STEVE FETTER:

Reasons for Nuclear Testing

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Many reasons have been advanced for nuclear testing: to demonstrate a nuclear capability; to test new weapon designs and new design concepts; to provide confidence in the reliability of stockpiled weapons and opportunities to maintain the skills of weapon scientists; to improve the safety and security of nuclear weapons; to test the effects of nuclear weapons on various types of military equipment; and as an explosive energy source for various engineering projects, ranging from canal building to electricity generation.

Although the reasons for testing are easily stated, there is little agreement on what effect a comprehensive test ban (CTB) might have on the rationale for testing. Some believe, for example, that a ban on testing would slow the proliferation of nuclear capabilities to other countries; others believe that a test ban would have little or no effect on proliferation. In other cases there is widespread agreement about the probable effect of a test ban but no consensus about whether such effects would be beneficial for national security and international stability. For example, nearly everyone agrees that a CTB would prevent the development of new types of nuclear warheads, but there is less of a consensus about whether this would be a good thing—that is, whether new warheads would be more likely to enhance or degrade deterrence, crisis stability, and arms race stability.

The goal of this chapter, therefore, is not merely to review the various reasons for nuclear testing, but to examine how this rationale would be affected by a CTB and to evaluate these effects with regard to concepts of nuclear strategy that are appropriate for the post-Cold-War world.[1]

I. Achieving a Nuclear Capability

The five nuclear powers—the United States, the former Soviet Union, the United Kingdom, France, and China—each tested nuclear weapons as soon as it become possible for them to do so, and India has also tested. The fact that the declared nuclear powers all have tested has led some to believe that if testing could be stopped, so would the acquisition of nuclear weaponry be stopped. Unfortunately, it is not so simple. Except for the United States, the nuclear powers conducted their first tests as much to inform the world of their nuclear capability as to test the validity of their designs. Moreover, there was no persuasive reason *not* to test—no treaties or generally recognized international norms of behavior were violated.

The costs and benefits of a first test are very different today. It is generally agreed that a first-generation nuclear device can be designed and built, and that high confidence in its reliability could be obtained, without a nuclear test explosion. High-speed computers and accurate computer models and nuclear data, coupled with extensive non-nuclear testing, have greatly reduced the need for testing; only the absence of weapons-grade uranium or plutonium prevents many nations from assembling reliable nuclear weapons. Any nation that is capable of obtaining weapons-grade materials, either by enrichment or by operating reactors and reprocessing, is probably capable of building a bomb without resort to nuclear testing. It is reported that Sweden, in a secret project during the 1950s, designed a nuclear bomb in which it had high confidence without nuclear testing.[2] According to many reports, Israel has developed advanced weapons[3] without having been known to have conducted a nuclear test;[4] Pakistan and South Africa are also widely credited with a nuclear capability.

A particular nation's judgment about the desirability of a nuclear test will, however, depend on its level of scientific and technological expertise and its strategic rationale for desiring nuclear weapons. Technologically unsophisticated nations, such as Pakistan, are more likely to validate theoretical calculations with a nuclear test than countries with greater expertise, such as Israel. On the other hand, nations that wish to develop advanced nuclear weapons in order to maximize their war-fighting utility are more likely to test than those that are content with a primitive nuclear capability. The faith of political and military leaders in the competence of their weapon scientists would also be a key issue. Even if, for example, Iraqi scientists could build a primitive nuclear weapon in which they would have confidence without testing, would Iraq's military leaders take this on faith or would they want a demonstration?

While the benefits of testing have diminished, the costs have increased. A nuclear test is a highly visible demonstration of nuclear capability which rivals cannot ignore. While a wise government may choose to forgo or postpone a nuclear capability even if it is convinced that a rival has developed nuclear weapons, it may not be able to withstand the domestic pressure that would develop in favor of proliferation if the rival vividly demonstrates its capability with a nuclear test. Israel, for example, must be acutely aware of the consequences that would flow from an overt demonstration of its nuclear capability. Not only would an Israeli test greatly stimulate the nuclear ambitions of Arab nations, but it would also trigger economic boycotts and the possible withdrawal of U.S. aid. In most cases, the legal obligations entailed in signing a CTB would be an insignificant addition to the inhibitions against nuclear testing that already exist, and a nation bent on testing simply would not sign a CTB in the first place.

