Freeze on nuclear-weapons

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The freeze and the counterforce race

The deployment of nuclear weapons that contribute to first-strike capabilities is destabilizing and must stop now

Harold Feiveson and Frank von Hippel

President Carter, in a 1980 report to Congress, speculated on how the Soviet Union might respond to the deployment of US weapons capable of destroying Soviet missiles in their silos:[1]

> . . . adopting a launch-on-warning posture is perhaps the least expensive but the most potentially destabilizing and dangerous response option available to Soviet leaders.

Despite this risk, by 1980 the United States was already embarked on a massive effort to threaten Soviet land-based missiles. Similarly, despite the obvious danger that the US would adopt a policy of launching its missiles on warning of a Soviet attack, the Soviet Union had several years earlier initiated a massive deployment of missiles equipped with accurate multiple independently targetable reentry vehicles—"MIRVs"—capable of threatening US land-based missiles. (See the figure on page 40.)

This reckless superpower competition to develop "counterforce" weapons—that is, weapons designed to destroy the nuclear weapons of the adversary—has finally provoked, in the United States, a popular demand to "freeze" the nuclear arms race. In the words of the Nuclear Weapons Freeze Campaign's *Call to Halt the Nuclear Arms Race*,[2] this would be

> a mutual freeze on the testing, production and deployment of nuclear weapons and of missiles and new aircraft designed primarily to deliver nuclear weapons.

In the last election, voters in states and cities representing a third of the country's population passed resolutions similar to this.

While a freeze would catch in its net many nuclear weapons systems, it was to counterforce systems that President Reagan referred when he rejected the idea of a bilateral freeze on the nuclear-arms race. He stated[3] that such a freeze would "only codify existing Soviet advantages," and he has made clear that the Administration is determined to deploy a new generation of counterforce missiles. This sets the stage for a sustained national debate on US policy toward counterforce weapons.

It is on the issues these weapons raise that we focus our discussion in this article. We argue that a freeze on the counterforce race at this time would be in the interests of both the US and the USSR, above all because it would fore-

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Six reentry vehicles streak toward targets on Kwajalein Atoll in the Western Pacific. Two Minuteman-III ICBMs, launched from Vandenberg Air Force Base in California, delivered the Mark-12 reentry vehicles—unarmed in this test. The deployment pattern evident in the

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stall a destabilizing enhancement of each side's first-strike capabilities. In the process of making this argument we provide some background information for scientists who may wish to become involved in the debate.

Why counterforce?

Because, to a considerable degree, opposition to a freeze and support for counterforce programs are two sides of the same coin, we must ask, "Why build up counterforce capabilities?" The answer appears to have many facets: the symbolic value of nuclear weapons as the "big sticks" upon which the superpowers depend as their ultimate recourse if they get into serious trouble abroad, the image held by many nuclear-weapons decision-makers of a zero-sum competition between the two superpowers, and the almost inevitable progress in the areas of technology that are critical for missile accuracy.

A key factor spurring the US side of the counterforce race has been an effort by the US to make credible its willingness to use nuclear weapons in areas where US conventional forces alone might be insufficient to deter Soviet aggression. During the 1950s the United States promised all-out nuclear attacks against the Soviet Union if the US decided that Soviet actions threatened US vital interests. Since the USSR developed a nuclear arsenal comparable to that of the US, however, such threats of "massive retaliation" against the Soviet population for anything other than an all-out Soviet nuclear attack on the US have become less and less credible.

Furthermore, as the US reached a level of nuclear plenty in which it had many times the number of nuclear weapons required to hold Soviet cities hostage, it became possible to think of using the extra weapons to develop more credible threats against targets whose destruction would not quite be the equivalent of the destruction of Soviet society. The obvious targets for such threats were the Soviet military and in particular their nuclear weapons aimed at the US.

The arms race ensued, in which each side has tried to threaten the other and foil the threats against its own nuclear weapons. In the case of the ICBMs, it has until now been a race between the hardening of underground silos on one side and the number and accuracy of the ICBM warheads on the other side. It is in this race that some see the Soviet Union as being ahead and the US thereby weakened in its ability to affect the decisions of the Soviet and other governments.

Thus, in 1980, the Carter Administration in its justification of the counterforce capabilities of the proposed MX land-based missile claimed that[1]

> An asymmetry in hard-target-kill capability could lead to perceptions of Soviet advantage that could have adverse political and military implications including: (1) greater Soviet and less US freedom of action in the employment of conventional forces . . .

More recently, General Lew Allen Jr, then Chief of the Air Force, in a closed hearing before the Senate Armed Services Committee, stated that even

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Estimated size and destructive power of strategic arsenals, 1982

