U.S.-Soviet Mutual Constraints

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In the past, U.S.-Soviet nuclear arms control has focused on limiting the number of deployed nuclear delivery vehicles, specifically long-range missiles and bombers. The SALT I, SALT II, INF, and START treaties have used this approach almost exclusively. This path to arms control gained prominence primarily because limits on deployed delivery vehicles are easily verified with reconnaissance satellites. As I will explain, however, this approach by itself may be unable to sustain reductions much below the START levels. New approaches to arms control that limit the production or stockpiles of fissile materials or warheads, or that limit the development and testing of certain types of warheads or missiles, are necessary not only for continued progress in superpower arms control, but also to strengthen and expand the nuclear nonproliferation regime.

WHAT'S WRONG WITH THE OLD APPROACH?

Reducing the number of nuclear delivery vehicles continues to be important, because delivery vehicles often represent most of the economic value of a weapon system. But this traditional approach to arms control is becoming less useful for several reasons:

- New mobile intercontinental ballistic missiles (ICBMs), such as the Soviet rail-mobile SS-24 and road-mobile SS-25, and the proposed U.S. rail-garrison MX and road-mobile Midgetman missiles, are far more difficult to count with satellites than their fixed, silo-based predecessors. This problem has been solved satisfactorily in START by counting the missiles as they are produced (with "perimeter-portal" monitoring), but confidence in the count will be lower than with silo-based ICBMs, especially at much lower limits.

- Limits on small delivery vehicles, such as sea-launched cruise missiles (SLCMs), are almost impossible to verify with satellites. One could attempt perimeter-portal monitoring of declared cruise-missile production facilities, but since such facilities are not distinctive there would be little assurance that additional missiles were not being produced at covert facilities. Alternatively, one could inspect ships or conduct perimeter-portal monitoring at loading facilities, but the U.S. Navy has objected strenuously to such intrusive procedures, with some justification. Even if such inspections were permitted, it would not prevent excess weapons from being stockpiled in hidden warehouses and deployed during a crisis. (Only *deployed* cruise missiles are subject to the START limits, so as it stands there would be no need even to hide the production or stockpiling of nondeployed missiles.) Such concerns have already been raised by the U.S. House Armed Services Committee about the START treaty.[1]

- A related problem is that the conventional version of the U.S. SLCM is virtually identical to the nuclear-armed version, so that counting SLCMs may not give much information on the number of possible *nuclear* SLCMs. For example, a country could produce and deploy large numbers of conventional cruise missiles that could be rapidly armed with nuclear warheads, which could be stockpiled nearby. Although current U.S. SLCMs cannot be converted rapidly, and although START specifies that conventional air-launched cruise missiles (ALCMs) must be distinguishable from nuclear ALCMs, there are no significant technical barriers to designing a SLCM or an ALCM that could be converted quickly from conventional to nuclear. This problem might be solved by banning dual capability (i.e., requiring that all cruise missiles be either nuclear *or* conventional), but this "solution" would raise additional objections.

- Many of the warheads that the superpowers may wish to limit in future arms control agreements (e.g., a short-range nuclear forces agreement) are not associated with distinctive delivery systems. For example, atomic demolition munitions have no delivery vehicle. Tactical nuclear bombs can be delivered with a wide variety of aircraft, and U.S. nuclear artillery shells are fired from standard 8-inch and 155-millimeter artillery pieces. Short-range ballistic and cruise missiles are often dual capable. It is highly unlikely that the deployment of such delivery systems would ever be limited to such an extent that their potential nuclear capabilities would be significantly constrained. Since the nuclear warheads associated with these systems are easily hidden and are capable of rapid redeployment, verifying limitations on such systems will be extremely difficult without controls on the warheads themselves.

- Even after INF, START, and unilateral withdrawals of tactical weapons are implemented, the United States and the Soviet Union will each retain over 10,000 deployed warheads, mostly on strategic delivery vehicles. At such high warhead levels, cheating would have to occur on a massive scale to alter the nuclear balance; indeed, some analysts claim that no amount of cheating would disturb the balance at these levels. Since large-scale cheating would be easily detectable, neither country would be tempted to try. If, however, the number of warheads is greatly reduced, then strategically significant but undetectable cheating becomes more plausible and therefore more tempting and more worrisome. Thus, the standard for adequate verification is rising even while weapon technology is making verification more difficult.