II. New Weapon Designs

The principal reason for nuclear testing has been to support the development of new nuclear weapons, at least in the United States and the former Soviet Union. The perceived necessity of developing new warheads has often supported by noble justifications: increasing stability, strengthening deterrence, reducing collateral damage, or even eliminating the threat of nuclear attack through defense. Unfortunately, nuclear testing has had little to do with these lofty goals.
In the United States,[5] most nuclear testing has been devoted to the development of warheads for new delivery vehicles. In fact, nearly every U.S. nuclear weapon system has been deployed with a custom-designed warhead. While designing a new warhead requires at least a half-dozen nuclear tests, it is important to note that custom-designed warheads are rarely necessary to deploy a new delivery vehicle.

Nearly all U.S. weapon systems deployed over the last two decades could have used warheads that were already in the stockpile. For example, the MX missile could have used the warheads developed for the Minuteman III; the Trident II could have used the MX, Minuteman-III, or Trident-I warheads; and so forth. Just as astronauts are not redesigned for space travel, nuclear warheads need not be custom-designed for each new missile—careful attention to the packaging would suffice.[6]

Maintaining a stable deterrent relationship remains a central goal of U.S. (and presumably Russian) policy, but no new warheads are required to maintain a stable deterrent. Both the United States and Russia have more than enough nuclear weapons, and enough types of nuclear weapons, mounted on enough types of delivery vehicles, to provide for a very survivable and awesome deterrent force. In fact, substantial reductions beyond those already planned by Bush and Yeltsin are possible, desirable, and have already been proposed by Russia.

Over the years, many changes have been required in the U.S. arsenal to strengthen deterrence, but none of these changes depended on nuclear testing. For example, improved Soviet air defenses were countered by fielding air-launched cruise and short-range attack missiles (which could have been designed to use existing warheads), not to mention electronic countermeasures and stealth technologies. Longer-range sea-launched ballistic missiles (SLBMs) improved the survivability of submarines, but nuclear testing was not necessary to field these systems. Additional investments in survivability are not necessary, but if at some future date they are deemed necessary, more survivable systems can be designed to use existing warhead types. For example, the Midgetman mobile missile can be deployed with the MX warhead, just as the advanced cruise missile will use the air-launched cruise missile warhead.

Some U.S. weaponeers have recently claimed that nuclear testing is necessary to support the development of a new generation of nuclear weaponry. For example, they argue that very-low-yield nuclear weapons might be needed to deter the use of nuclear weapons (or chemical and biological weapons) by Third World countries or to destroy the hardened bunkers of despots such as Saddam Hussein.[7] They claim that current weapons have yields that are too high, thus deterring U.S. policy makers from using them. The Gulf War, however, showed that conventional explosives mounted on smart weapons were extremely effective at destroying hardened targets and conventional forces. The war also showed that fuel-air explosives, which have a destructive effect comparable to the proposed "micro-nukes," could be deadly to dug-in troops. Moreover, Iraq was deterred from using its extensive chemical and rudimentary biological weapons by current U.S. forces. There is no evidence to suggest that the United States needed micro-nukes in the Gulf, or that the United States or any other nuclear power will need new types of nuclear weapons to deal with such threats in the future.

Earth-penetrating warheads, which would require nuclear testing, have been proposed to attack hardened targets while reducing collateral damage. But earth-penetrating warheads would be most valuable in a counterforce first strike—especially in a strike against the command and control system. To the extent that this development occurs, it will make a first strike more attractive and deterrence less stable. Some novel nuclear weapon concepts, such as a nuclear-driven microwave weapon, have been promoted because of their potential to destroy re-locatable targets (i.e., mobile missiles and command posts) and disrupt communications. A basic tenant of U.S. doctrine is that strategic forces and their command and control should be invulnerable to preemptive attack; this is the rationale behind the development of mobile missiles. If opposing forces are also invulnerable, then neither side has an incentive to start a war (either because of a hope of conducting or a fear of suffering a disarming first strike), and deterrence is stable. Therefore, to the degree that a CTB prevents nuclear powers from developing a capability to destroy re-locatable targets and communication systems, it is a positive contribution to the security of all nations.

Nuclear-driven microwave weapons are just one example of a larger collection of concepts known a "nuclear directed-energy weapons" (NDEWs). The basic idea is to convert a portion of the energy released by a nuclear explosion into some other form, and, by directing the energy into a narrow beam, achieve a much greater destructive effect at long distances than would be achieved by the nuclear explosion alone. In the United States the development of most NDEWs is related to the Strategic Defense Initiative, although the concepts are by no means limited to defensive applications. The best-known NDEW concept is the X-ray laser, which was initially intended to destroy ballistic missiles in their boost phase. But even if they could be made to work (and there is no reasonable prospect that they could), X-ray lasers could be rendered powerless for this purpose by fast-burn, single-warhead boosters that burn out at altitudes of less than 80 kilometers, since even the most powerful X-ray laser beams could not penetrate deeper into the atmosphere to intercept them.

