Debate on a comprehensive

Pro

A critic on the inside says that a treaty is vital to world security, that it is technically feasible, and that the nuclear weapons laboratories should end their opposition to the idea.

Hugh E. DeWitt

The 1963 Limited Test Ban Treaty prohibits nuclear explosions in the atmosphere, the oceans and space. Nevertheless, nuclear tests continue at an alarming rate—almost one explosion per week somewhere in the world—although now the testing is largely underground.

In the 1963 treaty, the United States committed itself to negotiate toward a comprehensive test ban, which would end the testing of nuclear weapons altogether. Many people in this country and in other countries strongly believe that a comprehensive test-ban agreement between the major nuclear powers would put a brake on the current runaway development of new nuclear weapons, and reduce the possibility of nuclear war. As a physicist for 26 years on the staff of the Lawrence Livermore National Laboratory, I have observed the development of nuclear weapons from the inside of the weapons establishment. During this time I have reached some possibly heretical conclusions for a weapons-lab employee, and the rest of this article should be understood in their light:

- Some form of comprehensive test ban treaty that ends nuclear testing is both feasible and vital to the security of the world.
- The weapons labs themselves bear a heavy responsibility for our present situation in which the two superpowers compete to obtain an illusory nuclear superiority.

Both of these personal convictions contrast sharply with positions taken by the weapons laboratories. The labs' stance on the first point was well summarized by Livermore director Roger Batzel when he stated:[1]

> . . . I believe the continued credibility of the US nuclear weapon deterrent cannot be assured for long without nuclear testing.

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Subsidence craters. This aerial photograph shows part of the Nevada test site, where US nuclear weapons are tested underground. The surface is marked by craters caused by the

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reliability. The same personnel who are charged with assessing the reliability of stockpiled nuclear weapons are involved in developing nuclear weapons. In their development work they are continuously having their judgments, based upon calculation and experience, tested against the reality of nuclear tests. Discrepancies between expectations and results are a constant reminder of the fallibility of computer calculation and "experience." Without testing, confidence in the judges of reliability will justifiably erode even in the unlikely event that the weapons laboratories can retain experienced personnel under such a circumstance.

Reopen the debate

As we have seen, nuclear weapons testing plays a major role in maintaining confidence in the country's nuclear deterrent. Some have argued that the United States understands fundamental nuclear-weapons phenomena well enough. Some have, as an act of faith—not through hard evidence—asserted that the US understanding of the application of nuclear explosions for military purposes encompasses all Soviet developments. They have said that US weapons are already safe enough and secure enough. They have argued that modernization without nuclear testing can maintain the survivability of weapons systems even in the face of as-yet-unknown threats; and they assert that the United States can, without testing, maintain confidence in its stockpile, or that, in any case, for some unspecified reason, confidence in the nuclear-weapons stockpiles of the United States and the Soviet Union will erode at the same rate.

There should be a debate on the subject. The United States in 1983 should reevaluate the desirability of a comprehensive test ban as a national goal. Indeed, it should be more than a national debate, it should be an international debate, because US confidence in its nuclear deterrent has international implications.

In 1983 we find nuclear weapons parity between the United States and the Soviet Union. It is a delicate balance. Will a comprehensive test ban increase chances of maintaining that stability or will it detract? Will a comprehensive test ban allow the US to maintain the reliable deterrent that a majority of its citizenry wants? A real discussion is called for. An informed debate should begin.

References

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2. J. C. Mark, Bulletin of the Atomic Scientists, March 1983, page 45. □

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On the second point, the weapons laboratories maintain that they do not make national policy, but carry it out, and that when they advise policymakers they simply present the scientific truth. In this article I want to take a close look at these claims as a way of addressing the question of why even now, 38 years after the end of World War II, the labs feel that it is so important to continue nuclear testing.

Labs are an active lobby

Glenn T. Seaborg, as chairman of the Atomic Energy Commission during the Kennedy Administration, was deeply involved in the US–Soviet negotiations that culminated in the Limited Test Ban Treaty and moved nuclear testing underground. He has recently written a very significant book,[2] *Kennedy, Khrushchev and the Test Ban*, in which he describes the intricate negotiations that began in 1958 and culminated five years later in the first serious nuclear weapons treaty between the rival superpowers. At the time, Seaborg himself was strongly in favor of a treaty to end all nuclear weapons tests, and he still holds this position. Furthermore, as he explains in his book, both Kennedy and Krushchev had a deep commitment to a total ban on nuclear testing. Indeed, both men felt that such a ban would be a major step in the direction of world peace.