These emerging issues indicate that relying solely on limits on delivery vehicles, while good enough for START, may not be sufficient to sustain superpower disarmament in the more distant future. In addition, the traditional approach is receiving increased criticism from those who feel that it is making little progress in ending the qualitative arms race. A common criticism of the SALT/START process is that the superpowers are merely agreeing to do what they had

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[1] Breakout, Verification, and Force Structure: Dealing with the Full Implications of START (Washington, DC: U.S. Government Printing Office, House Committee on Armed Services Print #21, 24 May 1988).

planned to do anyway: eliminate obsolete weapons and replace them newer and more effective ones. Such critiques apply even to START, the most ambitious arms control agreement to date, which is advertised as a 50 percent reduction in strategic forces but which permits the U.S. to deploy or retain every new system it recently developed, including the highly accurate Trident II and MX missiles, the B-1B and the B-2 bombers (armed with new, fast, stealthy cruise and short-range attack missiles), and the long-range land-attack SLCM.

Thus, even while they discourage Third World nations from acquiring nuclear weapons, the superpowers continue to develop, test, and deploy new types of nuclear weapons that they claim are essential for their security, even after the end of the Cold War. Many observers in non-nuclear-weapon states do not believe that such behavior--"advocating water, but drinking wine"--is consistent with Article VI of the Non-Proliferation Treaty (NPT), which states that "parties to the Treaty undertake to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament."[2] Nor do they believe that such behavior can long continue without seriously weakening the nonproliferation regime.

ALTERNATIVE APPROACHES TO MUTUAL RESTRAINT

Fortunately, nuclear arms control can be pursued in ways that promise not only to increase confidence in future superpower agreements, but which also promise to strengthen the NPT. In addition to delivery vehicles, one can limit the nuclear warheads themselves (or, alternatively or in addition, the quantities of uranium and plutonium available for weapons), and one can limit or ban the development and testing of certain types of weapons. As figure 1 indicates, these three approaches are nearly orthogonal, in that they operate on very different types of activities, conducted at different types of facilities, and often controlled by different bureaucracies and involving different groups of scientists, engineers, and other workers. Since deploying an effective weapon system requires progress along all three of these dimensions, constraints on two or three dimensions make undetected cheating far more difficult and implausible than constraints on just one.

Figure 1. Three basic approaches to nuclear arms control.

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          |Delivery
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          |         Research,
          |        Development,
          |       and Testing
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    Warheads and Fissile Materials
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[2] NPT reference.

Mutual Restraints on Warheads and/or Fissile Materials[3]

The first nuclear arms control proposal, the Baruch plan, proposed to prevent the proliferation of nuclear weaponry by placing all supplies of uranium ore and all nuclear facilities capable of producing weapon-grade uranium and plutonium under international safeguards. Since all nuclear weapons contain at least several kilograms of weapon-grade uranium or plutonium, a limit on the production of these materials is equivalent to a limit on the production of nuclear weapons. A bilateral fissile-material production cutoff was a high priority on the U.S. arms control agenda between 1956 and 1969, but was dropped as efforts shifted to limits on delivery vehicles. Restrictions on the production of fissile material remain at the heart of the NPT, but such restrictions apply only to the non-nuclear-weapon states. As of 1989, 42 non-nuclear-weapon states signatory to the NPT had opened their nuclear facilities to the inspectors and safeguards of the International Atomic Energy Agency (IAEA).[4] Applying these restrictions and safeguards more uniformly and universally would reinforce the NPT by making it less discriminatory.

A first, very modest step to controlling the potential number of nuclear warheads (and reinforcing the NPT) would be to verifiably ban the production of additional highly-enriched uranium (HEU) or plutonium for use in weapons. The United States unilaterally discontinued the production of HEU for weapons in 1964 and the production of plutonium in 1988, and the Bush administration recently dropped its plans to resume production in the future.[5] The Soviet Union announced the end of its production of HEU for weapons in 1989;[6] half of its plutonium production reactors have been shut down, with the remainder slated for shutdown by 2000.[7] Since the superpowers have already produced enough material for 50,000 nuclear weapons, there simply is no need for additional production in an era of declining arsenals. A bilateral, verifiable production cutoff would alleviate worst-case analysis of Soviet warhead production and their potential for rapid breakout. More importantly, it would pave the way for a global ban on the production of fissile material for weapons--a ban that could include important NPT nonsignatories, such as China, France, India, Israel, and Pakistan. President Gorbachev and

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[3] Fissile materials are those that can sustain a fast-neutron chain reaction. The two most common fissile materials are uranium-235 and plutonium-239; other fissile materials are exist (e.g., uranium-233), but they are more expensive to produce and fabricate. For a review of restraints on warheads and fissile materials, see Frank von Hippel and Roald Z. Sagdeev, eds., ***Reversing the Arms Race*** (New York: Gordon and Breach, 1990); and Federation of American Scientists, ***Ending the Production of Fissile Materials for Weapons, Verifying the Dismantlement of Nuclear Warheads: The Technical Basis for Action*** (Washington, DC: Federation of American Scientists, May 1991).