On the other hand, X-ray lasers could be much more effective offensive weapons. Because they would be relatively small and light, X-ray lasers could be stationed inconspicuously in space or "popped-up" into space on a few minutes notice. A handful of X-ray lasers could preemptively destroy attack-warning and communication satellites just before an attack; the development of a weapon that could instantaneously destroy these satellites would be extremely destabilizing.

Because the offensive potential of X-ray lasers as antisatellite weapons outweighs their defensive potential, a CTB would be a logical step toward eliminating the threat that would be posed by the development of these weapons. Similar arguments can be made for other NDEWs, since each would demonstrate the ability to destroy satellites long before they would be capable of destroying boosters or RVs.

Although continued weapon development has been the most important rationale for continued testing, such arguments are growing increasingly feeble. Nuclear weapon development is at a standstill in Russia and the United States, and no new designs are needed for a stable deterrent. Stabilizing developments, such as the deployment of mobile missiles, can occur without nuclear testing, and many of the developments that require testing, such as mini-nukes, earth-penetrating warheads, and NDEWs would worsen arms race and crisis stability.

III. Reliability of Stockpiled Weapons

The argument that nuclear testing is needed to ensure the continued reliability of stockpiled nuclear weapons is by no means universally accepted. Indeed, a rather long stream of expert testimony has been produced by current and former weapon designers on both sides of the issue.[8]

Stockpile confidence is not the same as stockpile reliability. Reliability is an objective measure of warhead performance, and can be measured to any degree of accuracy by performing enough tests. Confidence, on the other hand, is the belief of those responsible for the stockpile that the weapons are reliable. The difference between confidence and reliability could become extreme in the absence of continued nuclear testing. One could have perfect confidence in weapons that would be unreliable if used, or one could lose confidence in weapons that were perfectly reliable. Therefore, proving that nuclear weapons could be kept reliable during a CTB is not the same as proving that confidence could be maintained.

This is not a trivial point, since deterrence is more a matter of perception than reality. If leaders are convinced of the reliability of each other's weapons, then the requirements of deterrence are satisfied independent of the actual reliability of the weapons. The difference between confidence and reliability would only be revealed on the fateful day that deterrence failed.

Some CTB advocates welcome a decline in confidence, because they believe that this would improve crisis stability since the effectiveness of a first strike would be subject to even larger uncertainties. But even if this argument is theoretically sound, it is politically unwise. Political and military leaders are unlikely to be convinced that it is somehow better to believe that one's own weapons are unreliable.

The U.S. weapon laboratories claim that it is impossible to maintain the reliability of nuclear weapons without testing.[9] Their arguments are based mostly on the fact that nuclear testing was used to correct a series of problems that occurred with stockpiled weapons in the past. But the fact that nuclear testing was used to correct problems does not prove that testing was necessary. In some cases tests indicated that a problem did not exist after all; in many others, solutions were available that did not require testing—it was merely cheaper or more convenient to redesign the warhead. Moreover, two thirds of the problems were design errors, all of which were detected and resolved within four years of the date of first production. Most of these problems occurred with warheads designed in the late-1950s.[10]

Only once was a problem discovered in a stockpiled weapon as a result of a nuclear test; in other cases testing was used only to assess recognized possible problems. Indeed, the rate of nuclear testing for such purposes has been very low. Potential problems can be detected and evaluated by careful disassembly and inspection of stockpiled warheads, by nonnuclear testing, and by continuing improvements in computer modeling.

If problems are detected with stockpiled weapons during a test ban, there would be several ways to restore confidence in the weapon system without resorting to nuclear testing. If, for example, the problems are due to aging and deterioration of weapon components, the weapon could simply be remanufactured to its original specifications. In testimony before the U.S. Congress, both Admiral Sylvester R. Foley (then-Assistant Secretary of Energy for Defense Programs) and Roger Batzel (then-director of Lawrence Livermore National Laboratory) stated that, given enough time and money, remanufacture could be achieved.[11] Programs could begin now to test and certify alternate materials for key warhead components that are known to deteriorate, such as high explosives. Once a test ban begins, the much smaller post-Cold-War arsenals could be maintained by the continuous remanufacture of a few weapon types at a much lower rate.