With this kind of commitment, coupled with the scare of the 1962 Cuban missile crisis, one may ask why Kennedy and Krushchev were not able to attain their goal of a comprehensive test ban in 1963. Obviously, each man had to contend in his own country with powerful forces opposed to a nuclear test ban. Seaborg discusses some of the opposition and how it affected the treaty negotiations. A recurrent theme in his book is the role of the American nuclear weapons labs and the efforts of leading weapons scientists to block the treaty; Krushchev evidently had similar troubles with the Soviet nuclear-weapons establishment. A few examples from the American side illustrate the influence of the US weapons labs:

▶ In 1957, Edward Teller and Ernest Lawrence met with President Eisenhower to argue against a moratorium on testing. They told Eisenhower that the Soviets could cheat with clandestine tests, and that US testing must continue anyway, to develop "clean" bombs, which they foresaw coming within seven years. These fallout-free devices would be deployed as tactical nuclear weapons in Europe. It has now been 26 years since the meeting with Eisenhower, and we have no "clean" bombs.

▶ As the test-ban negotiations proceeded, verification became a major issue because of studies from the weapons labs suggesting that nuclear bombs could be exploded in large cavities deep underground and decoupled sufficiently to look like much smaller explosions. One such study suggested that a 300-kiloton bomb might look like a one-kiloton explosion. There were also arguments about testing in space, on the other side of the Sun, for example. By 1963 the weapons labs prevailed and nuclear testing was allowed to continue underground.

I don't have the space to detail the numerous later examples of the influence of the weapons labs on US policy, but a recent example is important.

▶ President Carter began his four-year term with a determination to complete the comprehensive test-ban treaty negotiations. In the summer of 1978, Department of Energy secretary James Schlesinger took Harold Agnew, director of Los Alamos, and Batzel to see Carter to argue against United States participation in a comprehensive test-ban treaty. At that time, the Soviet Government was in favor of the treaty, and agreement seemed to be very near.[3] Yet the arguments of the weapons-labs leaders were apparently persuasive, and progress toward a comprehensive test-ban treaty stopped after that visit. Agnew later said[4] concerning that meeting,

> No question about it.... We influenced Carter with facts so that he did not introduce the [treaty] which, we subsequently learned, he had planned to do.

At this point, one can only speculate as to what alarming facts caused Carter to change his mind on the need to complete the comprehensive test-ban treaty. The Reagan Administration is far more inclined to see things the same way as the nuclear-weapons establishment, and on 19 July 1982 Reagan announced[5] an end to negotiations toward a comprehensive test-ban treaty, and thus a change in a 20-year-old US policy.

Corporate survival. The nuclear-weapons establishment occupies a very secure place in the American government. This is illustrated by the revealing testimony[6] of Major General William W. Hoover, director of the Department of Energy's Office of Military Application, before the Procurement and Military Nuclear Systems Subcommittee of the House Armed Services Committee. Hoover, speaking to a friendly Congressional subcommittee, indulged in a bit of humor and

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likened the weapons establishment to a large corporation:

> We are something unique in the US Government—that is, a totally government-owned, integrated industry. A corporation, if you will, for which we are responsible.
>
> I would like the committee to consider themselves as the board of directors of that corporation. My remarks are in essence a prospectus of our corporation, and the record of this hearing will serve as our stockholders report.
>
> Let me touch briefly on the assets of our corporation.... The total number of employees is about 35 000. That includes production plants, test facilities, and the laboratories—those people who work for the weapons program.
>
> ... The results of our R&D activities lead to our product line... warheads supporting weapons systems of the Department of Defense.

Hoover goes on to describe the weapons laboratories' "product line," which includes nine different types of mainly strategic nuclear warheads, such as the W76 for the Trident I missile, the W87 for the MX missile, and the B83, a "modern strategic bomb" for high-speed low-altitude delivery. He also talks of the "theater nuclear product line," meaning smaller nuclear bombs for fighting tactical nuclear wars.