[4] IAEA, ***Annual Report for 1989*** (Vienna: IAEA Report GOV/2440, 1990), p. 103. An additional 40 NPT-signatory states had signed safeguard agreements but do not currently have significant facilities to be safeguarded; another 10 states are not signatories but had accepted IAEA safeguards on specific nuclear facilities as part of agreements with the countries that had supplied those facilities.

[5] U.S. Department of Energy, ***Nuclear Weapons Complex Reconfiguration Study***, DOE/DP-0083, January 1991, p. 49.

[6] Speech by President Gorbachev in London on 7 April 1989.

[7] Thomas B. Cochran and Robert S. Norris, ***Soviet Nuclear Warhead Production*** (Washington, DC: Natural Resources Defense Council working paper NWD90-3, February 1991); V.F. Petrovsky, statement to U.N. General Assembly, 25 October 1989.

Foreign Minister Shevardnaze publicly declared their support for a production cutoff in 1989;[8] given current U.S. plans not to resume production, a bilateral cutoff should be popular with the U.S. Congress, though vigorous opposition from the Department of Energy--whose job it has been to produce fissile material--certainly can be expected.

The verification of a fissile material production cutoff would be straightforward. Civilian facilities would be placed under IAEA-type safeguards, with similar safeguards installed at mothballed uranium-enrichment facilities and plutonium-production reactors. Although some provision would have to be made for the continued production of HEU for U.S. naval reactors and tritium for the remaining stockpile of nuclear weapons, acceptable safeguards should not be too difficult to design since the potential for diversion in these cases is rather small.[9]

Although it is a step in the right direction, a production cutoff merely caps the inventories of uranium and plutonium at their current, very high levels.[10] If controls on fissile materials are to provide a meaningful constraint on the arms competition, these stockpiles must be reduced in a verifiable and irreversible manner. The simplest approach is simply to place an agreed amount of material under international controls.[11] If, for example, an arms control agreement cut the allowed number of deployed warheads in half, then each superpower could turn over a specified amount of each material (e.g., 50 tons of plutonium and 250 tons of HEU). If either country decided to break out of a set of interlocking treaties at a later date, they would have to build additional missiles *and* produce additional fissile material (or perhaps even build facilities to produce the material, if the old facilities were dismantled under the agreement). Thus, the two types of agreements are mutually reinforcing.

One objection to turning over a fixed amount of material is that one party may have produced significantly more material than the other, leaving it with a greater relative advantage after equal reductions. If, for example, the United States had produced 100 tons of plutonium and the Soviet Union had produced 150 tons, turning over 50 tons each would give the Soviet

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[8] Warren Donnelly, ***Proposals for Ending U.S. and Soviet Production of Fissile Materials for Nuclear Weapons*** (Washington, DC: Library of Congress, Congressional Research Service, Issue Brief IB89141, 9 November 1989).

[9] Maintaining a stockpile of 50 kilograms of tritium (about half the current stockpile) would require operating a 600-megawatt reactor; if used to produce plutonium, such a reactor could produce 200 kilograms of plutonium per year--only about 0.2 percent of the current U.S. plutonium stockpile per year, assuming 100 percent diversion. The amount of HEU flowing through the U.S. naval fuel cycle amounts to less than 1 percent of the U.S. HEU stockpile per year, and only a small fraction of this could credibly be diverted to weapon uses. The Soviet Union does not use HEU in its naval reactors.