If laboratory techniques and remanufacturing are not sufficient to restore confidence in an aged warhead, there is often an alternate warhead that could be used on the delivery vehicle. Consider, for example, the U.S. intercontinental ballistic-missile (ICBM) force. If the warhead used on the MX (and probably Midgetman) missile should develop serious stockpile confidence problems, then either of the two Minuteman-III warheads could be substituted with little loss in effectiveness. Similar arguments can be made for the other legs of the triad. The U.S. Trident-II missile, for example, will carry two very different warhead types; if confidence wanes in one, greater reliance can be placed on the other. One could also consider using ICBM warheads on SLBMs, and vice-versa.[12]

Finally, if one believes that a combination of nonnuclear techniques, remanufacturing, and substitution would not be sufficient to resolve all important stockpile confidence problems that might arise, one could design and test a small set of super-reliable, deterioration-resistant, easily remanufactured warheads before a test ban entered into force. Such a program need not be excessively expensive since only three strategic weapons need to be developed: one for ballistic missiles, one for air-launched missiles, and one for bombs. The weapons need not be deployed in large numbers; the existence of super-reliable designs would simply be an insurance policy against catastrophic failure in the regular stockpile. Thus, any decrease in the safety or effectiveness or increase in the cost of the stockpile associated with the introduction of super-reliable warheads need only be accepted in the unlikely event that other measures short of nuclear testing could not solve the problem.[13]

IV. Retention of the Technological Base

The stock of weapon scientists with nuclear testing experience would diminish gradually under a CTB, and the cessation of testing and weapon development may accelerate the loss of trained scientists and make the recruitment of high-quality personnel more difficult. This raises several interrelated questions.

First, would it be difficult for the weapon laboratories to keep experienced scientists and hire high-quality personnel under a CTB? The fact that weapon laboratories would no longer be stockpiling new types of warheads would undoubtedly lead some to leave, but many motivations for weapon-related work would persist under a CTB. Much work would remain that is challenging and creative, laboratory equipment could still be first-rate, and the contribution to the national defense as important. Scientists wanting a new challenge could move to nonweapon programs at weapon laboratories, where they would still be available for consultation about stockpile problems.

Second, even if reasonably good scientists are available, can they keep the stockpile reliable without the skills and practical experience that nuclear testing can give? Although tests are essential to confirm predictions about designs that extend the state-of-the-art, they are not necessary to maintain and remanufacture established designs. Experienced weapon designers are involved in the production of a warhead, but only in the initial phases when it is uncertain whether the production processes can match the specifications of the designer. After this, there is little designer involvement; continuous remanufacture could maintain continuity of knowledge and skills in the production process. Furthermore, every activity other than nuclear testing that contributes to design expertise would be available under a CTB. Besides exploring the theoretical aspects of weapon design, scientists could investigate many aspects of weapon physics by using the nonnuclear testing and computer simulation. Experiments in a wide variety of areas could be done using the small fusion explosions created in the laboratory with inertial confinement fusion. The design of advanced conventional explosives would also help to maintain skills of direct relevance to nuclear weapon design. Of course, if some low level of nuclear testing is allowed under a test ban treaty, this would also help to maintain skills. And even though testing experience is unlikely to be important for maintaining the stockpile, there would still be some scientists remaining with testing experience twenty or more years after a CTB was negotiated.

Third, will those responsible for maintaining the stockpile have confidence in their own work without recourse to nuclear testing? This question underscores the difference between confidence and reliability. As pointed out above, well-trained, competent people who make correct decisions could lose confidence, and incompetent scientists could be completely self-confident. Many of today's weapon designers say that they would be less self-confident without access to nuclear testing, even if they were only responsible for maintaining old designs. This may turn out to be true, but it is hard to find examples of a similar loss of self-confidence in other technical fields where testing is difficult or impossible. There may be a perverse effect at work here: without experimental data to prove them wrong, scientists become more confident in their theoretical judgment. This effect might be exaggerated if those who are most comfortable with experimental proof leave the laboratories.

Fourth, it is often said that budgetary support for the weapon laboratories—whose primary mission, the development and testing of new weapons, would have been effectively banned—would evaporate under a CTB. This is unlikely to happen in the United States. It is doubtful that a CTB would be ratified by the U.S. Senate without support from the Joint Chiefs of Staff. This support, in turn, is unlikely without certain assurances, or safeguards, from the president that would partially compensate for the loss of nuclear testing. In the case of the Limited Test Ban Treaty, these safeguards included well-funded weapon laboratories, a vigorous underground nuclear testing program, and maintenance of the capability to resume atmospheric testing should Russia violate the treaty.[14] In the case of a CTB, safeguards might include well-funded laboratories, a vigorous nonnuclear testing program, and maintenance of the capability to resume underground testing on short notice.