Delivery Vehicle	Warheads per delivery vehicle	Total number of warheads	Yield per warhead (kilotons)	Total blast area, all warheads, airbursts (10^3 km^2)	Total fallout area, all warheads, groundbursts (10^3 km^2)
US arsenal					
Intercontinental ballistic missiles					
Titan II	1	52	9000	60	400
Minuteman II	1	450	1200	120	370
Minuteman III					
Mark 12 warhead	3	750	170	60	50
Mark 12A warhead	3	900	335	110	150
Subtotal		2512		350	970
Submarine-launched ballistic missiles					
Poseidon	avg. 9	2736	40	90	130
Trident I	avg. 8	1920	100	100	230
Subtotal		4656		190	360
Bombers	avg. 7.5				
Bombs		1264	1200	330	1000
Short-range attack missiles		1114	170	80	70
Cruise missiles		192	200	15	15
Subtotal		2570		425	1095
Total		**9378**		**965**	**2425**
Soviet arsenal					
Intercontinental ballistic missiles					
SS-11	1	518	950	130	340
SS-13	1	60	600	10	25
SS-17	1	32	6000	30	170
	4	480	750	110	230
SS-18	1	58	20 000	120	930
	8	1400	900	350	770
	10	750	500	120	220
SS-19	1	60	10 000	80	520
	6	1800	550	320	580
Subtotal		5158		1270	3785
Submarine-launched ballistic missiles					
SS-N-5	1	18	1000	5	10
SS-N-6	1	356	700	70	160
SS-N-8	1	292	800	70	140
SS-N-17	1	12	750	5	5
SS-N-18	avg. 7	1680	200	150	130
SS-N-20	avg. 10	200	200	20	15
Subtotal		2558		320	460
Bombers	avg. 2				
Bombs		152	1000	40	90
Short-range attack missiles		161	1000	40	90
Subtotal		313		80	180
Total		**8029**		**1670**	**4425**

though the developing vulnerability of US ICBMs is[6]

> perhaps not dangerous in that it will incite them [the Soviets] to first strike, it nevertheless gives them confidence in their nuclear forces. That confidence means that we will find the threshold of nuclear war much higher than in the past, and we will see greater Soviet confidence in their ability to be adventuresome and provocative to the United States across a broad range of areas.

General Allen is widely considered a moderate in matters of nuclear-weapons policy. Yet here he was arguing in favor of keeping the threshold of nuclear war low!

And still more recently, Richard DeLauer, the Reagan Administration's Undersecretary of Defense for Research and Engineering indicated the same priorities when he worried that[7]

> increases in nuclear hardness of Soviet ICBM silos and other important facilities have reduced our ability to put those targets at risk. Knowing this the Soviets feel less constrained from adventurism around the world . . .

Another purpose of the Reagan Administration in pursuing increased counter-silo capabilities is to undermine the economy of the Soviet Union by forcing it to initiate costly programs of military investments in new mobile strategic systems or even active missile defense. Thus, in the Reagan Administration's first 5-year defense guidance document, the Defense Department was advised to develop weapons that[8]

> are difficult for the Soviets to counter, impose disproportionate costs, open up new areas of major military competition and obsolesce previous Soviet investments.

Unfortunately, if either superpower decides that its fixed land-based missiles are obsolete and deploys a mobile land-based missile or deceptively-based missile less vulnerable to attack by accurate warheads, these missiles will also be more difficult for the other side to count by its "national technical means" (primarily satellites) and therefore to eliminate by agreement. And, if either side decides to deploy a defense of its ICBM silos, the result could be the abrogation of the Treaty on the Limitation of Anti-Ballistic Missile Systems.

A final reason for the drive by both sides toward counterforce capabilities is that it is the path of least resistance. With major laboratories working continuously on more accurate systems as well as new warhead designs and new delivery vehicles, techniques for improvement will be found. Once new technology is available—and it is often available at relatively modest cost—the defense establishments usually find it irresistible. This is especially so for counterforce weapons, which both the US and Soviet military see as more usable and appropriate to traditional military roles than "city-busting" deterrent forces.

The chimera of limited war. An important element in the analyses used to justify the counterforce race is the idea that it might be possible to fight a nuclear counterforce war in a carefully controlled manner. However, because the means of command and control are inevitably vulnerable to nuclear destruction, it is extremely doubtful that a nuclear war could be limited and prevented from escalating into an all-out civilization-shattering exchange. Moreover, even if a nuclear exchange could be strictly limited to military targets, a strategically significant counterforce attack would probably cause tens of millions of civilian deaths.

Command and control systems can be "hardened" to some extent against nuclear attack, and the Reagan Administration proposes to spend about $20 billion over five years for that purpose. But these systems will remain inherently more vulnerable than nuclear-weapons systems. As John Stein-

