The Feasibility of Comprehensive Test Ban

Prepared Statement of Frank von Hippel
to be given in the hearings on
The Future of Nuclear Testing in the Soviet Union

before the Subcommittee on Armed Services
of the
Supreme Soviet's Committee on Defense and State Security
(Moscow, 27-28 September 1990)

I appear today as an independent U.S. scientist who has made a considerable effort over the years to understand the arguments being made for and against further restrictions on nuclear testing.

I was first drawn deeply into this issue as a result of the Soviet unilateral testing moratorium of August 1985 - February 1987. At that time, the principal objection of the U.S. government to further limitations on testing seemed to be the possibility that the Soviet Union might cheat by mining huge underground caverns and exploding its weapons in them, thereby "decoupling" their shock from the rock and reducing the strength of the resulting seismic signals to those of an explosion approximately one hundred times weaker (see Figure 1).

I therefore collaborated with Evgeny Velikhov in 1986 in the initial phases of organizing a Soviet-U.S. collaboration under which jointly operated seismic stations have been established in the Soviet Union and U.S. By now, this collaboration is well along in establishing the basis for in-country seismic verification systems in both countries that could detect and identify even decoupled nuclear explosions down to yields of about one kiloton. This yield should be compared with the 150 kiloton limit on underground nuclear testing in the U.S.-USSR Threshold Test Ban that is just now being ratified by the Supreme Soviet and the U.S. Senate.

During 1986 and 1987, I joined in the effort to persuade the U.S. Congress to cut off funding for U.S. testing above one kiloton if the Soviet Union continued its moratorium. The U.S. House of Representatives voted in

favor of this measure. However, the White House persuaded the Senate that Congress should not interfere in its testing negotiations.

I submit for the record two articles on the subject that I coauthored during that period:

"A Low-Threshold Nuclear Test Ban," and

"A Low-Threshold Test Ban is Feasible."

The latter article was paired by the editors of "Science" magazine, the leading U.S. science magazine, with an article "Facing Nuclear Reality" by three scientists from the Lawrence Livermore National Laboratory, one of the two U.S. nuclear-weapons laboratories.

Arguments for Nuclear Weapons Tests

It will become clear from this exchange that the U.S. nuclear-weapons establishment believes that nuclear testing must continue even if the verification problems are dealt with. Several reasons have been offered:

1) New nuclear weapons are needed to maintain "deterrence;"
2) It is necessary to test nuclear weapons on occasion to make sure that they can still be depended upon to work -- i.e. are "reliable."
3) Improvements must be made in warhead safety.
4) Warheads have to be designed to be less susceptible to unauthorized use.
5) It is necessary to test the resistance of new military equipment to the effects of nuclear explosions.

I will discuss each of these arguments in turn.

The Need for New Nuclear Weapons to Maintain "Deterrence." History has shown that, even at the worst of the Cold War, both the Soviet and U.S. leaderships have always been more than adequately frightened that a serious military confrontation between them might turn into a nuclear war -- by accident if not intentionally.

The U.S. was already strongly deterred by this fear in the 1960's, during the crises over Berlin and Cuba, when the U.S. may have had on the order of one hundred times more strategic nuclear warheads than the Soviet Union.

As McGeorge Bundy, President Kennedy's national-security advisor, has

said:*

> "Think-tank analysts can...assume that the loss of dozens of great cities is somehow a real choice for sane men. They are in an unreal world. In the real world of real political leaders...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."

With the U.S. and USSR today each possessing many thousands of strategic nuclear warheads -- a large fraction of which would survive any first strike -- and with neither country possessing strategic defenses that would be effective against a large strike, we are fated to be each other's mutual nuclear hostages until we decide to release each other.