It is inevitable that the technological base for weapon development and stockpile maintenance will erode under a test ban, but this process is likely to be gradual. It is important to note that many proponents of a CTB believe that the deterioration of the technical base is <u>good</u>, because it serves to dampen the arms race, make breakout more difficult, and is consistent with a decreased reliance on nuclear weapons for more than simple deterrence.

V. Improved Safety and Security

If nuclear weapons must exist, they should be as safe and secure as possible. Nuclear weapons should be immune from accidents such as a nuclear explosion or a dispersal of plutonium if a bomb is dropped accidentally, and they should be protected from unauthorized use by both terrorists and armed forces personnel.

No known accident with nuclear weapons has resulted in an appreciable nuclear yield, because a large number of nuclear reactions will take place only if the chemical explosive is detonated symmetrically. Weapons are designed so that this is not possible with a detonation at one point in the high explosive, as might happen in an accident. This attribute is called "one-point safety."[15] It is generally assumed that all U.S. nuclear weapons currently deployed meet this criterion. If doubts arise about whether a stockpiled warhead meets the one-point safety criterion, mechanical safing devices could be incorporated or a safe substitute warhead could be found and adapted to the delivery vehicle, neither of which requires a nuclear test.[16]

It is also remotely possible that during an accident the arming system might supply the proper signal to detonate the weapon. To guard against this, many weapons have environmental sensing devices (ESDs). ESDs in missile warheads and bombs can sense acceleration and altitude and will permit the weapon to detonate only if the missile has been launched or the bomb dropped from a given altitude. Most U.S. weapons also incorporate sophisticated electrical safety systems that isolate the warhead electrical system to prevent accidental power surges and to disconnect the power until the weapon receives the proper arming code. The further refinement of such devices and the upgrading of older warheads would not be impeded by a CTB.

Even in the absence of a nuclear yield, accidents involving nuclear weapons can have serious environmental and political effects. About thirty accidents have occurred with U.S. nuclear weapons in aircraft, and in about one quarter of these accidents the high explosive detonated. The majority of these incidents occurred in the 1950s, when long-range bombers and the procedures for handling nuclear weapons were relatively new. Two accidents resulted in widespread plutonium contamination: in 1966, a B52 bomber crashed in Palomares, Spain, and in 1968, another crashed in Thule, Greenland.[17] In no case since the incident at Thule has the high explosive detonated or burned, but accidents still happen. The latest U.S. incidents occurred in 1980, when a Titan-II missile exploded and a B52 carrying nuclear weapons caught fire. It is estimated that a worst-case plutonium-dispersal accident could result in as many as several thousand delayed cancer deaths.[18]

One of the most effective ways to reduce the possibility of plutonium dispersal is to minimize the probability that the high explosive will detonate in an accident. For this reason, most U.S. weapons designed after 1976 use an insensitive high explosive (IHE). Stray bullets and crashes will not detonate IHE. Since IHE is significantly less energetic than normal high explosives, nuclear weapons must be redesigned to use it, which requires nuclear testing. A CTB would therefore prevent old warheads from being retrofitted with IHE (but it would not prevent replacing non-IHE warhead with IHE warheads developed for another system).

It should be noted that use of IHE reduces but does not eliminate the plutonium-dispersal problem, since a fire—such as occurred on the B52 in 1980—could cause even IHE to burn. The consequences of a fire are much smaller than those of a detonation, because a much smaller fraction of the plutonium would be dispersed as respirable particles. Protection against jet-fuel fires can be provided by surrounding the plutonium with a layer of high-melting-point material; this is known as a "fire-resistant pit" (FRPs). FRPs cannot prevent plutonium dispersal from missile-propellant fires, which generate much higher temperatures. The risk of plutonium dispersal from fires can be substantially reduced simply by not loading nuclear weapons onto fueled aircraft or aircraft on or near runways during peacetime.

Fortunately, the U.S. nuclear arsenal is very safe, and will be made substantially safer by the accelerated retirement of older systems as specified by the recent Bush initiatives. With the exception of the Minuteman-III, Trident-I, and Trident-II warheads, the long-term stockpile is equipped with IHE; several also use FRPs.[19] Moreover, announced changes in deployment patterns, such as the safe storage of tactical warheads in bunkers and ending the transport or peacetime deployment of nuclear weapons aboard aircraft, has greatly reduced the probability of an accident.

The gain in safety that could be achieved through continued nuclear testing is very small. If, however, the comprehensive use of IHE is desired, this could be achieved with a program of 4 to 13 additional tests over the next two to three years.[20] If improved plutonium-dispersal safety is considered to be of utmost importance, programs to rapidly incorporate IHE should begin now, and should not be used as an excuse to block movement toward a CTB.

