet proposal requires that the British and French not "build up" their forces in the interim period.

Both of these points indicate that although there is much that is new in the Soviet proposal, there is also a repetition of some existing positions which have so far not led to fruitful negotiations (This is intended as a caution, not necessarily as criticism of the Soviet Union, since there is much to be said on both sides of the LRTNF issue, and, particularly, on the need for an accommodation concerning British and French forces).

With these reservations, the calculations and analysis below seek to answer the following questions:

A. What would be the effect of the proposed reductions (50% on launchers, 6000 warheads, not more than 3600 warheads on any single leg of the triad) on existing Soviet forces?

B. What would be the effect on existing US forces if American LRTNF were included?

C. What would be the effect on US forces if American LRTNF were excluded (closer to the US definition of strategic)?

D. What would be the effect if certain specified Soviet modernization were allowed?

E. What would be the effect if certain specified US modernization were allowed?

F. Making certain assumptions about the negotiability of US modernization to allow for the retention of the triad, what would be the counter-force capabilities of the respective sides after both sides had optimised their strategic forces at the 50 (60-40) lower level?

A. The Effect of the Formula on Soviet Strategic Forces.

Table 3

Current Soviet Strategic Nuclear Weapons				
	Launchers	% of Total	Warheads	% of Total
ICBM	1393	(55%)	6415	(63%)
SLBM	979	(38%)	2899	(29%)
Bombers	175	(7%)	820	(8%)
	2547		10,134	

After 50% cut in launchers and 6000 warheads ceiling		
Launcher ceiling - 1273	Warhead ceiling - 6,000	
300 SS-18 (10 warheads)	3000	
100 SS-19 (6 warheads)	600	
	3600	(60%)
208 SS-N-18 (7 warheads)	1456	
60 SS-N-20 (9 warheads)	540	
	1996	(33%)
100 Bombers (4 warheads)	400	(7%)
768	5996	

Table 3 assumes that the Soviets would maximise their ICBM warheads by taking the full 60% sub-ceiling in this category. It can be seen that the 10 warhead SS-18's quickly gobble up the warhead ceiling for the Soviets, leaving them with the dilemma of finding the appropriate balance of launchers and warheads. The SS-18's and SS-19's are the most capable counter-force weapons in the Soviet arsenal: to maximise the warhead total at 60% (3600), the Soviets would need to reduce their heavy SS-18 and 19s by 40%, to reduce their SS-18 and SS-19 warhead total by 30%, and to remove all older ICBMs. In sum, the Soviet proposal goes a considerable way to recognizing the American concern with the counter-force capabilities of the Soviet heavy missiles, but is still some distance from the earlier American proposal.

A second general observation is that the Soviet proposal allows for a small <u>proportionate</u> increase in the SLBM and bomber forces at the reduced levels. Soviet bombers currently constitute a small fraction (7%) of their strategic forces. Whether they would opt for a slightly larger percentage of the force in the form of a new strategic bomber is open to question. It should be noted, however, that the Soviet proposal for a ban on ALCMs may suggest that they are <u>not</u> interested in developing their manned bomber/cruise missile strategic forces beyond a minimal level.

Finally, the table clearly demonstrates that warheads, not launchers, drive the calculation. Indeed, the low number of launchers required to produce the maximum warhead ceiling - 768 compared with the allowed ceiling of 1261 - is a clear incentive to move to single-warhead launchers, as Tables 6 and 7 will indicate.

B. What would be the effect if the US reduced according to the formula, including its LRTNF?

Table 4 indicates the extraordinary complexity involved in the proposal to add together all American theatre and central strategic forces. Indeed, without further clarification it is difficult to envisage a plausible reduction regime within the general ceilings proposed by the Soviets; for this reason Table 4, unlike the other tables, does not attempt to illustrate a post-reduction force structure. Although the precise nature of this proposal remains to be determined, the following observations illustrate the dilemmas. First, carrier based aircraft add significantly to American LRTNF, and would seriously skew the reduction proportions if they were included. It is possible that, although they might be included at the outset of a negotiation, they would be dropped rather quickly if progress were possible without their inclusion.

Table 4

US Forces with Present LRTNF[28]

	Launchers	Warheads
ICBMs	1,024	2,124
SLBMs	648	5,760
Bombers	324	3,642
	(1,996)	11,526
P II currently deployed	108	108
GLCM currently deplyed	128	128
Incremental total	2,232	
Fighter Bombers (based in Europe)	390	780
Incremental total	2,622	
Carrier-based bombers	900 (?)	1,800
Total	3,522	14,342

After 50% cut

		Warhead ceiling
Launchers (not including carrier forces)	1,761	6,000

Second, even if one were to set aside the political and alliance issues

28 Marshall Akhromeyov stated that the US has 2210 strategic launchers. Since it is not clear precisely what launchers are included in his figure, the above figures are based on standard Western sources. However, the similiarity in figures suggests that the launcher types cited above are those included in the Soviet figures

involved in the reduction of American nuclear forces in Europe, Table 4 indicates the improbability of this proposal from an American point of view. American planners would be faced with the choice of removing a large number of these forces from the European theatre without a commensurate reduction in Soviet theatre forces, or of accepting disproportionate reductions in their central strategic forces (those based in the US). In turn, such disproportionate reductions would, de facto, dismantle the triad. There is little possibility, therefore, either in political or strategic terms, that the inclusion of theatre forces will be acceptable to the US.