Where most of the debate over nuclear deterrence in the U.S. has focused has been on the possibility of deterring Soviet aggression at a level less than an all-out nuclear attack on the U.S. by the threat of resort to nuclear weapons. Here, it was hoped to deter Soviet non-nuclear aggression -- especially against Western Europe. It was argued that, if the U.S. continued to develop ever more "useable" nuclear warheads, the Soviet leadership would take our threats more seriously.

Given the apparent irreversible dissolution of the East-West military confrontation in Central Europe, this argument is no longer being pressed very hard.

Indeed, during the first half of 1990, the development of three new U.S. nuclear warheads was cancelled.** The development of other warheads is being

---

* McGeorge Bundy, "To Cap the Volcano," *Foreign Affairs*, October 1969, p. 2.

** The warhead for the "Follow-on-to-Lance," a short-range nuclear missile intended for Europe -- along with the missile.

A new 155-mm nuclear artillery shell -- also intended for Europe.

The warhead for the anti-submarine "Sea Lance" missile that was to replace the older "SUBROC" missile. With retirement of the SUBROC, the only remaining U.S. naval nuclear weapons will be nuclear-armed cruise

put on hold.* Only two warheads remain in active development:

- o A warhead for the second-generation short-range attack missile (SRAM II) for U.S. strategic bombers. The characteristics of this warhead will not alter significantly the threat to the Soviet Union represented by these missiles.
- o An "earth penetrator" warhead for long-range nuclear cruise. This warhead might increase the destructiveness of these missiles against missile silos or underground command posts by approximately the same amount as if the explosive power of their current warheads had been doubled. However, ballistic missiles, because of their much shorter flight times, will remain the most serious threat to such facilities.

Another indication of Congress' reaction to the improving relations between our two countries is the recent action by the House Armed Services Committee to completely eliminate the special funding under the Strategic Defense Initiative for the development of nuclear directed-energy warheads. (Final Congressional action awaits the House-Senate conference.)

The U.S. weapons laboratories are, of course, still receiving a considerable amount of money for "exploratory development" of ideas for different types of nuclear warheads that might conceivably be developed in the future. These ideas include such weapons as nuclear-explosion-powered X-ray lasers and hyper-velocity pellets for use in space and a nuclear-powered microwave generator for destroying from space the electronics of military

---

missiles and nuclear bombs for carrier aircraft.

* Both the Senate and House Armed Services Committees have denied pre-production funds for the B-90 nuclear bomb, which is designed to be used either against submarines or land targets. This bomb was proposed to replace several older naval bombs.

The House Armed (but not the Senate) Services Committee has denied pre-production funds for a warhead for the tactical version of the short-range attack missile (SRAM-T) which is proposed for NATO forces in Europe. The final Congressional decision on this warhead for this year will be made soon in the House-Senate conference committee.

The warhead for the Midgetman mobile ICBM is also on hold because the production decision on that missile is on hold.

systems on the earth's surface.

A sober assessment shows that, even if they could eventually be developed, none of these warheads would bring with it the potential for significant defense capabilities against a large Soviet ballistic-missile attack -- especially if the Soviet Union undertook relatively easy countermeasures.* With regard to the microwave generator, Theodore Taylor's 1987 *Scientific American* article, "Third Generation Nuclear Weapons," which emphasized this weapon, did not take into account that, above a certain power, the atmosphere becomes an effective shield against microwave beams. It would therefore be relatively easy to shield the electronics of military systems against such weapons, if they were developed.**

In any case, the energy is draining out of these U.S. nuclear-warhead development programs as concern about "the Soviet threat" fades in the U.S. This may be seen in both the recent downward trend of the U.S. testing budget (see figure 2) and the recent decline in the rate of U.S. nuclear testing -- from 14 per year during 1986-88, to 11 in 1989, to 5 tests in the first two thirds of 1990 (see figure 3). It is becoming increasingly well understood in the U.S. that our huge expenditures on new nuclear weapons are extravagant at a time when we desperately need our scientists and engineers to be working on our increasingly serious economic, environmental and educational problems.