I must comment at this point that many Livermore staff members who are committed to their work on weapons design believe sincerely in the idea of deterrence, and they will say that their nuclear bombs are designed and made for the purpose of never being used. One can only ask: Does the General's "theater nuclear product line" really mean only deterrence? I should also mention here that the Livermore Lab, which designs and develops many of these devices, is a large establishment with over 7000 employees and a proposed FY 1984 budget of 584 million dollars. Nuclear weapons work is big business!

Later in his testimony, Hoover makes a significant statement about the weapons laboratories' stake in testing:

> Like any good corporation, we have an investment strategy which we have been pursuing for the last couple of years and we intend to pursue it in the decade of the eighties.... We think we need to increase our manpower in research, development, and technology by about 15% above what it was a couple of years ago. We think we need to increase the level of underground testing.

This kind of direct statement to Congress from a high Department of Energy military official provides one clear answer as to why we have no comprehensive test-ban treaty now and are not likely to have one in the near future. The nuclear-weapons establishment is a very powerful "corporation," staffed with intelligent and dedicated people whose livelihoods are tied to never-ending nuclear-weapons work. This establishment will not remain neutral and quietly allow elected representatives to curtail their enjoyable and profitable weapons work through limitations such as a comprehensive test-ban treaty.

Objections to a test ban

There are more serious reasons given for the ongoing nuclear testing. Two suggested reasons come from an unlikely source, Jack Anderson's nationally syndicated newspaper column. In a column[7] titled "Test Ban Folly," Anderson refers to classified White House documents presented at a secret Pentagon technical briefing and shown to him. From this information Anderson makes essentially two points:

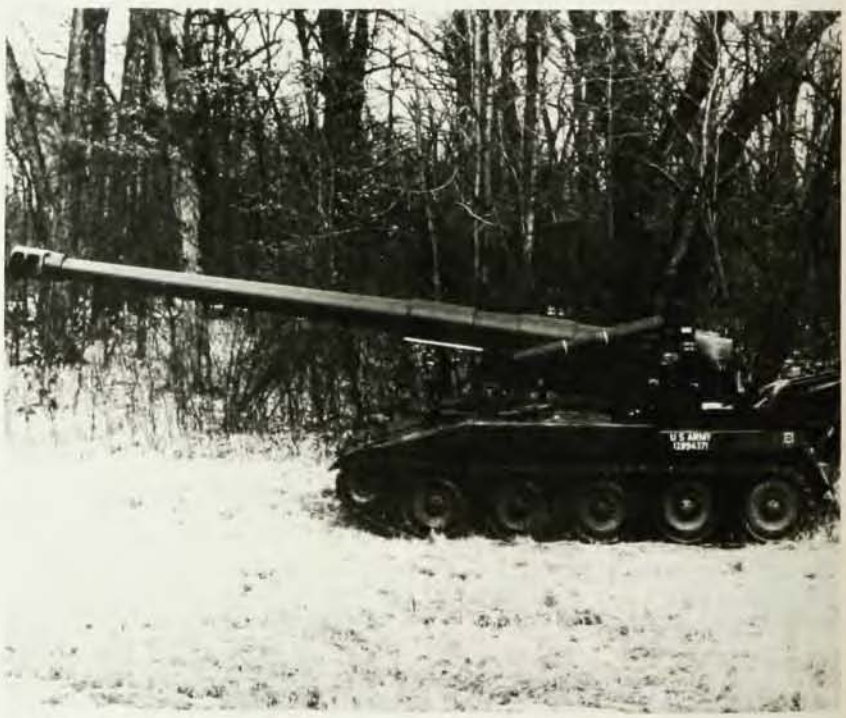
- The Soviet Union is believed to have cheated extensively on the Threshold Test Ban Treaty of 1974, and is supposed to have exploded as many as 11 underground shots above the agreed-on 150-kiloton limit since 1978. (Although the United States has not ratified this treaty, the US and the USSR have said they will comply with the 150-kt limit.)
- Nuclear weapons testing must continue indefinitely because the weapons labs are not confident that new bombs manufactured from proven designs will actually explode to design specifications. In other words, without continued proof testing, America's nuclear stockpile cannot be relied on the future.

On both points it is my impression that Anderson was taken advantage of and shown the supposedly sensitive documents to spread ideas that cannot withstand scrutiny.