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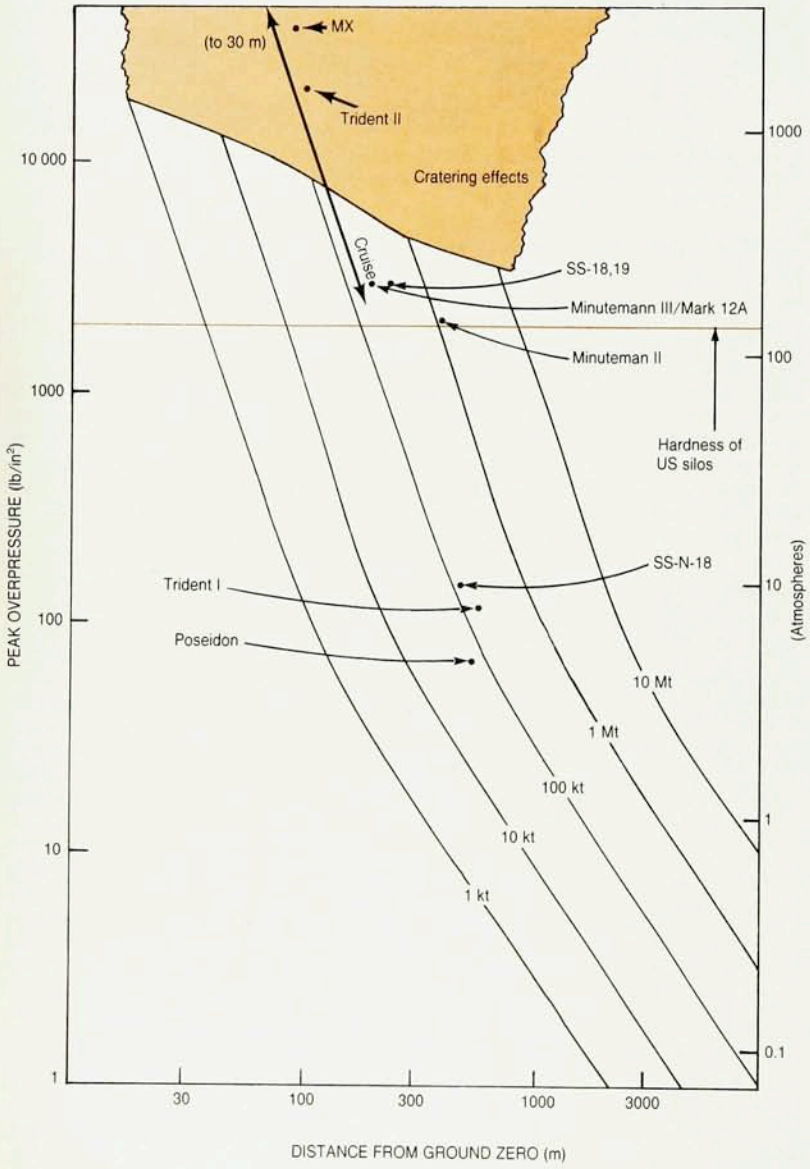
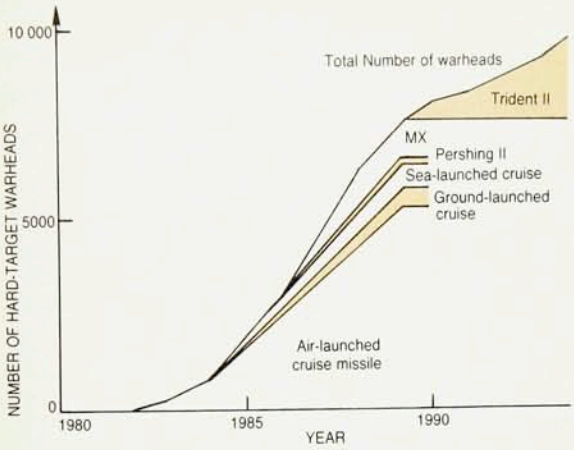


Weapon capability curves showing the overpressures produced by warheads of various yields as a function of distance from ground zero. Such curves indicate weapons' ability to destroy hard targets. Cratering effects may knock out silos that are hard enough to escape destruction by overpressure;[10] silos in the shaded region would be covered by debris to a depth of at least 4 m. The points shown for various US and Soviet warheads indicate estimated yields and median miss distances.[13,15]

Figure 1



Proposed new US counterforce weapons. The proposed nuclear-weapons modernization program includes more than 10 000 new warheads, each of which is expected to be capable of destroying a Soviet ICBM silo.[6,14] Figure 2

bruner, an expert in command and control, recently pointed out[9]

> . . . once the use of as many as 10 or more nuclear weapons directly against the USSR is seriously contemplated, US strategic commanders will likely insist on attacking the full array of Soviet military targets. Political motives for engaging in limited strategic attacks will not likely prevail against the risks of leaving a vulnerable command system exposed to counterattack from a severely provoked enemy.

In the strategic literature, nuclear war often seems like a long-distance version of the artillery duels of World War I. The side-effects of the missile exchanges are labeled "collateral damage" and are seldom discussed. They are far from unimportant, however.

Hidden in the Defense Department's scenarios for limited strategic nuclear war, for example, are Soviet "barrage attacks" on US airbases that house bombers and refueling aircraft. In these scenarios, warheads of half-megaton size explode over and around the bases to destroy aircraft caught on the ground and aircraft that have just become airborne. The blast and heat from a single 0.5-megaton warhead exploded in the air over a B-52 base would kill the population in an area of the order of 100 square kilometers.[10] A number of urban areas in the US would be destroyed or partially destroyed by such barrage attacks on bomber bases. Such attacks would be still more damaging if, in a time of tension preceding the war, bombers were dispersed to major civilian airfields, as occurred during the 1962 Cuban missile crisis.

In the United States, ICBM bases are generally more isolated from nearby populations than are bomber and submarine bases. However, the Minuteman bases contain so many separate targets—150 to 200 silos, each of which is ordinarily assumed to be targeted by two half-megaton warheads—that the lethal radiation field from the overlapping fallout patterns would extend for many hundreds of miles downwind.[11]

As a result of all these effects, the Department of Defense was forced in 1975 by the Senate Foreign Relations Committee to admit[11] that a full-scale Soviet attack on US ICBM, bomber and missile-submarine bases would kill 3 to 16 million Americans. More recent US government estimates[12] have raised this range to 24 to 45 million. Estimates[12] of the consequences of a US counterforce attack on Soviet strategic nuclear forces are of the same order of magnitude.