Turning to the issue of security, nuclear weapons are, of course, closely guarded by military personnel. To provide an extra measure of assurance that nuclear weapons cannot be used by unauthorized persons, most U.S. weapons (and reportedly all Russian weapons) are fitted with permissive action links (PALs), which act as a sophisticated electromechanical lock on the weapon's arming system. The weapon becomes operational only after the proper authorization code—which is held by the National Command Authority—is entered into the PAL. The latest U.S. PALs require a six-digit or twelve-digit code, and the number of attempts is limited so that one cannot try all possible codes. Most weapons also incorporate a mechanism that will render a weapon unusable by destroying key components if an attempt is made to bypass the PAL.

Except for naval weapons, all U.S. nuclear weapons are protected by PALs. A test ban would not inhibit extending PAL technology to existing naval weapons, because all but the most sophisticated PALs operate on components that do not require nuclear tests to certify their reliability.[21]

VI. Nuclear Weapons Effects

Yet another reason for nuclear test explosions is to subject various types of military equipment to the effects of nuclear weapons to determine how they would function in the harsh environment of nuclear war (or to predict how effective the weapons would be against enemy equipment). Nuclear warheads themselves are the most common subjects of these tests, to determine how well a reentry vehicle can survive the effects of nearby nuclear explosions. A test ban that prevented the development of new warheads would therefore largely remove the rationale for effects testing. Nuclear effects testing is also used to test command, control, and communications (C^3) equipment and ballistic-missile defense (BMD) components, as well as to verify the survivability of basing modes for nuclear weapons.

Since the Limited Test Ban Treaty (LTBT) was signed in 1963, all U.S., Soviet, and U.K. nuclear testing has been performed underground; France and China have more recently restricted their testing to underground. This greatly limits the types of nuclear effects experiments that can be done. For example, one can test the vulnerability of a reentry vehicle to the X-rays and neutrons produced by an explosion, but one cannot test C^3 or BMD systems for the effects that are produced only by atmospheric explosions. Understanding these effects is crucial for building C^3 and BMD systems that would be effective during nuclear war, but the existing LTBT already prohibits gaining such understanding; a CTB would not change anything in this respect. The LTBT also prevents nuclear experiments to determine the hardness of silos, mobile missile launchers, and bombers. A CTB would only eliminate nuclear weapons as test sources of X-rays, gamma rays, neutrons, and ground shock, and there are other ways to generate these phenomena.

A promising method for generating the X-rays and neutrons produced by nuclear weapons is inertial-confinement fusion (ICF). In ICF, tiny pellets of deuterium and tritium are illuminated by intense laser or particle beams; the pellets implode, producing a small thermonuclear explosion. In the not-too-distant future, yields of up to 1 ton may be achievable; an object located a few meters away from such an explosion would experience very large X-ray fluxes. Roger Batzel, then-director of Lawrence Livermore National Laboratory, stated that ICF may substantially augment, and in some cases substitute for, nuclear vulnerability, lethality, and effects tests now done underground. More vulnerable equipment, such as communications satellites, can be tested using existing X-ray machines or accelerators. Very-low-yield nuclear explosions (e.g., up to 10 or 100 tons), if permitted by a CTB, would be very valuable for effects testing. All current U.S. effects testing could be conducted with explosions less than about 1 kiloton.

Summary

The statement that nuclear testing is necessary as long as nuclear weapons are required for deterrence is simply vacuous. Weapon development, which has been the primary reason for testing, has virtually ended in Russia and the United States; no new types of nuclear weapons are needed to maintain a stable deterrent, or for any other reason. The need for effects testing has nearly evaporated with the need for new weapons. Moreover, confidence in the reliability of the deterrent, as well as the necessary technological base, can be maintained without nuclear testing. Safety and security, while laudable goals, can be increased without testing by changes in deployment patterns already taking place, and by installing PALs on all weapons. If the United States nevertheless considers the comprehensive use of IHE a high priority, this can be achieved with a relatively small program of nuclear testing over the next few years.

Notes

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[1] For a more complete review of these issues, see Steve Fetter, ***Toward a Comprehensive Test Ban*** (Cambridge, MA: Ballinger, 1988).

[2] Christer Larsson, "Build a Bomb!" ***Ny Teknik***, 25 April 1985.

[3] Most of these reports are based on details provided by Mordechai Vanunu, a former technician at Israel's secret Dimona reactor site. See "Revealed: The Secrets of Israel's Nuclear Arsenal," ***Sunday Times*** (London), 5 October 1986.