This does not mean that the U.S. will stop testing entirely soon -- even if the Soviet Union should stop. There is an extremely hard core of opposition in the Administration to a Comprehensive Test Ban. However, I expect that the 80 percent of the testing activities that are associated with the development of new types of nuclear warheads will continue to decline.

The Need to Test to Maintain Warhead Reliability. The U.S. nuclear- weapon laboratories began pushing the argument that nuclear testing is essential to

---

* Dan L. Fenstermacher, "The Effects of Nuclear Test-ban Regimes on Third-generation-weapon Innovation," *Science and Global Security 1* (1990), p. 187.

** Dan Fenstermacher and Frank von Hippel, "A Limitation on Nuclear-Powered Microwave Weapons," submitted to *Science and Global Security*.

maintain warhead reliability in 1977, when the trilateral test-ban negotiations were making significant progress towards a Comprehensive Test Ban. The U.S. Joint Chiefs of Staff were convinced by this argument and decided to oppose a test ban.

Dr. Ray Kidder, a senior weapons designer at the Lawrence Livermore National Laboratory, challenged this argument and, after some rounds of debate, the Congress seems to understand the issue much better.

The current focus of the debate is on whether a warhead remanufactured to the original specifications after many years will be reliable. The U.S. Department of Energy (DoE), which is responsible for U.S. nuclear weapon design and production, accepts that this is possible but argues that certain materials -- especially plastics -- may become unavailable.

It would seem to be less costly to assure the continuing availability of such materials than to continue to support the billion-dollar-a-year nuclear warhead design and testing establishment. Last year, therefore, the U.S. Senate asked the DoE to produce a detailed report on the remanufacturability of the warheads that are to be kept in the U.S. nuclear stockpile indefinitely. As the DoE did not produce this report voluntarily, this year the request has been given the force of law.

The Need for Improvements in Warhead Safety. This year, as skepticism about the reliability argument increased in Congress, the nuclear weapons labs began to argue that some current U.S. nuclear-warhead designs are not safe enough.

The issue has generally not been that there might be an accidental nuclear explosion. U.S. (and, I understand, Soviet) nuclear warheads are designed so that, even if the chemical explosive in the warhead is detonated by a bullet or in an airplane crash, there will not be a significant nuclear yield.*

The main concern has been that the detonation of the chemical explosive might disperse the warhead plutonium into the environment.

Two such events have occurred for U.S. weapons during the 1960's, when

---

* To obtain a significant nuclear yield, it is necessary to trigger the chemical explosive simultaneously at many different points.

the U.S. was keeping nuclear-armed strategic bombers in the air at all times out of fear of a surprise attack by Soviet ballistic missiles. Two bombers crashed, the chemical explosives in their bombs exploded and an area was contaminated with plutonium. One of these events occurred in a rural area of Spain and one on the ice off Greenland.

We have calculated that, if such an event were to occur near an urban area and the wind were blowing toward the city, hundreds of cancer deaths might result over the following decades -- just as might occur after a serious release from a chemical plant.*

Because of this hazard, most modern U.S. (and, I understand, Soviet) nuclear warheads contain "insensitive high explosive" that would not be detonated even by a bullet or an airplane crash. Some warheads contain sensitive high explosive, however. Recently, attention has focused on two of these: the warhead on the first-generation short-range attack missile, the SRAM-A and the warheads for the Trident II submarine-launched ballistic missile.

In view of the reduced levels of Soviet-U.S. tensions, it was recently decided to take the SRAM-A off of the bombers that the U.S. keeps on runway alert. In a few years, this missile will be replaced by the SRAM II, whose warhead will contain insensitive high explosive.

The W88 warhead for the Trident II is a new warhead that contains sensitive high explosive because this explosive is lighter per unit energy than insensitive high explosive. The U.S. Navy wanted to maximize the yield-to-weight of this warhead so that the Trident II would be able to compete with the U.S. Air Force's MX missile in threatening Soviet missile silos. A high-level group is now reviewing the safety implications of this choice and the warhead may be redesigned to contain insensitive high explosive. An alternative approach that would not require further testing would be to use the MX warhead, which already contains insensitive high explosive.