C. American Force Reductions Excluding LRTNF

Table 5 assumes that negotiations led to the exclusion of the American LRTNF from the definition of strategic forces. It then assumes that the US would choose to maintain the current proportions of its triad, where, it will be noted, a high percentage of warheads (50%) are on submarines, whereas a high percentage of launchers (51%) and a relatively low percentage of warheads (18%) are ICBMs. Essentially, this internal asymmetry creates considerable dilemmas for the US in drawing down its forces. To meet the warhead ceilings, and to maintain the triad, the US would face the following problems:

(1) If it maintains its ICBM warhead totals at approximately the same level (18% or 1050 after reductions), in order to maintain its ICBM launcher percentage it must retain its older Minuteman II missiles. The US could achieve the proportionate reduction ceiling using only 355 Minuteman III and Minuteman III Mark 12A. Other things being equal, this would make the US ICBM force even more vulnerable to a counter-force strike by Soviet SS-18 and 19s. In Table 5 therefore, the number of ICBM launchers has been increased by including the single warhead Minuteman II. The US could then maintain 500 ICBM launchers while reducing to a 6000 warhead total. The existing proportions of its warhead triad could be maintained without significant variation in

its launcher ratios. However, the question that will arise still concerns ICBM vulnerability. In the force structures posited in Tables 5 and 7, the 500 US ICBM lanchers are likely to be considered highly vulnerable to the 3600 Soviet warheads on the counter-force capable SS-18s and 19s. This issue is addressed in Table 6.

(2) To maintain the SLBM warhead total close to 50%, as indicated in the reduction section of Table 5, a trade-off between ICBMs and strategic bombers is required. The difficulty with this trade-off is that the large numbers of warheads per strategic bomber cannot be reduced without a change in the accepted counting rules, for there is no obvious way to confirm that a bomber capable of carrying 24 or more warheads will henceforth carry only (say) 20.[29] On the other hand, if

Table 5

US Forces (without LRTNF)

	Launchers	% of Total	Warheads	% of Total
ICBM	1024	51%	2124	18%
SLBM	648	32%	5760	50%
Bombers	324	16%	3642	32%
	1996		11,526	

US Present Forces Without LRTNF

(6,000 warhead ceiling, 50% launcher reduction reduction)

Launcher ceiling 998		Warhead ceiling 6,000
225 Minuteman II	(1 warhead)	225
275 Minuteman III Mark 12A	(3 warheads)	825
		(1050)(18%)
192 Poseidon C-3	(10 warheads)	1920
144 Trident C-4	(8 warheads)	1152
		(3072)(51%)
100 Bombers		(1878)(31%)
936		6000

29 Under the SALT II counting rules, 20 was the agreed number of ALCMs per bomber, but there was no rule for counting the number of gravity bombs

bombers were traded for ICBMs (generally valued as the most responsive, penetrating, counter-force element of strategic forces), the traditional American commitment to the manned bomber would be jeopardised. The question arises, therefore, as to the bomber ceiling below which American planners would consider that the triad had been lost.

To summarise, the net effect of the proposed reductions is the following: the Soviets would obviously choose to maintain a 60% sub-ceiling for their ICBMs. This drives them to a choice between SLBMs and bombers in their remaining forces, with the circumstantial evidence suggesting rather strongly that they would choose to maintain their bomber force at a low level, leaving it as a residual hedge against uncertainty. On the other side, the reduction may exacerbate the perceived American problem with the vulnerability of their ICBM forces, but it nonetheless allows them to draw down in a manner which would permit the maintenance of the triad. These issues, are further explored in the next section on modernization.

D. Soviet Force Reductions After Certain Specified Modernization

Table 6

USSR With Modernization

Launcher ceiling 1273	Launcher ceiling 6000 (Subceiling 3600)
150 SS-18 (10 warheads)	1500
100 SS-19 (6 warheads)	600
100 SS-X-24 (10 warheads)	1000
500 SS-25 (1 warhead)	500
	(3600)
100 SS-N-18 (7 warheads)	700
80 SS-N-20 (9 warheads)	720
83 SS-NX-23 (7 warheads)	581
	(2001)
100 Bombers (4)	400
1213	6001

Table 6 indicates a plausible Soviet force structure with the modernisation which the Soviet proposal apparently permits. The most important aspect of the modernisation is to introduce the mobile, 10 warhead SS-24, and the mobile, single warhead SS-25. The consequence of this modernization is not to improve Soviet counterforce capability, for the mobile SS-24 is not likely to be more accurate than the SS-18, but to reduce the vulnerability of Soviet ICBMs. This is obtained in two ways: through mobility, and through introduction of the single warhead SS-25 which allows an increase in the number of launchers to be achieved within the 3600 warhead constraint. It might be noted, therefore, that, neither of these systems appear to pose a greater counter-force threat to the US than the pre-modernised force structure identified in Table 3.