[4] One cannot rule out the possibility that Israel has tested, or had access to the test data of others. It is reported that the French shared data from their first nuclear test with Israeli scientists. Steve Weissman and Herbert Krosney, ***The Islamic Bomb*** (New York: Times Books, 1981), p. 113. On 22 September 1979, U.S. nuclear-burst-detection satellites detected a signal in the South Atlantic that had the appearance of a 2- to 4-kt nuclear explosion. A panel of experts convened by the White House concluded that the signal probably was not a nuclear explosion, but other equally informed experts came to the opposite conclusion. It has been widely speculated that the signal was caused by an Israeli or joint Israeli-South African nuclear test explosion. Since Israel is reputed to have had nuclear weapons as much as a decade earlier, the test, if it occurred, may have been of an advanced weapon design.

[5] Because so little is known about the Russian nuclear testing program or about their nuclear weapon stockpile (numbers of types, safety and security features, accidents involving nuclear weapons, etc.), I will concentrate on the U.S. testing program. Although there are undoubtedly differences between the U.S. and Russian programs, the similarities probably greatly outnumber the differences.

[6] I am grateful to Richard Garwin for this splendid analogy.

[7] See, for example, William M. Arkin and Robert S. Norris, "Tinynukes for Mini Minds," ***The Bulletin of the Atomic Scientists***, Vol. 48, No. 3 (April 1992), pp. 24-25.

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[8] See, for example, interview with Andrei Sakharov**,** *Voter: Newspaper of the Popular Anti-nuclear Movement "Nevada-Semipalatinsk,*" 24 May 1990; letter to President Jimmy Carter from Norris Bradbury, Richard Garwin, and Carson Mark, August 15, 1978, in House Armed Services Committee Report No. 95-89, "Effects of a Comprehensive Test Ban Treaty on United States National Security Interests," August 14, 15, 1978, Appendix 3, p. 181; letter to Representative Dante Fascell from Hans Bethe, Norris Bradbury, Richard Garwin, Spurgeon M. Keeney, Jr., Wolfgang Panofsky, George Rathjens, Herbert Scoville, Jr., and Paul Warnke, May 14, 1985; letter to Representative Henry J. Hyde from Roger E. Batzel and Donald M. Kerr, June 7 1985 in Hugh E. DeWitt and Gerald E. Marsh, "Weapon Design Policy Impedes Test Ban," ***Bulletin of the Atomic Scientists***, Vol. 41, No. 10 (November 1985), pp. 11-13; interview with Harold Agnew, *Los Alamos Science*, 152 (Summer/Fall 1981), p. 152; J. W. Rosengren, "Some Little-Publicized Difficulties With a Nuclear Freeze," RDA-TR-122116-001 (Arlington, VA: R&D Associates, October 1983); Ray E. Kidder, "Evaluation of the 1983 Rosengren Report from the Standpoint of a Comprehensive Test Ban," UCID-20804 (Livermore, CA: Lawrence Livermore National Laboratory, June 1986); Jack W. Rosengren, "Stockpile Reliability and Nuclear Test Bans: A Reply to a Critic's Comments," RDA-TR-138522-001 (Arlington, VA: R&D Associates, November 1986); Ray E. Kidder, "Stockpile Reliability and Nuclear Test Bans: Response to J.W. Rosengren's Defense of His 1983 Report," UCID-20990 (Livermore, CA: Lawrence Livermore National Laboratory, February 1983); Ray E. Kidder, "Maintaining the U.S. Stockpile of Nuclear Weapons During a Low-Threshold or Comprehensive Test Ban," UCRL-53820 (Livermore, CA: Lawrence Livermore National Laboratory, 1987); George H. Miller, Paul S. Brown, and Carol T. Alonso, "Report to Congress on Stockpile Reliability, Weapon Remanufacture, and the Role of Nuclear Testing," UCRL-53822 (Livermore, CA: Lawrence Livermore National Laboratory, 1987), and John D. Immele and Paul S. Brown, "An Exchange on Stockpile Confidence," ***International Security***, Vol. 13, No. 1 (Summer 1988), pp. 196-209.

[9] On the hand, the scientific directors of both Russian nuclear laboratories, Yuri Trutnev and Evgeny Avrorin, have stated informally that they would support a comprehensive test ban signed by both countries.

[10] For details, see Steve Fetter, "Stockpile Confidence Under a Nuclear Test Ban," ***International Security***, Vol. 12, No. 3 (Winter 1987/88), pp. 132-167.