[10] The U.S. is estimated to have produced about 500 tons of HEU and 100 tons of plutonium for weapons; the Soviet Union is estimated to have produced roughly equal quantities of both materials. Frank von Hippel, David Albright, and Barbara Levi, ***Quantities of Fissile Materials in U.S. and Soviet Nuclear Weapons*** (Princeton, NJ: Princeton University, Center for Energy and Environmental Studies, PU/CEES Report #168, 1986); Thomas B. Cochran, William M. Arkin, Robert S. Norris, and MIlton M. Hoenig, ***Nuclear Weapons Databook***, Vol. 2: ***U.S. Nuclear Warhead Production*** (Cambridge, MA: Ballinger, 1987). Perhaps 10 to 20 percent of these materials are in the production pipeline and in scrap awaiting recovery.

[11] Although material could be stored in safeguarded facilities, eventually some provision for the ultimate disposal of the material would have to be made. This is fairly straightforward for HEU, since it could be mixed with natural or depleted uranium to fuel commercial reactors. If used in this manner, the economic value of the current U.S. stockpile of HEU reserved for use in weapons is roughly $10 billion. The ultimate disposal of plutonium is more problematic, since it is uneconomic at present to use plutonium as fuel in commercial reactors.

Union a two-to-one advantage. This problem could be solved if both sides declared the size of their stockpile and reduced to equal levels on both sides. This would, however, involve the additional complication of preparing and verifying the stockpile declarations. The superpowers can probably estimate their own stockpiles of weapon-grade uranium and plutonium to within a few percent, but it is doubtful whether these estimates could be verified by the other side to better than 10 percent.[12] Even so, this would provide yet another constraint on worst-case breakout scenarios.

A significant shortcoming to this approach is that the number of warheads that can be built with a given amount of fissile material is not well-defined. By redesigning warheads to be more efficient in their use of fissile material, a given amount of material might be sufficient to build, say, twice as many warheads as in the original arsenal. This would be highly improbable, however, if controls on fissile materials were coupled with a ban on nuclear testing (see below), in view of the dubious benefit provided by untested weapons (especially those that minimize fissile materials). This is another example of the mutually reinforcing nature of different types of arms control agreements.

Another approach is to verifiably dismantle the warheads associated with delivery systems slated for elimination. For example, START calls for the elimination of 154 SS-18 missiles, which presumably are armed with 1,540 warheads. Although the missiles represent a much larger fraction of the economic value of the weapon system than the warheads, dismantling the warheads would not only provide another constraint on Soviet breakout, but would also serve as a powerful symbol of superpower restraint that would reinforce the nonproliferation regime. Without warhead dismantlement, warheads from delivery systems slated for elimination can simply be stockpiled for later reuse (although the fissile material they contain might have to be recovered to comply with an agreement limiting the stockpiles of these materials). In fact, the United States reworked the warheads of the Pershing II missiles, which were eliminated by the INF Treaty, into B-61 bombs, which can be returned to Europe.[13] The question of what happens to the warheads of dismantled delivery systems was raised repeatedly in the U.S. Senate hearings on the ratification of the INF Treaty, and concern over warheads is sure to be voiced again in the START ratification debate.

The verified dismantlement of agreed types of warheads would be far more complex than simply turning over agreed amounts of fissile materials, but the symbolic value would also be far greater. This approach would involve perimeter-portal controls around the dismantlement facilities, with checks made at the portals to ensure that the warheads delivered to the facility are intact and of the agreed types. The warheads could then be dismantled in the privacy of one's

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[12] The production records used to determine stockpile size could be authenticated in much the same way as other documents and manuscripts are authenticated. In addition, physical evidence remains that could be used to confirm these records. For example, the quantity of plutonium produced in a production reactor can be estimated by measuring the quantities of long-lived radionuclides in permanent structural components of the core. See Steve Fetter, "Estimating Plutonium Production from Long-lived Radionuclides in Permanent Structural Components of Production Reactor Cores," in Frank von Hippel and Roald Z. Sagdeev, eds., ***Reversing the Arms Race: How to Achieve and Verify Deep Reductions in the Nuclear Arsenals*** (New York: Gordon and Breach, 1990).

[13] Robert S. Norris and William M. Arkin, "Beating Swords into Swords," ***Bulletin of the Atomic Scientists***, November 1990, pp. 14-16.

own facility. The most difficult aspect would be devising methods to ensure that the warheads are of the agreed types and are intact without revealing sensitive design information.[14] It is unclear whether warhead dismantlement would have significant advantages over controls on fissile materials alone, since the fissile materials represent a large fraction of the value of a warhead, and since fissile materials are the only warhead components that are produced in large, distinctive facilities, and whose lack of production could therefore be verified with confidence.