Dangers of counterforce

Figure 1 shows some estimated yields and median miss distances, ordinarily termed "circular errors probable," or CEPs, of the various US and Soviet counterforce warheads. These points are superimposed on a graph showing the peak overpressure felt by a silo as a function of the explosion's horizontal distance from the silo. One can see that warheads on modern ICBMs—the US Minuteman II and III equipped with Mark 12A warheads, and the Soviet SS-18 and SS-19—are expected to produce within their CEPs an overpressure equal to or beyond that which US silos are designed to withstand. The labels at the top of the figure indicate that the next generation of US warheads—to be carried by the MX, Trident II and cruise missiles—are expected to be so

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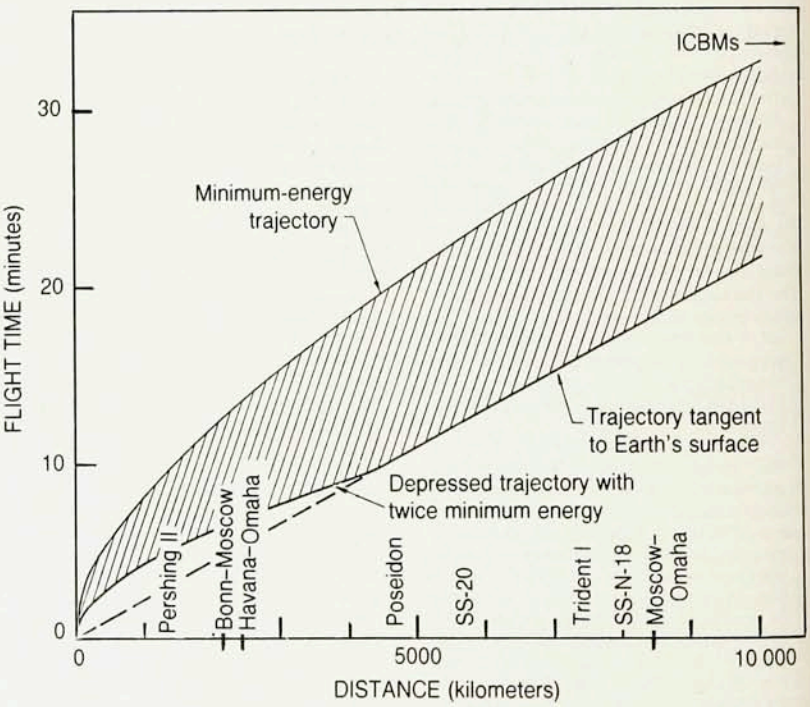

Travel times. The range of times required for warheads to follow ballistic trajectories between two points on the Earth's surface are shown here as a function of the great-circle distance between the two points. These times are upper limits on the times available for making decisions in launch-on-warning systems. The top of the band gives travel times for elliptical trajectories, which require the minimum energy for a given range. The bottom of the band gives times for circular orbits just above the Earth's surface. For short distances, the graph shows flight times along "depressed" ballistic trajectories of twice the minimum energy. Actual flight times would be 1–2 minutes longer than shown, principally because of the slower average speed of the warhead during the "boost" phase, when the average acceleration is on the order of a few times that of gravity. Along the bottom of the graph are a few relevant distances and the estimated full-load ranges of various US and Soviet ballistic missiles.[4,16] Figure 3

accurate that their target would ordinarily be within the radius of cratering effects produced by a nuclear ground burst.

The principal threat to US land-based missiles today is the large number of accurate warheads carried by two types of large Soviet ICBMs. These Soviet missiles are designated the "SS-18" and "SS-19" by the US Defense Department. The Defense Department believes[13] the Soviets soon will have (or may already have) roughly 4000 silo-lethal warheads on a total of almost 700 SS-18 and SS-19 ICBMs.

Each warhead on the 1000 US Minuteman missiles is believed[13] to have a similar ability to destroy silos, but there are only 2100 Minuteman warheads for 1400 Soviet ICBM silos of all types, versus about four SS-18/19 warheads per US silo. Therefore, given roughly equal destructive capability per warhead, a larger fraction of Soviet ICBMs might be expected to survive a US first strike than *vice versa*.

The Reagan Administration's plans[6,14] to increase the US threat to Soviet missile silos includes the following, as shown in figure 2: at least 1000 accurate high-yield warheads on a force of 100 MX missiles; thousands of silo-killing warheads on a force of new submarine-launched Trident II, or "D-5," ballistic missiles; several thousand warheads on slower but highly accurate air-, sea- and ground-launched cruise missiles; and 108 accurate Pershing II missiles, which could hit key targets in the western USSR within ten minutes of being launched from West Germany. The deployment of all these "hard-target killers" would make the Soviet land-based missiles at least as vulnerable as those of the US.

The Soviet Union should find the prospective vulnerability of land-based missiles even more disturbing than does the United States at present. Whereas only one quarter of all US strategic warheads are on ICBMs, two thirds of the Soviet Union's strategic warheads are based in silos. Furthermore, the other two legs of the Soviet "triad" are already somewhat vulnerable: The Soviet bomber force is much less capable than that of the US and is not ordinarily on alert status; and the security of the small percentage of Soviet ballistic-missile submarines that are at sea at any one time is being eroded by enormous US investments in large ocean sound-surveillance systems, nuclear attack submarines and antisubmarine aircraft.[1] (There is no comparable Soviet threat to US ballistic-missile submarines.)