In the plausible force structure identified above, the Soviets are also presumed to deploy the SS-N-23, a liquid fuelled, seven warhead SLBM which is more accurate than its predecessors but which is not thought to have a significant counter-force capability. They may or they may not choose, within the warhead and launcher totals, to modernize a relatively small bomber force.

E. American Central Strategic Forces After Specified Modernization

Table 7

US Central Strategic Forces With Modernization

Launcher Ceiling 998	Warhead Ceiling 6000	
50 MX (10 warheads)	500	
198 Midgetman (1 warhead)	198	
250 Minuteman (3 warheads) Mark 12A	750	
	(1448)	(24%)
216 Trident D-5 (8 warheads)	1728	
128 Trident C-4 (8 warheads)	1024	(46%)
	(2752)	
75 B-1 Bombers (24 warheads)	1800	(30%)
917	6000	

Table 7 assumes both that the LRTNF issue can be separated from the reduction of US central strategic forces, and that certain modernization is permitted. It might also be noted that, politically, it will be extremely difficult for any American administration to abandon the MX, the Midgetman (if it proves to be a cost-effective system), and the Trident D-5. All of those systems are included, therefore, in the modernized force structure identified above.

Although there are many plausible alternative formulations, Table 7 adheres relatively closely to the existing pattern of the American triad. (In fact, SLBM forces have been slightly decreased, and ICBM forces slightly increased).

The table illustrates, in effect, that a modernized American force is feasible within the Soviet force level proposals without jeopardising most American concerns about the maintenance of the triad. There are, however, certain issues to be noted. First, the actual number of submarines is reduced from 37 to 17, which may raise issues about the vulnerability of the submarine force if say, only, 50% are at sea at any one time. Second, the warhead total of the B-1B bomber force continues to be lower than the system capability, but it would be difficult to reduce further the number of bombers without seriously depleting this leg of the triad. Third, the US may continue to express concern about the vulnerability of its ICBM force if, after modernization, its 500 launchers are opposed by 3600 counter-force capable Soviet ICBM warheads. To some extent, of course, the problem may be solved by the mobility of the Midgetman, but at this point we turn to an examination of the counter-force problem after reductions.

F. Counter-Force Capabilities After Reductions, But Before Modernization

Table 8 seeks to identify counter-force capabilities assuming the forces posited in Tables 3 and 5 (that is, Soviet and American strategic forces after reductions).

Table 8

A. US Counter-Force Strike 800 Minuteman Mark 12A warheads against 400 SS-18 and SS-19 targets.

Minuteman III 12A SSKP = 0.615 OAR = 80%

Hardness = 2,000 psi

TKP = SSKP x OAR

TKP = 0.49

Probability of survival of targets $= (1-TKP_1) \times (1-TKP_2)$

$= (0.51) \times (0.51)$

$= 0.26$

$= 26\%$

B. Soviet Counter-force strike: 1,000 SS-18 Mod 4 warheads against 500 US ICBM targets

SS-18 Mod 4 SSKP = 0.654 OAR = 70%

Hardness = 2,000 psi

TKP = SSKP x OAR

TKP = 0.46

Probability of survival of targets $= (1-TKP_1) \times (1-TKP_2)$

$= (1-0.46) \times (1-0.46)$

$= 0.30$

$= 30\%$

In the American case, 800 Minuteman III Mark 12A warheads (267 missiles) are double targeted against the 400 SS-18 and SS-19 missiles which the Soviets would retain under the 3600 warhead limit. 104 missiles (or as many as 1040 warheads) would survive. In the Soviet case, 1000 SS-18 warheads (100 missiles) are double targeted against the 500 American ICBMs which would remain after force reductions. 150 missiles (or as many as 450 warheads) would survive. While there are many additional factors to be considered in such exchanges, it is clear that neither side would have the capability to eliminate the ICBM forces of the other under the reduction regime contemplated or, indeed, to deny a significant ICBM riposte.

G. Counter-Force Capabilities After Modernization

Table 9

A. 600 SS-18 warheads are targeted against 300 fixed silo US ICBMs

SS-18 Mod 4

SSKP = 0.654
Hardness = 2,000 psi
OAR = 70%
TKP = SSKP x OAR
= 0.46

Probability of survival of the targets $= (1-TKP_1) \times (1-TKP_2)$
$= (1-0.46) \times (1-0.46)$
$= 0.30$
= 30%

B. 700 Trident D-5 warheads are targeted against 350 Soviet fixed-silo ICBMs

Trident D-5

SSKP = 0.98
Hardness = 2,000 psi
OAR = 80%
TKP = SSKP x OAR
= 0.78

Probability of survival of the targets $= (1-TKP_1) \times (1-TKP_2)$
$= (0.22) \times (0.22)$
$= 0.05$
= 5%

Table 9 makes similar calculations assuming the force structures posited after modernisation, as indicated in Tables 6 and 7. In the Soviet case, it is assumed that 600 S-18 warheads (60 missiles) are targeted against the 300 fixed silo US ICBMs deployed in the modernised force structure. 90 silos would survive, to which must be added the number of mobile Midgetman which might survive a barrage attack. Since the American force is now a mixed one, varying from the single warhead Midgetman to the 10 warhead MX, the number of warheads surviving cannot be calculated accurately using the above targeting strategy.