Mutual Restraints on Weapon Development and Testing

A fundamental assumption of U.S. national security policy has been that Soviet superiority in numbers (of tanks, troops, missiles, etc.) can and should be offset by U.S. superiority in technology. This has required a vigorous research and development effort, with large, well-funded laboratories leading the search for new defense technologies. The SDI program can be seen as the latest example of a misguided belief that U.S. scientists and engineers, if given enough time and money, can solve our security problems with some new gadget.

Security problems are ultimately political, however, and have no technical solution. The end of the Cold War has driven home the lesson that cooperation is a far more solid basis for security than competition. A continued technical competition for superior nuclear weaponry is not only wasteful, but can easily undermine cooperative security arrangements by breeding fears of sudden technological breakthroughs. We need to move beyond controls on the deployment of weapons and warheads, to control the development and testing of technologies that could upset a stable balance. This is especially important because as warhead levels decrease, perceptions that new technologies could alter the balance increase. But if the promise of new warfighting technologies can be made to fade, military planners will be forced to abandon dangerously destabilizing strategies based on the ability to fight a nuclear war, and rely instead on a stable, mutual deterrent at far lower levels.

Restrictions on development and testing have been the most controversial of all arms control proposals. Perhaps the most elusive and hotly debated nuclear arms control proposal of all is a comprehensive test ban (CTB), which would end all nuclear testing in all environments. In the past decade, we witnessed an energetic debate about the degree to which the Anti-Ballistic Missile (ABM) Treaty restricted research, development, and testing of ABM technologies. Unlike arms control treaties that limit the deployment of particular weapons, restrictions on development and testing have wide-ranging and perhaps unforeseen consequences; it is the sweeping nature of such restrictions that has created such passion in the CTB and ABM debates. Here I will focus on testing limitations: on nuclear explosions, on the flight of ballistic missiles, and on weapons designed to destroy ballistic missiles and satellites.

Nuclear testing limitations[15]

[14] For a discussion of several possibilities, see The Federation of American Scientists, ***Ending the Production of Fissile Materials***.
[15] For a review of the history of testing limitations and an analysis of arguments for and against a nuclear test ban, see Steve Fetter, ***Toward a Comprehensive Test Ban*** (Cambridge, MA: Ballinger, 1988).

Nuclear testing is already restricted by three treaties: the Limited Test Ban Treaty (LTBT) of 1963, which moved testing underground; the Threshold Test Ban Treaty (TTBT) of 1974, which limited underground tests to yields of less than 150 kilotons; and the Peaceful Nuclear Explosions Treaty (PNET) of 1976, which provided similar limits for non-military explosions. Although the moderating effect of a test ban on weapon modernization was cited as an advantage by the Kennedy administration, the main concern at the time was the radioactive pollution caused by atmospheric testing. Although Kennedy and Khrushchev seemed to favor a complete ban on testing, they settled on a limited treaty when they were unable to agree on verification provisions for underground explosions. With the fallout of atmospheric testing eliminated, public support for a test ban largely evaporated.

Some hoped that weapon modernization would be inhibited by underground testing, but the weapon laboratories in both countries soon learned to cope with testing in this medium. Indeed, just a few years after the LTBT was signed, the rate of underground testing exceeded the previous atmospheric rate. The net effect of the Treaty was to speed weapon development.

Similarly, the TTBT did little to impede weapon development. By allowing explosions up to 150 kilotons, the TTBT permitted the design and deployment of new U.S. warheads with yields over one megaton; at this level the Treaty is of almost no value in constraining the nuclear competition. A yield threshold this high certainly could not have been justified on the basis on verification difficulties. For all practical purposes, nuclear testing remains essentially unrestrained.

After nearly 35 years of debate, a complete ban on testing remains as elusive as ever. Until the early 1980s, a CTB was an official goal of U.S. policy, with the United States claiming that intrusive verification procedures, which the Soviet Union would not permit, were the only barrier to a CTB. The Soviet Union, whose nuclear testing program is severely constrained by public protests, favors a CTB and is now willing to permit all necessary verification measures, but the United States has changed its position, claiming that it must test as long as it relies on nuclear weapons for its security.