Under these circumstances, as the US threat to Soviet missile silos grows, the Soviet Union may become tempted to put its ICBMs on a launch-on-warning status and, during periods of crisis, entertain ideas of preemptive attack.

An indication that the Soviet Union is at least considering launching its missiles on warning of US attack recently appeared in an article by Soviet Defense Minister, Dmitri Ustinov:[18]

> With modern detection systems and the combat readiness of the Soviet Union's strategic nuclear forces, the United States would not be able to deal a crippling blow to the socialist countries. The aggressor will not be able to evade an all-crushing retaliatory strike.

The warning times involved in an

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Vulnerability of US silos

How does one estimate the percentage of the 1052 US ICBM silos that would survive a Soviet counterforce attack? In 1979, the Department of Defense released[5] the 1978–88 vulnerability projection shown below. In the unclassified version of the graph, the DOD deleted the numbers on the vertical axis—but not the ticks. Let us calculate the deleted numbers.

In calculating "silo kill probabilities," one ordinarily assumes that the distribution of warheads as a function of distance R from their targets will be proportional to

$$\exp[-0.7\ (R/\mathrm{CEP})^2]$$

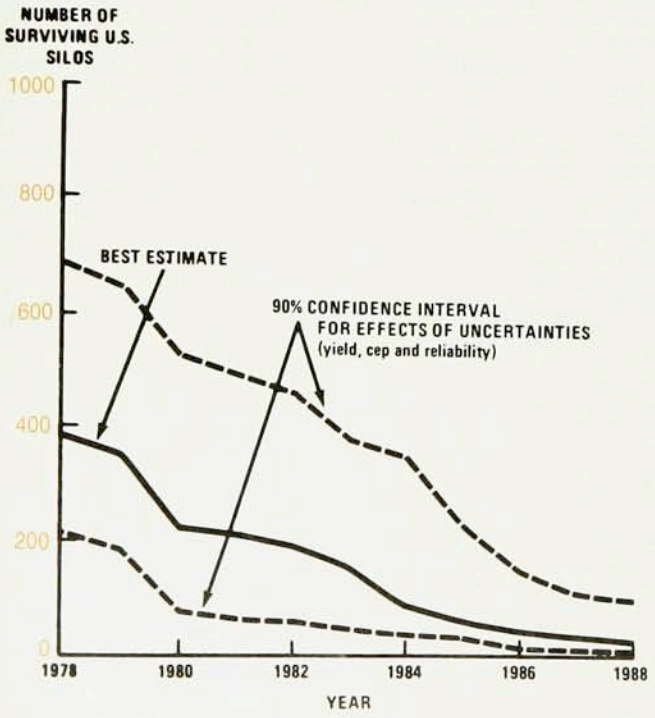
a gaussian probability distribution in which CEP is the "circular error probable," or median miss distance. One assumes that a silo is destroyed if a warhead lands within a "lethal radius" R_L. For hardness higher than about 100 lb/in^2,

$$R_L \approx 460\ (Y/H)^{1/3}\ \text{meters}$$

Here the yield Y of the warhead is measured in megatons and the hardness H of the silo is measured in thousands of pounds per square inch.[10]

In 1978, as today, the principal threat to US missile silos was the large number of accurate warheads carried by the most modern Soviet "SS-18" and "SS-19" intercontinental ballistic missiles. In 1978 there were about 200 of each of these missiles, many of which were believed to carry payloads of 6–10 warheads. These warheads have estimated yields of 500–750 kilotons and estimated accuracies such that half would land within 315–425 meters of their targets.[13,16,17] We assume that in a counterforce attack two of these warheads would be aimed at each US missile silo; a Soviet attack using a larger number per silo would be much more disarming of the Soviet Union than the US because there are an average of only two warheads available to be destroyed in each US missile silo.

Silos in the US are designed[14] to protect their missiles against blast effects associated with peak overpressures up to 2000 lb/in^2. This corresponds to a lethal radius of 300–340 meters for the Soviet warheads. Assuming that each Soviet warhead had an arrival reliability of 80–100 percent, one can estimate that 225–640 US missile silos would have survived the postulated Soviet attack in 1978. We have, therefore, labeled the vertical axis in the figure as shown. —HF & FvH



attack could be less than ten minutes, as figure 3 shows. Herbert York points out that with a US launch-on-warning system, these short times mean that[19]

> the determination of whether or not doomsday has arrived will be made either by an automatic device designed for the purpose or by a preprogrammed President who, whether he knows it or not, will be carrying out orders written years before by some operations analyst.

The danger of preemptive attack is inherent in counterforce weapons. These weapons are presented by their proponents not as first-strike weapons, but as weapons that would only be used to destroy any enemy missiles held back in a first strike. Unfortunately, such a strategy would almost assuredly be futile, for, if there were ever a time when a nation would be prepared to launch its nuclear weapons on warning it would be after it had struck first. The only chance—a very small one—for a successful use of counterforce weapons would be in a "preemptive" first strike.

The Carter Administration recognized the possibility of the Soviets being driven to a preemptive attack as one of the risks associated with the US counterforce development program:[1]

> Under extreme crisis conditions Soviet leaders who had little confidence in the deterrent value of their own air-breathing, submarine and residual ICBM forces might perceive advantages in launching a first strike. In this context, such Soviet leaders might view the threat to their silo-based ICBM force as being of major concern since currently about 75 percent of Soviet strategic weapons . . . are in its fixed-silo ICBM force.