In the American case, there is a critical change with the introduction of the highly accurate Trident D-5 and MX missiles. Assuming only the use of the Trident D-5 (the combination of D-5 and MX is equally plausible), 700 warheads (or 88 missiles) double targeted against the 350 fixed silo Soviet ICBMs give a 95% terminal kill probability - only 18 missiles would survive.

This scenario also is limited, however, since under the modernization posture described, the Soviet SS-25 missiles are mobile, and therefore much more difficult targets for a counter-force attack. The scenario nevertheless indicates the powerful counter-force capabilities of the D-5, and, in the event that it is deployed, the critical need for the Soviets to move to mobile missiles if they continue to place the preponderance of their strategic assets on ICBMs. Since mobile missiles are less accurate than fixed missiles, such a move could also reduce the Soviet counter-force threat against American ICBMs.

Summary

The analysis above has assumed that American LRTNF could be detached from the core proposal. Given subsequent Soviet statements, this appears to be a realistic assumption as far as missiles are concerned (the GLCMs and Pershing IIs vs the SS-20s and SS-4s), but the issue of US carrier and land-based aircraft is still open, since we must presume that the Soviets still define these weapons as "strategic" nuclear charges. It was also assumed that certain American modernization would be permitted. On that basis, the core proposal does not appear to pose intolerable strains on the American triad, and, perhaps paradoxically, certain modernization on both sides offers the possibility of mutually stable deployments at lower levels. However, the exception is the D-5, which, with its presently predicted accuracy, will pose a critical counter-force threat to the Soviet Union. Before drawing substantive conclusions from this analysis, we next consider the American proposal.

VI. The American Proposal at Geneva

The outlines of the American proposal were reported in the American press on October 31st 1985, and subsequently both confirmed and elaborated by various American spokesman[30] as follows:

- a ballistic missile warhead ceiling(including land and submarine based launchers) of 4,500

- a ballistic missile launcher ceiling (land and sea based) of 1,250, but with indications that the ceiling could be raised to 1,450

- a warhead sub-ceiling of 3,000 on ICBMs

- a throw-weight limit on strategic ballistic missiles, the effect of which is that neither side can exceed more than 50% of existing Soviet throw-weight

- a limit of 350 on heavy bombers which, in the Soviet case, apparently includes the Backfire

- a separate limit of 1500 on air-launched cruise missiles (ALCMs), with no limit on other nuclear armaments (gravity bombs and short-range attack missiles) carried by bombers

- a limit of 120 on the number of bombers allowed to carry ALCMs

- an equal limit of 140 on the number of Soviet and American launchers in Europe, which would include the ground-launched cruise missiles (GLCMs) and Pershing IIs on the American side, and the Soviet SS-20s and SS-4s directed towards Western Europe

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30 See particularly Paul Nitze, Speech to the Overseas Writer's Club, November 8,1985

- a ban on all mobile missiles, and on new types and modernization of heavy ICBMs.

- the American offer does not address directly the question of SDI research, but American and Soviet differences regarding research which is permissible within the bounds of the ABM Treaty continue to differ. As in the analysis of the Soviet proposal, this issue is not addressed here.

Analysis

The following questions are addressed below:

a. What would be the effect on the ballistic missile forces of the respective sides if the American force reductions were accepted without modernization?

b. What is the effect of the proposed American ban on mobile ICBMs?

c. What are the implications of the American bomber ceilings?

d. What are the issues implied in the American LRTNF proposal?

e. Finally, what are the crucial areas of differences between the American and Soviet proposal?

Table 10 demonstrates a plausible draw down of American forces to the proposed ceiling of 4500. It assumes that the US would continue to place most of its ballistic missile warheads on submarines, and reduces the triad of strategic forces accordingly. It will be noted again that ICBMs constitute only 30% of present American strategic ballistic warheads while SLBMs constitute 70% .

The Effect of Proposed American Reductions on Ballistic Missile Forces

Table 10

Current US Strategic Ballistic Missile Forces	
Launchers	Warheads
ICBM 1024	2124
SLBM 648	5760
1672	7884
After Reduction: A Plausible US Force Structure	
Launcher Ceiling 1250	Warhead Ceiling 4500 (ICBM sub-ceiling 3,000)
450 Minuteman II (1 warhead)	450
300 Minuteman III 12A (3 warheads)	900
(750)	(1350)
48 Poseidon C3 (10 warheads/3 submarines)	480
336 Trident C4 (8 warheads/18 submarines)	2688
(384)	(3168)
Total: 1134	4518

Since the proposed American sub-ceiling of 3,000 warheads is on land-based missiles, the US would have no difficulty in observing the sub-ceiling. Nevertheless, the reductions pose considerable problems for the American strategic force posture. In order to meet both the warhead ceilings and to drive up the number of ICBM launchers, for example, the US might be forced to use the older, single warhead Minuteman IIs to make up most of its ICBM force instead of the triple warhead MInuteman IIIs. Despite maintaining the greater part of its forces at sea, the submarine force is reduced to 21 boats, which might well raise doubts about their vulnerability since it might then be assumed that only 8-10 submarines would be at sea in normal operations.