In any case, the hazard from plutonium dispersal is already quite low. We estimate, for example, that it would cost about $100 million per life saved

---

* Steve Fetter and Frank von Hippel, "The Hazard from Plutonium Dispersal by Nuclear-warhead Accidents," *Science and Global Security 2* (1990, in press).

to replace ten years early approximately 3,000 U.S. strategic warheads containing sensitive high explosive. Approximately one thousand times as many lives could be saved by using these funds in other ways.

The Need to Improve the Security of Warheads. The need to improve the security of nuclear warheads against unauthorized use is not currently a major issue in the U.S. debate but may become so in the future.

All U.S. warheads except those on submarine-launched ballistic missiles have "permissive action links" (PALs) which require the insertion of a secret code before the warhead can be detonated. Unauthorized launch is safeguarded against on submarines by requiring several officers to throw switches in different parts of the ship before a missile can be launched. In addition, many U.S. warheads can sense accelerations and the low pressures of high altitudes and space and will not explode unless the expected launch-to-target sequence is sensed.

The warheads whose security has been of greatest concern have been tactical warheads stored in places such as West Germany and Turkey. With the reduction in U.S.-Soviet tensions, most of these warheads will be withdrawn and hopefully dismantled.

The Necessity to Test the Resistance of New Military Equipment to the Effects of Nuclear Explosions. The longest-range effects of nuclear explosions on military equipment shielded by the atmosphere are blast, heat and the electromagnetic pulse. The "hardness" of U.S. military equipment against such effects are tested primarily with chemical explosives and electro-magnetic pulse simulators.

In space, however, there is no atmosphere to block the X-rays, gamma rays, and neutrons from a nuclear explosion and they can have effects at long-range. Most U.S. nuclear-weapons effects tests are therefore to test the "hardness" of warheads and satellites against the effects of this radiation.

Since a Comprehensive Test Ban would stop the development of new types of nuclear warheads, there would be no need to test the hardness of new nuclear warheads. The hardening of satellites against the effects of nuclear

explosions on the order of one hundred kilometers away could be done using other sources of radiation.

How Long Should Testing Continue?

If the arguments for indefinitely continued nuclear testing are rather weak, how soon should we stop?

The recent debate in Geneva over the future of the Non-Proliferation Treaty (NPT) provides a strong argument that all testing should stop by 1995. That is when the approximately 140 signatories of the NPT will meet to decide whether to renew it and in what form and for how long.

The last Non-Proliferation Treaty review conference before 1995 just broke up -- primarily as a result of disagreement between the U.S. and a large group of non-nuclear-weapon states. The non-nuclear-weapon states wanted the U.S. to make a commitment to a CTB by 1995. The U.S. refused to make such a commitment.

However, there appears to be a more moderate view emerging in the U.S. nuclear weapon establishment that may be willing to accept a CTB by 1995. This view is that perhaps five years more testing is required to provide the U.S. with a very safe, very secure, very reliable nuclear arsenal that can be remanufactured indefinitely without testing.

The ultimate decision on the future of nuclear testing must not be made by nuclear technicians, however. It must be made by citizens and politicians. It is they who will have to balance the high costs of continued nuclear testing, measured in human resources and in the undermining of the non-proliferation regime, against the improvements that can be made in safety, security and remanufacturability with perhaps 50 more tests. In my own view the costs outweigh the benefits.

A Soviet Unilateral Moratorium?