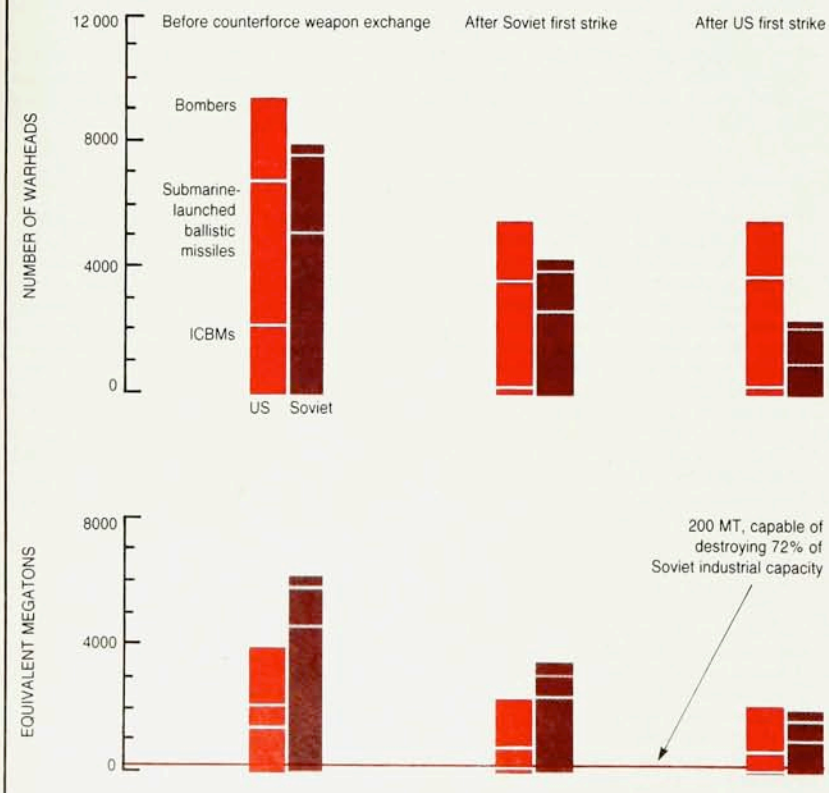
As of today neither side has been pushed into adopting a launch-on-warning system, for despite improving counterforce capabilities, each side maintains an overwhelming deterrence capability, sufficient beyond question to withstand a preemptive attack. The box below outlines this current, still relatively stable, balance of weapons. A new round of deployments dominated by counterforce weapons is therefore likely to be either sufficiently threatening to each side's deterrent to provoke desperate measures such as launch-on-warning, or merely futile and wasteful. This is the fundamental rationale for the nuclear-weapons-freeze proposal.

Why not a bilateral freeze?

The Reagan Administration has cited several objections to a bilateral freeze that go beyond its concern to protect US counterforce programs. Its spokesmen have argued[20] that a freeze would be unverifiable, would lead to a loss of deterrent by eroding the ability of the US to respond to a Soviet nuclear attack, and would reduce Soviet interest in negotiating arms reductions. While such claims need detailed attention, as we hope independent scientists will provide, we can raise a few points of skepticism immediately.

Although it is not surprising that opponents of a freeze focus on the weakest points of its verifiability, this should not obscure the fact that methods of verifying the most important elements of a freeze have already been worked out in considerable detail. For example, methods to verify compliance with prohibitions on flight testing and

The current balance



Both superpowers now possess enormous strategic arsenals with vast destructive capability, as the table on page 38 shows. The blast areas given are those that would experience peak overpressures greater than 0.25 atmospheres, or 3.5 lb/in^2. The destruction of ordinary buildings within these areas would be nearly total.[1] Fallout areas given in the table are those in which unsheltered people would be subject to a dose greater than 600 rads. Above this level, people sheltered above ground in ordinary housing would begin to die. (We use the methodology of reference 2 and assume the following: bursts on the ground, an average wind speed of 40 km/hr and a transverse wind shear of 1 km/hr for each km of altitude. We also assume that for weapons with yields over 100 kilotons, 50 percent of the yield is from fusion.)

If forces were frozen at their present levels, how much incentive would there be for a preemptive first strike? That is, how much firepower would one side have left after an all-out counterforce attack by the other? Defense Department reports contain charts[3] like the one shown at left, giving estimates in terms of numbers of warheads and "equivalent megatonnage." (Equivalent megatonnage takes into account the fact that the area a warhead subjects to a given peak overpressure increases as the two-thirds power of the warhead yield. A one-eighth-megaton warhead, for example, would contribute one quarter of an equivalent megaton.) However, in unclassified versions of such reports, the *absolute* numbers of surviving warheads and megatonnage are suppressed. Also, the results of a first strike by the United States are never shown.

on deployment of new ballistic missiles were incorporated in SALT II and subjected to intensive study. Similarly, the United States and the Soviet Union have over several years worked out verification procedures to monitor a comprehensive nuclear test ban, including underground tests. Verification of certain other elements of a freeze, such as a ban on building cruise missiles, would be more difficult, but not impossible when the numbers of missiles involved are large. Given our vast intelligence-gathering capabilities and the comprehensive character of a freeze, it would be very difficult for the Soviet Union to conceal cheating on a scale sufficient to create a threat anywhere nearly as serious as that posed by the current nuclear arms race.