Finally, it will be noted that even using the Minuteman II, the US falls considerably short of the launcher ceiling allowed in their own proposal, demonstrating once again that, with many MIRVed missiles deployed, the warhead ceiling dominates the calculation. It might also be noted that lower launcher levels pose problems for military planners concerned with the counter-force capabilities, since there are fewer silos to be attacked by the counter-force capable warheads of the opposing side.

Table 11

Current Soviet Ballistic Missile Forces

	Launchers	Warheads
ICBM	1393	6415
SLBM	979	2899
	2372	9314
Launcher ceiling 1250+		Warhead ceiling 4500 (ICBM subceiling 3,000)
300 SS-18 (10 warheads)		3,000
137 SS-N-18 (7 warheads)		957
60 SS-N-20 (9 warheads)		540
(197)		(1497)
Total 497		4497

In the US case, the need to maintain as high a launcher ceiling as possible suggested that the US might choose to retain their older but improved Minuteman II launchers. The warhead ceilings pose much more severe problems to the Soviets, as Table 11 indicates. Lacking accurate, single warhead missiles from its older inventory, the Soviet Union quickly exhausts the ICBM warhead sub-ceiling, using only 300 SS-18s. Although certain trade-offs with the SS-19 are conceivable, these trade-offs do little to solve the Soviet dilemma. In order to increase the number of launchers therefore, one must presume that the Soviets would place increasing value on the SS-25 single warhead mobile missile now starting to be deployed. At this point, however, the issue of the proposed American ban on new mobile missiles arises.

Mobility and Modernization

In the American proposal, as with the Soviet proposal, restrictions on modernization leave somewhat obscure the question of what modernization is allowed. In the American proposal, however, it seems clear that the ban on mobility would preclude the Soviet SS-24 (A ten-warhead missile due to be deployed in silos in 1986 and made road-mobile in 1987), and the single warhead SS-25. The ban would also preclude the American Midgetman, a single warhead, mobile launcher due to be deployed in 1992. The ban on new heavy missiles might also apply to the SS-24 if it were deployed only in a fixed basing mode, but it would not apply to the MX, which will be the centre of the American ICBM modernization programme if the Midgetman programmme was cancelled, because the weight of the MX is below that listed in SALT II as defining a "heavy" missile.

Table 12 indicates the effect of the American proposal if all American ballistic missile modernization programmes now planned (the Midgetman, the MX, the Trident D-5, and the advanced technology (Stealth) bomber were deployed in conformity with the US reduction proposal.

Table 12

Modernized US Forces	
Launcher ceiling 1250+	Warhead ceiling 4500
50 MX (10 warheads)	500
370 Midgetman (1 warhead)	370
450 Minuteman II (1 warhead)	450
100 Minuteman III 12A (3 warheads)	300
(970)	(1620)
216 Trident D-5 (8 warheads/9 submarines)	1728
144 Trident C-4 (8 warheads/9 submarines)	1152
(360)	(2880)
Total 1330	4500

In brief, Table 12 assumes that the present preponderance of SLBMs in the American strategic deployment is maintained though not quite to the same degree as previously. With 360 SLBM launchers, the US is able to maintain a large number of sea-based warheads, but it might be noted that the transition to the 24-tube Trident submarine leaves the United States with still fewer ballistic missile submarines. The American decision to move to the larger Trident submarines may well become an issue in the context of force reductions, since the greater power of the Trident submarine must be set off against the ability of the opponent to apply increasing anti-submarine (ASW) warfare resources against each individual submarine target.

In regard to ICBMs, it can be seen that a mixed force of MIRVed Minuteman III Mark 12A and MX missilies can be combined with a mixed force of single warhead Minuteman II and Midgetman single warhead missiles. Clearly Midgetman missiles could be increased in order to come closer to the launcher ceiling and complicate the counterforce targeting of the opponent. However, this would require a corresponding reduction in SLBM warheads in order to maintain the 4500 ceiling. Equally, the Midgetman could be substituted for the older Minuteman II, but, of course, at great expense.

Table 13 demonstrates the effect of the exercise on Soviet strategic forces. In this case the balance of ICBM and SLBM forces is reversed, so that the Soviets retain the preponderance of ICBM forces which characterizes their present force structure. Modernization permits them to deploy the SS-N-23 MIRVed launcher on submarines. More importantly, however, the introduction of the SS-25 mobile ICBM allows them to deploy a much larger number of launchers while still adhering to the 3,000 warhead sub-ceiling. A mixed force of SS-18s, mobile SS-24s, and SS-25s gives the Soviets a plausible force structure after modernization, allowing them to meet the warhead ceiling and sub-ceiling while deploying a sizeable number of launchers.

Table 13

Modernized Soviet Forces	
Launcher ceiling 1250+	Warhead ceiling 4500
150 SS-18 (10 warheads)	1500
100 SS-X-24 (10 warheads)	1000
500 SS-25 (1 warhead)	500
(750)	(3000)
48 SS-N-18 (7 warheads)	336
80 SS-N-20 (9 warheads)	720
64 SS-N-23 (7 warheads)	448
(192)	(1504)
Total 942	4504

Does mobility increase or decrease the stability of these forces? To answer this question, it is necessary to consider the counter-force capabilities of both sides in the post-reduction period.