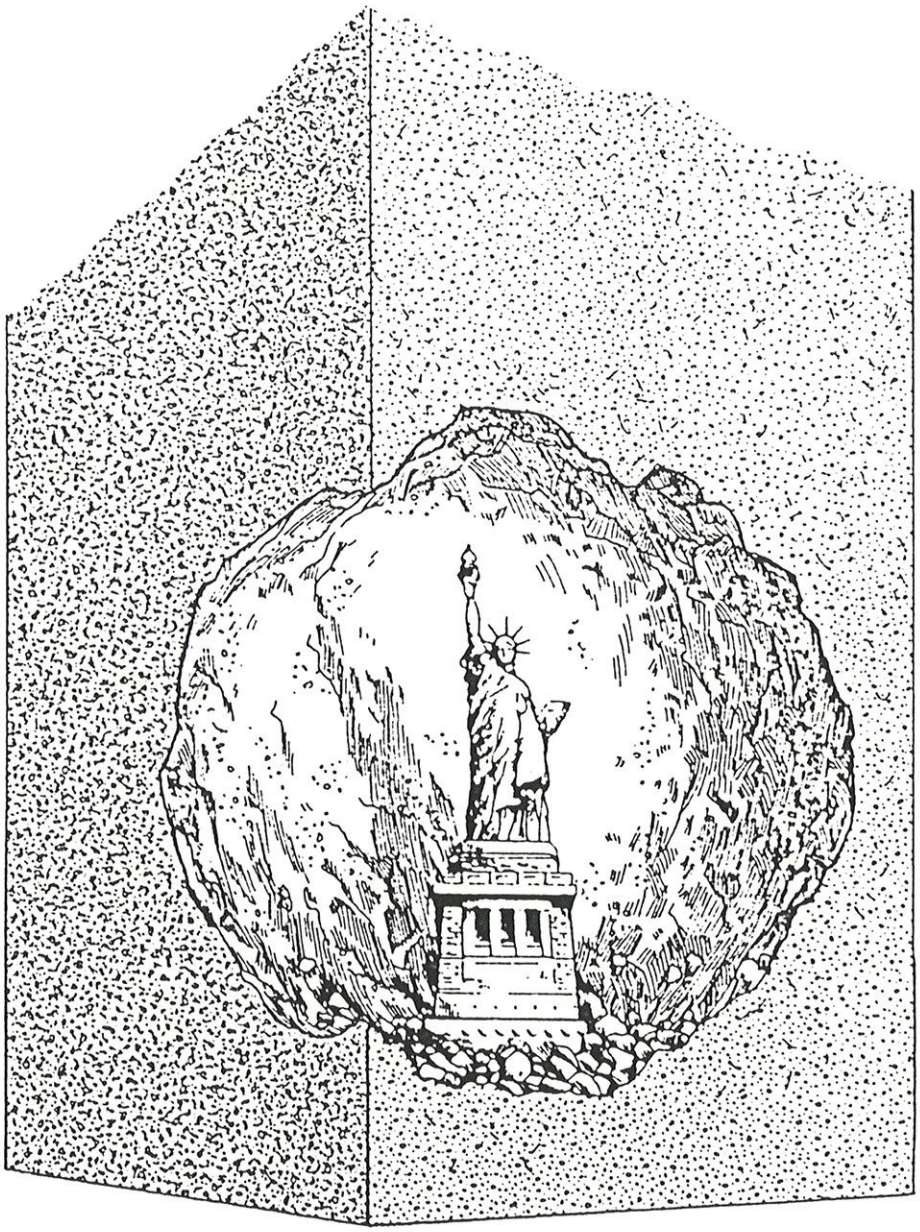
Finally, there is the question of whether the Soviet Union should halt testing, even if the U.S. continues for a while.

Here again, you have a political not a technical decision. However, I think that I have made clear that likely U.S. progress toward new types of

nuclear weapons during the next several years would not significantly affect the nuclear balance. Indeed, after so many hundreds of nuclear tests by both sides, U.S. progress during the 1985-87 Soviet test moratorium was so small that the U.S. Defense Intelligence Agency even put out a report saying that Soviet nuclear-weapons technology had advanced relative to U.S. nuclear-warhead technology during that period!