Continued testing is not without cost, however. The United States is coming under increasing criticism from non-nuclear-weapon states for its refusal to ban testing, especially now that the Soviet Union appears willing and eager. Although testing is not mentioned specifically in Article VI of the NPT, the preamble recalls the determination expressed in the LTBT "to seek to achieve the discontinuance of all test explosions of nuclear weapons for all time and to continue negotiations to this end." Rightly or wrongly, many non-nuclear-weapon states believe that a CTB is the *sine qua non* for superpower compliance with Article VI. At the last NPT review conference, a group of nonaligned nations insisted that achieving a CTBT should serve as a litmus test for compliance with Article VI; for the first time, no compromise language could be drafted that was acceptable to all parties. Many observers believe that unless substantial progress is made toward a CTB in the next four years, it will be difficult to get general agreement on a lengthy extension of the NPT during the final review conference in 1995. It is conceivable that states that are unhappy with the NPT more generally (e.g., a coalition of Arab states) could use test ban issue to derail the NPT. In this case, a CTB may do more than just reinforce the nonproliferation regime--it may be necessary to keep the regime from collapsing completely.

Out of frustration with the U.S. position, a group of LTBT signatories convened a conference in New York earlier this year to propose an amendment to the LTBT that would ban underground tests as well. Even though it was recognized in advance that the United States would never agree to such an amendment, the conference was attended by 94 of the 117 states party to the LTBT (several of whom are *not* signatories of the NPT), which gives some indication of the symbolic importance that many states attach to this issue. In the end, 75 countries voted to continue consultations with a view to achieve a ban on underground testing; only the United States and the United Kingdom voted against.[16] (Nineteen states abstained, many of whom felt that a LTBT amendment conference was not the proper forum for CTB negotiations.)

The U.S. government argues that a CTB is a poor form of arms control, since nuclear testing is needed to maintain and improve the safety and reliability of nuclear weapons, and that a CTB would do little to slow the arms race in any case. Analysts outside government--many of whom have substantial experience designing nuclear weapons--believe that the safety and reliability of the stockpile can be maintained without nuclear testing.[17] The current stockpile is quite safe, and is becoming safer as the stockpile is modernized with the latest round of weapons that incorporate insensitive high explosives. Similarly, there is no reason that the reliability of the stockpile cannot be maintained with a vigorous program of computer simulation, disassembly, non-nuclear testing, remanufacture, and substitution.

There is some truth to the argument that, by itself, a CTB would not do much prevent a continued arms competition. A CTB would stop the development of new nuclear warheads, but it would not necessarily impede the development of new, more capable delivery vehicles. In recent years, for example, continued testing has allowed the development of new warheads for the MX and Trident II missiles, but warhead modernization contributed very little to the increased warfighting capability of these missiles. Most of the increase in capability is due to the increased accuracy of the missiles, which depends very weakly on warhead design. These missiles would be nearly as capable if they had used an existing reentry vehicle, or if the new reentry vehicle had been designed around an existing warhead. This can be seen as a benefit, in that a CTB would not prevent the deployment of mobile missiles and other systems that are deemed stabilizing. The Midgetman missile, for example, can use the warhead developed for the MX missile, and the advanced cruise missile can use the warhead developed for the old ALCM.

Although a test ban would not necessary prevent using an old warhead on a new delivery vehicle, the stockpile-to-target sequence would have to be similar to the conditions the warhead was designed to operate under. To take an extreme example, an old warhead could not be used in a strategic earth-penetrating warhead (EPW), since no existing warhead was designed to survive under these severe conditions. EPWs detract from stability since they are designed to attack the deeply buried command posts. Attacks on command posts are far are profitable before the weapons they command are used (i.e., in a first strike) than after; moreover, knowledge by

[16] Proliferation newsletter.
[17] York, Kidder, Mark, Garwin, etc.

leaders and commanders that they are threatened may encourage preemptive or launch-on-warning strategies, since they might believe that they would not survive to order a retaliatory strike. At the very least, developing a capability to destroy command and control centers would foster a dangerous devolution of launch authority to lower-level commanders, to ensure retaliation even after decapitation.

The development of new and significantly different types of warheads is undesirable in general, because such developments are usually part of efforts to increase counterforce and decapitation capabilities. For example, nuclear-driven microwave weapons might be capable of destroying mobile ICBMs, which their owners look upon as survivable retaliatory weapons. X-ray lasers, if developed, would be potent antisatellite weapons, capable of wiping out early-warning and communications satellites in an instant (see below). Even if such weapons do not upset the nuclear balance, they lead to an expensive competition in countermeasures--a competition fed by worst-case analysis.