In addition, we should not assume that verification beyond "national technical means" will remain impractical. While the Soviet Union is not about to convert itself into an open society, it did agree under the virtually complete Comprehensive Test Ban Treaty to allow the US to emplace sealed "black boxes" containing sensitive seismometers in strategic spots around the Soviet Union. And, under the SALT I Treaty, the Soviet Union has participated constructively in the "standing consultative commission" in which each side has agreed to explain questionable activities detected by any of the multitude of telescopic "eyes" and electronic "ears" that continually monitor surface activities from outer space.

The Reagan Administration claims[20] that in the long run a freeze could erode US deterrent capability by stopping the development of offensive nuclear systems while allowing Soviet nonnuclear air defense and antisubmarine-warfare capabilities to develop unimpeded. In fact, under a freeze, a country's confidence in its ability to make a first strike will erode far more rapidly than its ability to deter a first strike by the other side. A first strike must be virtually perfect, with thousands of warheads coordinated in time and space to high precision. An effective deterrence force need be neither perfectly reliable nor highly accurate. For instance, the possibility that even a few bombers can get through an air defense system would represent a substantial deterrent to any rational political leader. As McGeorge Bundy, national security advisor to President Kennedy, has written,[21]

> . . . a decision that would bring even one hydrogen bomb on one city of one's own country would be recognized in advance as a catastrophic blunder; ten bombs on ten cities would be a disaster beyond history; and a hundred bombs on a hundred cities are unthinkable.

That said, it is true that freezing bomber- and air-launched cruise-missile technology while allowing continued development of air-defense technology will erode the capabilities of both US and Soviet bombers to deliver their weapons on target.

By contrast, there is a consensus in the US defense establishment that no forseeable development in Soviet antisubmarine technology will be able to threaten US ballistic-missile submarines.[14] In any case, the contest between antisubmarine-warfare systems and ballistic-missile submarines would be largely unaffected by a freeze. For under a freeze, as usually defined, submarines could be replaced by

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Nevertheless, by making a few simple assumptions, one can reproduce the pattern of results roughly, as we have done in the chart at left.

We have assumed force structures such as those that would exist if a freeze on the deployment of new nuclear weapons occurs during the next few years. The inventories of strategic forces are those of 1982, but the missile accuracies are based on test results and might not be fully achieved in deployed missiles until a later date.

We have assumed also that the counterforce exchanges occur during a crisis, not as a "bolt out of the blue." That is, we assume the forces of both sides are on "generated alert," during which

- The Soviet Union increases the fraction of its ballistic-missile submarines at sea from 15 to 50 percent,[4] while the United States increases its corresponding fraction from 50 to 75 percent[3]
- The Soviet Union increases the fraction of its bombers on alert from 0 to 50 percent (75 percent in case of a Soviet first strike) while the United States increases its corresponding fraction from 30 to 75 percent.[3]

We assume that all bombers not on alert and submarines not at sea will be destroyed unused.

With respect to attacks on ICBM silos, we have assumed that the Soviet Union in a first strike would assign two ICBM warheads to each US silo and that the United States in a first strike would assign two Minuteman III warheads to each silo containing a MIRVed Soviet ICBM. We assume that only 20 percent of the silos so attacked would survive; however, if we had credited a two-warhead attack with a 100 percent probability of destroying an ICBM silo, the overall results would not change significantly. We have further assumed that, regardless of which side attacked first, each side would expend an additional 200 ICBM warheads attacking bomber and submarine bases and command and communications facilities.

It is evident from the figure that, under conditions of a generated alert, neither side has, at present, a strong incentive to strike first. Doing so would not significantly change the relative positions of the two sides. The Soviets, for example, in an attack on US Minuteman silos, would have to expend two high-yield warheads to destroy 1–3 mostly lower-yield warheads. Furthermore, even after a Soviet first strike, the US would still have about 2000 equivalent megatons of nuclear explosive power. Even a Soviet "bolt out of the blue" attack against US forces not on a crisis alert would leave the US with more than 1000 equivalent megatons. In 1969 the Department of Defense estimated[5] that an attack with 100 equivalent megatons could destroy 59 percent of Soviet industrial capacity and that an attack with 200 equivalent megatons would raise this figure to 72 percent.

There are, of course, those who argue that even thousands of equivalent megatons would not be enough to deter the Soviet Union. Paul Nitze, now chief US negotiator in the US–Soviet talks on intermediate-range nuclear forces in Europe, advanced such an argument in 1979. Nitze presented the Senate with a calculation in which it was assumed that[6]

> . . . approximately 80 percent of the Soviet urban and industrial population will have been evacuated, distributed in . . . an equal density over a million square miles . . . , equipped with shelters with a PF [protection factor against radiation] greater than 200, prepared to stay in those shelters for 2 weeks if necessary, and prepared to act with some prudence when the residual radiation levels call for prudence.

He then argued that the United States could only cover at most 3.5 percent of a million-square-mile area with fallout great enough to give the sheltered population lethal radiation doses. He did not discuss how the evacuated population would survive in the longer term with the Soviet economy destroyed.

More recently, the *Los Angeles Times* reported[7] that Thomas K. Jones, US Deputy Undersecretary of Defense for Strategic and Theater Nuclear Forces, believes that

> with a proper civil defense it would take only two to four years for the United States to fully recover after and all-out nuclear war with the Soviet Union.