[11] Admiral Sylvester R. Foley, responses to questions for Department of Energy budget hearing before the Subcommittee on Procurement and Military Nuclear Systems, Armed Services Committee, U.S. House of Representatives, 19 February 1986. Roger Batzel, responses to questions before the Armed Services Committee, U.S. Senate, April 1986.

[12] Although many of these substitutions should be straightforward, it is conceivable that a nuclear test would be desired in some cases. This possibility should be investigated, and, if necessary, nuclear tests performed, before a CTB takes effect. Warheads could be tested for the accelerations, vibrations, and temperature extremes that might be expected with other delivery vehicles. The delivery vehicles may have to be flight-tested with the new warheads, but a CTB does not prevent this. Such a program would undoubtedly be expensive, but it is an option for those who believe that, for unforeseen reasons, remanufacture may not always work.

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[13] For example, super-reliable warheads may use sensitive high explosives and greater amounts of high explosive, tritium, or plutonium, which may decrease safety and/or yield and/or increase the cost of building and maintaining such warheads.

[14] U.S. Congress, Senate Committee on Foreign Relations, ***Nuclear Test Ban Treaty, Hearings on Executive M***, 88th Congress, 1st session, 1963, "Letter to Senator Russell from the Chairman of the Joint Chiefs of Staff re: safeguards recommended by the JCS," p. 982.

[15] The official definition of one-point safety in the United States requires that "in the event of a detonation initiated at any one point in the high explosive system, the probability of achieving a nuclear yield greater than 4 pounds of TNT equivalent shall not exceed one in one million."

[16] It was reported recently that one U.S. warhead—the W79 8-inch artillery shell—may fail to meet the one-point safety criterion when inside the gun barrel of a howitzer. R. Jeffrey Smith, "Defective Nuclear Shells Raise Safety Concerns," ***Washington Post***, 23 May 1990. There are also concerns that the Trident-II warhead may not meet the criterion in its deployed configuration under certain extreme accident conditions. In both cases, the conditions that would lead to a significant (but still very small) nuclear yield have a very low probability of occurring. These warheads could, however, be safed by inserting a wire into the hollow interior of the plutonium core which would be withdrawn from the core shortly before the warhead detonates. In the case of the Trident II, the problem could also be resolved by reducing the number of warheads and/or using a less energetic propellant in the third stage.

[17] Paul S. Brown, "Nuclear Weapon R&D and the Role of Nuclear Testing," ***Energy and Technology Review***, September 1986, p. 9, and J. Carson Mark, personal communication, 27 April 1987.

[18] Steve Fetter and Frank von Hippel, "The Hazard from Plutonium Dispersal by Nuclear-warhead Accidents," ***Science and Global Security***, Vol. 2, No. 1 (1990), pp. 21-41, estimate that up to 2,000 cancer deaths could result from the dispersal of plutonium from all the warheads on a Trident missile based at Bangor Naval Base, 30 kilometers from downtown Seattle. Prompt deaths from plutonium exposure are highly unlikely even in a severe accident.

[19] R.E. Kidder, "Assessment of the Safety of U.S. Nuclear Weapons and Related Nuclear Test Requirements: A Post-Bush Initiative Update," UCRL-LR-109503 (Livermore, CA: Lawrence Livermore Laboratory, 1991), p. 3.

[20] Comprehensive use of IHE on ICBMs can be achieved by replacing the W78 Minuteman-III warheads with retired W87 MX warheads (1 test) or newly manufactured MX warheads (2-3 tests), or by replacing Minuteman III with the new small ICBM, which would use MX warheads (3 tests). Comprehensive use of IHE on SLBMs can be achieved by replacing the W76 Trident-I and W88 Trident-II warheads with a version of the W89 warhead (2-3 tests); alternatively, the W76 could be replaced by a new IHE version (an additional 4 tests). The W69 SRAM warhead could be replaced with the new W89 (2-3 tests), but since these warheads will not be deployed in peacetime this would make little sense. Adding 1-3 tests to deal with unforeseen contingencies gives a total of 4 to 13 tests, depending on whether new pits can be produced, whether retired or newly manufactured MX warheads are used, whether the W76 and the W88 are replaced by the same warhead, and on unforeseen contingencies. See Kidder, "Assessment of the Safety of U.S. Nuclear Weapons," pp. 4-5.

[21] A CTB would, however, prevent using the newer U.S. "category F" PALs, which automatically disable the warhead upon intrusion. Such PALs are of most value in protecting

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tactical weapons, most of which are slated for retirement or removal from the theatre in any case.