Resolving the test ban debate will not be easy. The Bush administration and the nuclear weapon laboratories are strongly opposed; the Soviet Union and many vocal non-nuclear-weapon states (including some threshold states such as India) are strongly in favor. Even if the Bush administration changed its mind or if a more favorably disposed president was elected in 1992, ratification of a CTB by the U.S. Senate would be very difficult (but not impossible with strong presidential support and the continuation of warm relations with the Soviet Union).

A more practical approach may be to lower the yield threshold of underground tests, to limit the number of tests per year, or to agree to some combination of thresholds and quotas. There are two problems with this approach: it will not end the criticism that the nuclear powers are failing to honor their obligations under Article VI unless the threshold and/or quota is very low; but if the threshold and/or quota *is* very low, the agreement would draw the same intensity of opposition from the weapon laboratories and conservative members of Congress as a CTB. If an agreement worth having will be as difficult to get as a CTB, then why not try for a CTB? A CTB may seem impossible to get, but it is illogical to settle for a more politically plausible agreement that isn't worth having.

One possible way to bridge the gap between the desirable and the politically possible is to negotiate a phased reduction, in which the yield and/or number of tests would be reduced according to a fixed schedule. For example, such an agreement might allow five or six tests per year up to 150 kt in the first two or three years and five or six tests per year up to 15 kt in the next five or ten years; after this, no tests at any yield would be allowed. It would be difficult for the weapon laboratories to argue convincingly against such an agreement, since it would allow current modernization programs to be completed and it would allow the laboratories plenty of time to conduct extensive reliability and safety tests. It is vitally important that such an agreement be negotiated and ratified in a single treaty--not a series that threshold agreements. In this way, non-nuclear-weapon states could see that the superpowers were on a smooth track to a CTB in the foreseeable future, while avoiding an endless series of ratification debates.

Ballistic-missile flight-test limitations

Before the deployment of multiple, independently targetable reentry vehicles (MIRVs) on highly accurate ICBMs in the mid- to late 1970s, missiles in hardened silos could withstand a first strike by a roughly equal number of enemy missiles. Today, however, a single MX-like missile carrying 10 warheads could destroy five to eight similar missiles carrying 50 to 80 warheads.[18] Accurate ICBMs and MIRVs are destabilizing because they give a large advantage to a first strike, and thus encourage preemptive attack. Limitations on the flight testing of ICBMs--especially on the testing of MIRVs--could have prevented what came to be recognized during the late 1970s and 1980s as the main source of instability in the strategic balance. But the United States, in its myopia, pressed its lead in missile technology forward, failing to realize that when the Soviet Union had this technology also, the United States would be at a relative disadvantage.

The genie is already out of the bottle for ICBMs, but flight-testing restrictions could still be an important part of reducing the incentives for sea-based preemptive attack. The START agreement will limit the number of SLBMs and the number of warheads deployed on these missiles, but it will not limit the counterforce capability of these missiles. The development of accurate SLBMs by the United States, coupled with the potential development of depressed-trajectory launches, could greatly increase the counterforce capability of SLBMs, thereby decreasing the stability of the nuclear balance. Accurate SLBMs could simultaneously threaten both soft area targets and hardened point targets, theoretically eliminating the synergy that currently exists between silo-based ICBMs and bombers (and future mobile missiles).[19]

The United States is proceeding with the deployment of the Trident II missile; it is only a matter of time before the Soviet Union deploys an accurate SLBM as well, barring a ban or strict limitation on the flight testing of ballistic missiles. While a flight test ban would prevent the modernization of U.S. ballistic missile forces, it would prevent the Soviets from developing a similar capability, and could prove useful in getting Third World countries to abstain from developing advanced ballistic missiles.[20] One need not ban the test firing of ballistic missiles, only the testing of reentry bodies traveling at high velocity. A ban on fast reentry bodies would make it difficult to achieve increases in accuracy, but it would permit reliability testing of missiles and the recovery of space payloads. The verification of a ban would be straightforward,

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[18] The probability that an incoming MX warhead (300-kilotons, 100-meter CEP) would destroy a silo hardened to 2,000 pounds per square inch (a Minuteman/MX silo) is essentially equal to one; if the reliability of the missile is 80 percent, then 10 warheads could destroy 8 of 10 silos. If two warheads were targeted against each silo, then all 5 silos attacked could be destroyed.