In this Section we have not applied the earlier calculations on counter-force to the US proposal, because the outcomes, as indicated in Table 8 and 9, are essentially unchanged.

It is nevertheless worth noting that, without modernization and with force reductions based on either the Soviet or American proposals, each side is left with many warheads which can be used to target the relatively few silos of the other side. Increasing the number of single warhead launchers reduces the counter-force problem, therefore, while adding mobility reduces it still further. Indeed, as was indicated earlier, the switch to mobile single warhead missiles makes counter-force attack so complex that the incentive to engage in pre-emptive, counter-force strikes is significantly reduced.

In sum, from an <u>arms control perspective</u> there is no obvious value to banning mobile, single warhead missiles unless verification problems are considered overriding. The current American concern with the verification of the SS-25, therefore, must be examined very carefully since the single warhead, mobile missile is otherwise a significant element in any resolution to the counter-force problem.

Bomber Ceilings

Unlike the Soviet proposal, which called for a ban on long-range air-launched cruise missiles (ALCMs), and did not specify a separate category for bombers, the American proposal establishes a 1500 limit on ALCMs, and a limit of 350 on heavy bombers.[31] Furthermore, the US considers the Backfire as a heavy bomber, thus abandoning the agreement reached in the SALT II negotiations which removed the Backfire from the strategic bomber count. It is unlikely that the Soviets will agree that the Backfire should be counted.

However, if agreement on the Backfire were reached, there would remain considerable differences in the application of the ALCM and bomber ceilings to the respective sides. In the American case, as Table 14 indicates, the 350 total is likely to have three distinct elements.

American strategic bomber force deployments call for two kinds of heavy bombers: stand-off platforms carrying long-range cruise missiles, and penetrating bombers carrying gravity bombs and short-range attack missiles. Under the terms of the SALT II agreement, the United States may currently deploy up to 120 bombers as ALCM carriers. Although some B-52s can carry 20 ALCMs, most currently carry 12; therefore, the 1500 ALCM ceiling is plausibly arrived at by postulating 120 ALCM carriers.

31 The earlier American proposal in the START negotiations of 1983 stipulated a limit of 400 heavy bombers and, by implication, 8000 ALCMs.

Table 14

Bomber Ceilings

Type	Number	Warheads
B-52 G and H	120	1500 ALCMs
B-1B	100	Variable*
Stealth	130	Unknown *

* 3000 Gravity bombs and SRAMs might be carried by a 350 bomber force together with 1500 ALCMs

The Congress has currently authorized the purchase of 100 B-1B bombers. The Stealth bomber, now in the development stage, is designed as a penetrator, and current USAF plans call for a purchase of 130. The combination of B-52s, B-1Bs and Stealth bombers produces 350, therefore, with B-52s currently deployed in a penetrator role being retired as the modern bombers are deployed.

Would the Soviet Union agree to a ceiling of 350 heavy bombers? It should be remembered that the Soviet Union currently deploys only about 175 heavy bombers, a number which has stayed roughly constant over the past 25 years. However, the Soviets have now opened the Bear-H production line. According to American sources, they are deploying these aircrafts with the AS-15 cruise missiles. Each Bear-H carries 8 AS-15s, with a range of 3000 kms.

Additionally, the Soviets have developed a new supersonic bomber - the Blackjack, which may enter service in 1988 or 1989. The Blackjack, may also be a cruise missile carrier, but, if so, it would be an expensive addition if it were deployed only as a stand-off ALCM platform. On the other hand if the Blackjack is seen as a penetrator bomber comparable to the B-1, it would tend to emphasize the point that the Soviets lag behind in advanced bomber technology, and that bombers have not been a priority weapons system in the development of their strategic forces.

Just as in earlier American proposals, therefore, they are likely to resist a formula which impels them to a production programme - a modernized 350 bomber force - incompatible with their own priorities and technological advantage. A negotiation which permitted freedom to trade between bombers and certain kinds of ballistic missiles might well be attractive to the Soviets, and compatible with the American position on bomber forces.

Longer-Range Theatre Nuclear Forces

The US proposes that each side restrict themselves to 140 missile launchers in the European theatre. In the American case this number would be achieved through the deployment of 32 GLCM batteries (4 missiles per battery) and 108 Pershing IIs, for a total of 236 warheads. The Soviets would be allowed to deploy 140 SS-20s (three warheads per missile), for a total of 420 warheads. Perhaps implicit in this calculation is recognition of the British and French nuclear forces, which would add 386 warheads to the Western aggregate. On the other hand, the US proposal excludes all land-based and carrier aircraft. It is therefore significantly less comprehensive than the Soviet proposal, which integrates all LRTNF with long-range strategic forces. Since that proposal in turn is clearly unacceptable to the Americans, LRTNF negotiations, as the most recent American response indicates,[32] involve trade-offs of great political and military complexity.