HF & FvH

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quieter models equipped with all the latest antisubmarine countermeasures. Only the capabilities of the submarine-launched missiles would be frozen. The one capability of these missiles that is relevant to antisubmarine warfare is range, and this is already great enough so that about half the equivalent megatonnage on both US and Soviet submarine-launched ballistic missiles can reach the capital city of the other from home waters. Indeed, when asked recently about the superiority of the range of the Trident II missile over that of the Trident I, Rear Admiral William A. Williams III, director of the US Navy's strategic and theater nuclear warfare division, stated that[14]

> we are not advocating the D-5 [Trident II] because of its greater range. The C-4 [Trident I] has a very comfortable range.

Another problem that would arise in the long run, argues the Administration, is that US strategic systems will begin to wear out earlier than their Soviet counterparts because they were generally deployed years earlier. In fact, most US systems are not creaking with age. The Minuteman III and Poseidon missiles have all been deployed since 1970, and all Trident I missiles since 1980. The submarines are older, but as we pointed out above, they can be replaced. Only the bombers—both US and Soviet—would have a real problem with aging, and then only if a freeze lasted for decades. But, of course, the freeze is not designed to last forever. It would serve best as a transition period between the arms race and genuine arms reduction.

Finally, we should emphasize once more that a freeze would slow the erosion of the stability of the nuclear balance by dramatically slowing the counterforce race, if not entirely stopping it. Contrary to the impression given by Administration spokesmen, significant parts of the US strategic program that a freeze would stop, including the MX and Trident II programs, are aimed primarily at threatening Soviet nuclear missiles—not at reducing the vulnerability or our own.

The Reagan Administration asserts that a freeze would weaken chances for deep reductions in strategic weapons, a goal of the on-going "START" (Strategic Arms Reduction Talks) negotiations. It contends that only the threat of a vigorous US buildup of strategic weapons will adequately motivate the Soviets to make a deal. The Administration's declared passion for reductions, however, is belied by its refusal in START to offer to stop the deployment of any of the planned US counterforce weapons. Only quantitative limits have been proposed: 850 ballistic missiles carrying a total of 5000 warheads not more than 2500 of which could be carried by ICBMs.

Within these quantitative limits the Administration proposes to pursue the technological arms race without constraint. The START proposal would allow the United States to deploy the MX, Trident II, Pershing II and cruise missiles while the older and less-threatening Poseidon, Trident I and Minuteman missiles are retired to bring the total warhead and missile count down to the proposed limits. The counterforce race could, therefore, continue unconstrained under a START agreement and could indeed become more dangerous as the number of targets for a first strike were reduced faster than the number of warheads that could be directed against them. This would compound the historic mistake that the United States and Soviet Union made when they decided against seeking to include a ban on multiple independently targetable reentry vehicles in the SALT-I agreement.[22]

Role of scientists

Scientists and engineers are not only the designers of nuclear weapons and their delivery systems, they also play key roles in developing "scenarios" of how these weapons might be rationally used. Gerard Smith, chief US negotiator in the SALT-I talks, recalls that[22]

> I sensed that civilian scientists and engineers in the office of the Secretary of Defense were more influential with Secretary [Melvin] Laird than professional military officers. These men would never have to be users of nuclear weapons. They were not members of military services with experience in fighting wars but a kind of elite which knew or gave the impression of knowing the new secrets of the nuclear-missile age.

McGeorge Bundy has also testified[21] to the unwillingness of national leaders to challenge these "nuclear gamesmen":

> Presidents and Politburos may know in their hearts that the only thing they want from strategic weapons is never to have to use them; in their public postures they have felt it necessary to claim more. They may not themselves be persuaded by the refined calculations of the nuclear gamesmen—but they do not find it prudent to expose them for the irrelevance they are. The public in both countries has been allowed by its leaders to believe that somewhere in ever growing strength there is safety and that it still means something to be "ahead." The politics of internal decision making has not been squared with the reality of international stalemate.

Independent scientists have, therefore, on occasion played a key role in challenging the rationalizations that have been proposed for continuing the arms race.

Perhaps the most recent debate in which independent scientists have been involved on a large scale in critiquing official US policy in the arms race was the national debate that occurred in the period 1967–1970 over proposals by the Johnson and Nixon Administrations to deploy a nationwide antiballistic-missile system. As with the current debate, the ABM debate began with a citizens' uprising—developing first around the suburban sites originally proposed for the nuclear-armed antimissile missiles. However, the opposition continued to broaden even after the Nixon Administration shifted the ABM sites away from populated areas—in part because critical scientists used the forums created by the initial uprising to focus public and congressional attention on the ABM's implications for the arms race.[23] Hans Bethe, for example, opened his 4 March 1969 talk at a teach-in at MIT as follows:[24]

> I believe that most of the audience here is against the ABM, and I believe that I am here to tell you why.

The ABM debate in the US educated both the US public and the Soviet leadership about the difficulties of missile defense, difficulties the military leadership on both sides had refused to admit. As a result, while the political leadership on neither side was strong enough to impose unilateral abstention from an ABM race on their militaries, together they were able to prevent the nuclear-arms race from expanding into this new dimension.

Today, rising public concern has created an opportunity for scientists to explain to the public the even greater dangers and futility of the counterforce race. In addition, scientists can help to define specific bilateral freeze agreements that are adequately verifiable and that can be used as a starting point for nuclear-arms reductions.

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