[19] In the past, silo-based ICBMs could only be destroyed with other ICBMs, since SLBMs were not accurate enough to achieve a high probability of kill. Bombers, on the other hand, can only be destroyed by SLBMs, since attacks by ICBMs would allow the bombers enough time to escape (about 30 minutes). If attacking ICBMs and SLBMs are launched simultaneously, the SLBMs will strike in as little as 15 minutes, destroying the bomber force but allowing ICBMs to be launched in the remaining 15 minutes before the enemy ICBMs arrive. The ICBMs might be destroyed if the SLBM attack is delayed (assuming that the ICBMs are not launched on warning of an attack), but then the bombers would survive. Accurate SLBMs would allow bombers *and* ICBMs to be attacked simultaneously in only about 15 minutes; using depressed trajectories, the time might be shortened to as little as 7 minutes.

[20] For an elaboration of this argument, see Steve Fetter, "Missiles and Weapons of Mass Destruction," ***International Security***, Vol. 15, No. 1 (Summer 1991).

since missile launches and reentries are already closely monitored with a variety of satellites and phased-array radars.

Although a complete ban on the flight testing of reentry bodies would be preferable, a ban only on depressed trajectory tests would be more palatable. The United States suggested such a ban in the past, but the Soviet Union wanted to couple this with limitations on the deployment of submarines, which the United States refused.[21] Although neither side has tested SLBMs in depressed trajectories nor indicated plans to do so in the future, unless such testing is banned, the possibility of accurate depressed-trajectory SLBMs will soon become the basis for worst-case scenarios that predict not only the destruction of silo-based ICBMs, but also mobile ICBMs and bombers before they can dash from their bases.

ABM/ASAT testing limitations

Much has been written in last decade about the centrality of the Anti-Ballistic Missile (ABM) Treaty to U.S.-Soviet arms control. Without a ban on defenses there can be no progress in offensive arms control, at least not in the foreseeable future. An effective defense would remove the deterrent capability of the opponent's arsenal, leaving the opponent naked to nuclear coercion if not nuclear destruction. To preserve the deterrent, the opponent would respond by improving the number, quality, and capabilities of his missiles and warheads, and by inventing and deploying weapons specifically designed to destroy or defeat the defense. The defense could then be expected to respond with a series of counter-countermeasures, and so on *ad infinitum*. The realization that this spiraling defense/offense arms race would not improve the security of either country led to the signing of the ABM Treaty in 1972.

Recently, proponents of strategic defense, bolstered by the success of the Patriot antitactical missile system in the Persian Gulf War, have been pressing to conduct tests of SDI technologies that would press against the limits of the ABM Treaty. The United States should resist romantic but unrealistic calls to replace a proven, stable regime of deterrence with one based on renewed competition in both defenses and offenses. The superpowers should use the Standing Consultative Committee established by the ABM Treaty to make explicit exactly what types of development and testing of new technologies the Treaty does and does not ban.

A related issue, but one that receives far less attention, is the testing of antisatellite (ASAT) weapons. The mutual deployment of certain types of ASAT weapons would not be to the advantage of either superpower, but it would be especially disadvantageous to United States, which relies heavily on satellites to communicate with its geographically dispersed forces. Satellites perform several functions that might make them tempting targets in a nuclear or conventional war. Satellites allow political and military leaders to command forces around the world, they detect missile launches and nuclear explosions, they provide navigation information to ships and submarines, and they keep watch over the military facilities of potential adversaries.

Satellites are fragile, and those orbiting close to the Earth are especially easy to destroy. Fortunately, the satellites whose survival is most vital to nuclear deterrence--communications and attack-warning satellites--orbit far above the Earth. A verified ban on ASAT testing would

[21] A reference here?

not only protect these satellites, it would also reinforce the ABM Treaty but preventing the testing of SDI weapons on satellites as a surrogate for tests on missiles. An important side benefit of an ASAT test ban would be to prevent a dramatic increase in space debris, which is already posing a hazard to space travel.

CONCLUSIONS

Focusing on delivery vehicles was wise in early arms control agreements. These negotiations were more adversarial, and limits on delivery vehicles could be verified with ease. The warming of superpower relations, combined with development of delivery systems that are hard to verifiably limit, call for a deepening of arms control efforts to include verifiable limits on warheads as well as the development and testing of new weapons. This will allow the superpowers to achieve a stable, secure balance with less cost and at much lower levels of nuclear weapons, and, perhaps more importantly, it will strengthen the NPT and the moral authority of the superpowers in limiting the proliferation of missiles and weapons of mass destruction.