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[32] In their response of February 24 to the Soviet proposal on INF, the US offered a three-year plan. In the first year, both sides would reduce to 140 launchers as described above, while the Soviet Union would also proportionately reduce their Asian-based SS-20s. A number of other conditions were added, however, which suggest that the US wishes to place the negotiations in broader political context.

Conclusions

The evidence presented in this paper has addressed two issues. The first is the question of counter-force capabilities. The second is the merits of the respective reduction proposals at Geneva, having regard to both the counter-force question and general negotiability.

In regard to counter-force capabilities, it is evident from the tables and calculations that both sides have counter-force capabilities, but, as presently constituted, in mathematical terms these forces give neither side a high-confidence capability to eliminate the fixed silo ICBMs of the other side. Although the Soviet land-based "heavy" ICBMs constitute a formidable force, therefore, this does not translate into a counter-force superiority which would give the Soviet Union a political advantage in a crisis situation, or, indeed, permit them to "win" a counter-force nuclear exchange. (It must be remembered, however, that this paper has not considered attacks against command structures, which some experienced observers believe to be the most critical and vulnerable targets).

On the other hand, still in counter-force terms, the Soviet commitment to land-based missiles looms as an increasing disadvantage as the United States moves to deploy the counter-force capable Trident D-5. For this reason alone, the Soviet move to mobility is understandable and, indeed, inherently stabilizing as long as the verification issues can be resolved. The same logic applies to the Midgetman, which, of course, was precisely the case made for the development of the Midgetman by the Scowcroft Commission and others.

Finally, calculating counter-force capabilities against mobile missiles suggests that mobile missiles enjoy inherent advantages in terms of "cost to attack". The implication is that with existing ceilings, or with the presently contemplated lower ballistic missile ceilings, mobile missiles offer little incentive to an all-out counter-force strategy, and therefore reduce the disposition to launch a pre-emptive strike in situations of extreme crisis.

In regard to the respective proposals at Geneva, the counter-force question remains essentially unchanged. Under both proposals and before modernization, neither side has a high-confidence capability to eliminate the ICBM forces of the other in such a way that there could be no ICBM riposte. After modernization, the US will be extremely close to that capability, but the Soviets may then have vastly complicated the calculation through the deployment of mobile missiles.

In considering the Geneva proposals more broadly, however, it may be useful to ask two questions:

How deep are the reductions in the respective proposals?

Which areas offer the most promise for negotiation?

In response to the first question, the Soviet offer would reduce strategic 'nuclear charges' to 6,000. However, in their proposal are included all American intermediate-range forces that can reach the Soviet Union, while excluded are the SS-20s targeted against both Europe and Asia, the GLCM and Pershing II missiles, and intermediate-range Soviet aircraft and SLBMs. In reality, the Soviets would be left with nuclear charges in the order of 9000 for targeting against North America and Western Europe, while the US, Britain and France would have less than 7,000 nuclear charges of long- or intermediate-range for targeting against the Soviet Union.

In the American proposal, the US, Britain and France would be left with more than 11,000 nuclear charges of long or intermediate range for targeting against the Soviet Union, while the Soviets would have around 9,000 for targeting against North America and Western Europe.

In sum, both proposals offer deep cuts in certain categories of weapons, but neither proposal offers a formula which would provide equally deep cuts in the total number of long- and intermediate-range nuclear charges. It will also be noted that, in the best of the outcomes offered by the 'deep reductions', the respective sides together would continue to hold approximately 16,000 strategic and intermediate-range nuclear weapons.

In response to the second question, the respective proposals on long-range ballistic missiles, particularly land-based ICBMs, suggest that, if considered in isolation, negotiation could bridge the difference. Insofar as ICBMs constitute the principal counter-force problem, convergence in this area is important. It has also been noted that lower ceilings on counter-force capable weapons can severely restrict counter-force options and, therefore, dispositions. On the other hand, it is unlikely that land-based ballistic missiles could be separated from other issues such as separate bomber ceilings and the counter-force capabilities of the Trident D-5. A complex negotiation which allowed both sides greater freedom to reduce and restructure their strategic forces is feasible, however, particularly if the problem of the intermediate-range forces is dealt with separately, as now appears to be likely.

Finally, the observations above prompt a general comment about the prospects for arms control agreements on strategic weapons. The evidence presented in this paper suggests that, in terms of strategic weapons, the period between the deployment by the Soviet Union of its modern weapons (the SS-18, the SS-19, the SS-N-20), and the future deployment of the Trident D-5 is one in which rough parity has existed. Insofar as rough parity is judged to be a constructive context for arms control negotiations (a proposition not necessarily accepted by all observers), the actual balance of strategic forces is now conducive to negotiations. It may not be too great a leap from the evidence, therefore, to suggest that since the technical elements appear to be negotiable, the critical factor is likely to be political will.

but neither proposal offers a formula which would provide equally deep cuts in the total number of long- and intermediate-range nuclear 'charges'. It will also be noted that, in the best of the outcomes offered by the 'deep reductions' of the respective sides, [illegible] would continue to have approximately 10,000 strategic and intermediate-range nuclear weapons.