Personally, I would like to see a Soviet moratorium because I want to achieve a Comprehensive Test Ban. A Soviet moratorium could not but increase the pressure on the U.S. to halt testing and bring a CTB that much closer.

FIGURE 1 **Minimum Cavity Size Required To Decouple a 5 kt Nuclear Explosion**



To fully decouple a 5 kt explosion in salt, a spherical cavity with a radius of at least 43 meters would be required. The height of the Statue of Liberty with pedestal (240 ft) is 85% of the required diameter (282 ft).

SOURCE: Office of Technology Assessment, 1988.

FIGURE 2 DoE Nuclear Testing Budget

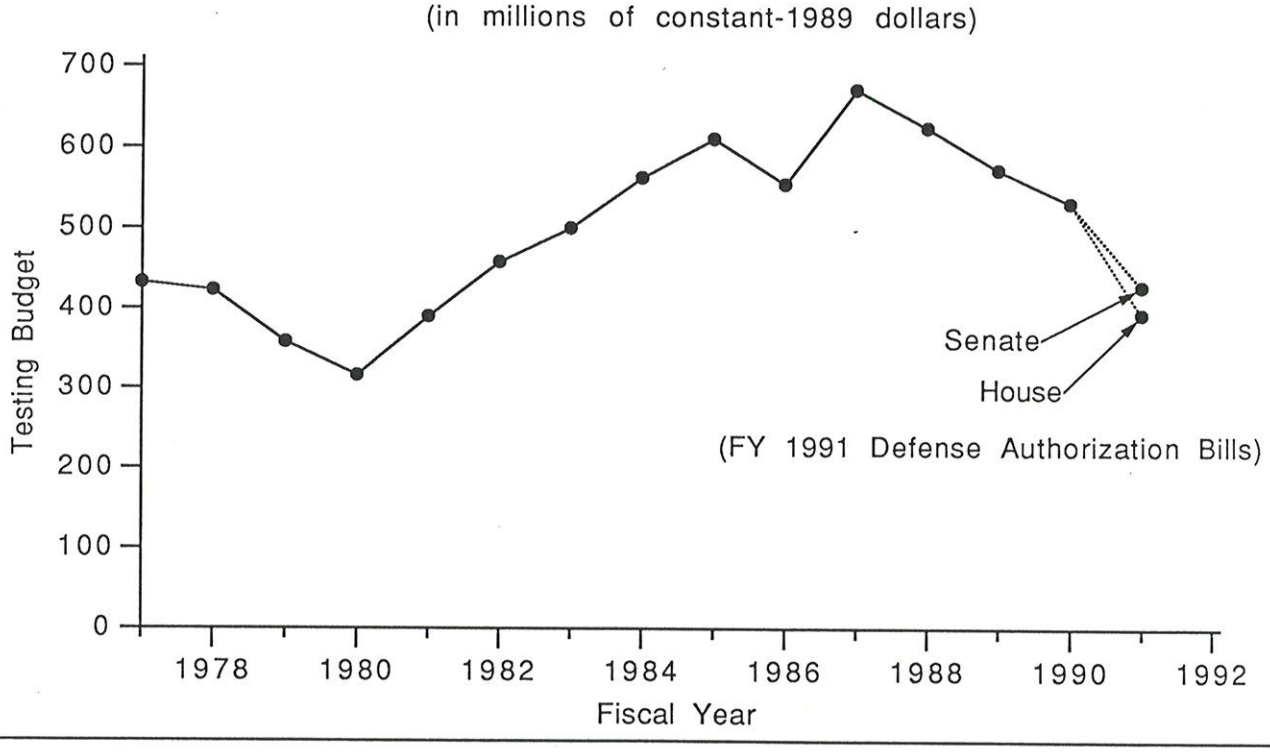


FIGURE 3 Soviet and U.S. Nuclear Tests by Year