In response to the second question, the respective proposals on long-range ballistic missiles, particularly land-based ICBMs, suggest that, if considered in isolation, negotiation could bridge the differences. Insofar as ICBMs constitute the principal counter-force problem, convergence in this area is important. It has also been observed that growing arsenals of counter-force capable weapons can severely restrict counter-force options and, therefore, dispositions. On the other hand, it is unlikely that land-based ballistic missiles could be separated from [illegible] such as separate bomber ceilings and the counter-force capabilities of the Trident D-5. A complex negotiation which allows each side greater freedom to reduce and restructure their strategic forces is feasible, however, particularly if the problem of the intermediate-range forces is dealt with separately, as now appears to be likely.

Finally, the observations above prompt a general comment about the prospects for arms control agreements on strategic weapons. The evidence presented in this paper suggests that, in terms of strategic weapons, the gap between the deployment by the Soviet Union of fourth-generation ICBMs (the SS-18, and SS-19) and the SS-N-20, and the future deployment of the Trident D-5 is one in which rough parity is assured. Insofar as rough parity is judged to be a constructive context for arms control negotiations (a proposition not necessarily accepted by all observers), the actual balance of strategic forces is now conducive to negotiations. It may not be too great a leap from the evidence, therefore, to suggest that since the technical elements appear to be negotiable, the critical factor is likely to be political will.

Appendix A United States Intermediate Range Forces

	Range (Km)	Missiles	Warheads	Kt/Warhead	EMT/Warhead	Total Warheads	Total Yield (Mt)	Total EMT
GLCM	2500	32[a]	4[b]	10-50	0.046-0.136	128	1.0-6.0	6-17
Pershing II	1800	108[a]	1	5-50	0.029-0.136	108	0.5-5.0	3-15
Pershing Ia	720	90	1	60-400	0.153-0.543	90	5.4-36	14-49
SLCM (Tomahawk)	2500	96	1	200-250	0.342-0.397	96	19-24	33-38
Totals						**422**	**20.5-35**	**56-119**

Aircraft	Range	Number
F-III E/F	4700	250
F-16	3800	510
		760

a. P. Nitze, Speech to Overseas Writers Club, November 8, 1985

See also *Arms Control Reporter 1985* p. 403 E3

b. GLCM are launched from transporter-launchers, *each* containing 4 missiles

Cochran, Arkin, Hoening, eds. *US Nuclear Forces and Capabilities*, pp. 179-181

Appendix B USSR Intermediate Range Forces

	Range (Km)	Missiles	Warheads	Mt/Warhead	EMT/Warhead	Total Warheads	Total Yield	Total EMT
SS-4	2,000	120	1	1.00	1.00	120	120	120
SS-20	5,000	413[a]	3	0.15	0.28	1161	174	325
Totals						**1281**	**294**	**445**
SS-N-21[c] (SLCM)	3,000			0.30				
Aircraft	**Range**	**Number**						
Badger	4800	400						
Blinder	4000	165						
Backfire	8000	230[b]						
		795						

a. The USSR has stated it has decreased the number of SS-20 missiles in the European USSR to 243. See "General Lebedev Outlines SS-20 Situation in Interview" *Foreign Broadcast Information Service* USSR October 25, 1985, p. AA2, and "Gorbachev Announces SS-20 Structures Dismantled" *FBIS-USSR* December 13, 1985 p. AA1

Richard L. Armitage, assistant US Defense Secretary for International Security Affairs stated the Soviets had more than 162 SS-20 missile sites east of the Ural Mountains. "A third of SS-20s in reach of Japan and east Asia" *Jane's Defence Weekly* February 8, 1986, p. 182

See Michael Gordon "U.S. Again Weighs Options for Reply to Soviet on Arms" *New York Times* February 21, 1986, p. 3. American officials state there are 170 SS-20s in Asia. The officials acknowledge that the USSR has reduced its European SS-20s to 243 but still use 441 as the total number since they state that there is no evidence the withdrawn missiles have been destroyed.

b. The Backfire bombers are split between the Soviet Air Force (130) and the Navy (100), and carry AS-4 ALCMs. (300-800 km. range, 200 Kt yield)

c. The Soviet Defence Ministry announced that they had begun deployment of the SS-N-21 on October 14, 1984. See J. Sands "A Review of Soviet Military Power 1985" Natural Resources Defense Council, Nuclear Weapons Databook Working Papers, July 1985, p. 30

Appendix C Counter-Force Capabilities of United States Intermediate Range Forces

	Total Warheads	CEP	CMP/Warhead	Total CMP	SSKP (H = 2,000 psi)	TKP (OAR = 80%)
GLCM	128	0.016	181-530	23,168-67,840	1.00	0.80
Pershing II	108	0.024	51-235	9,180-25,380	1.00	0.80
Pershing Ia	90	0.213	3-12	270-1,080	0.29	0.23
SLCM	96	0.149	18	1479-1,728	0.40	0.32
	422			**34,097-96,028**		

Appendix D Counter-Force Capabilities of USSR Intermediate Range Forces

	Total Warheads	CEP	CMP/Warhead	Total CMP	SSKP (H = 2,000 psi)	TKP (OAR = 70%)
SS-4	120	1.07	0.87	105	0.025	0.02
SS-20	1161	0.21	6.22	7,221	0.167	0.12
	1281			**7,326**		