Let me first dispose of the question of Soviet cheating on the 150-kt limit. Reputable seismologists outside the weapons establishment have not confirmed the claim of Soviet cheating. In their recent article[8] in *Scientific American* on the verification of a comprehensive nuclear test ban, Lynn Sykes of Columbia University and Jack Evernden of the United States Geological Survey state that

> When the correct calibration is employed, it is apparent that none of the Russian weapons tests exceed 150 kilotons, although several come close to it.

From inside the weapons establishment we have a statement[9] by Michael May, associate director-at-large of Livermore, that classified documents "conclude that there was no evidence that the Soviets had cheated on the Threshold Test Ban Treaty...." Ger-



Cannon. This Army photograph shows the M100E2 8-inch self-propelled cannon, typical of modern long-range artillery. The nuclear-weapons laboratories developed atomic projectiles that can survive the acceleration associated with long-range delivery. The survival of the warheads is asssured by testing.

ald E. Marsh gives more details on this subject in his commentary in the March issue of the *Bulletin of the Atomic Scientists*. While people in the nuclear-weapons labs believe in their work, they are honest and don't believe in the story of Soviet cheating. That story emanates from officials in Washington, and it has the appearance of an attempt to justify American renunciation of the unratified Threshold Test Ban Treaty so that the US can once again test at above 150 kilotons.

Anderson's second point is far more serious. From the documents shown to him, he states that leaders of the US nuclear-weapons labs believe that they must have the ability to test up to five kilotons to guarantee the performance of weapons in the US stockpile. He quotes from one of the unspecified White House documents:

> In the continued non-nuclear testing of weapons components, it turns out with some regularity that individual components fail or degrade. Even acceptable components may become unavailable as manufacturers shift product lines or go out of business.

Note that this reason for the necessity of continued testing has nothing to do with developing new designs or even modifying proven old designs. The documents that were shown to Anderson claim that even to maintain a dependable stockpile of nuclear weapons manufactured from well-tested designs, it is necessary to test the bombs occasionally. This would preclude a comprehensive test-ban treaty forever, because no US president is likely to sign a such a treaty knowing that the US stockpile of nuclear weapons may degrade to the point of unreliability.

The suggestion that certain necessary materials might become unavailable as manufacturers change their line of products is a startling excuse for reserving the right to continue to set off nuclear bombs. Surely the Department of Energy can somehow solve this problem, given the money and resources available to it! Furthermore, if present-day proven bomb designs are that sensitive to slight changes in materials, then one must ask why the weapons labs have produced such designs. I think the answer is simply that the weapons labs have never had to contend seriously with the prospect of cessation of nuclear tests, and thus felt no need to design bombs that could be dependably manufactured in the distant future. I will come back to this problem later to argue that the weapons labs could solve it quickly if they felt the need to do so.

Exciting new weapons. Another reason why the labs want to avoid the restrictions of a comprehensive test-

ban treaty is the exciting prospect of developing a whole new class of nuclear weapons. These are described rather vaguely as directed-energy weapons or third-generation weapons, and they have been widely promoted by Edward Teller since last summer. (See the news story on page 17.) The nature of these new devices is hidden behind walls of secrecy, and I may say very little about them. Teller claims that it is imperative for the US to develop these weapons because they would be "defensive" in nature and would provide a reliable defense against a Soviet nuclear attack. One of the ideas is the bomb-pumped x-ray laser described[10] a couple of years ago in *Aviation Week and Space Technology*. This marvelous device would supposedly send a burst of x rays at a Russian missile high above the Earth's atmosphere, and destroy it long before it reached the US. Teller and his colleague Lowell Wood from Livermore are reported[11] to have met with President Reagan last summer to promote the new weapons ideas and to propose a major increase in funding—$200 million per year—for the x-ray laser and related systems.

These ideas for new weapons provide excitement and challenge for the weapons laboratories. Regardless of whether they will ever work as weapons systems, they have their own dangers, I think, and should be examined carefully. The promise of a new nuclear defense against Soviet missile attack, as described by Teller, is misleading and dangerous if accepted uncritically by the American public and ill-informed officials. I see a number of serious consequences:

- For the x-ray laser to be developed into a weapon, it would have to be tested in space. This would probably violate the Outer-Space Treaty of 1967, which prohibits the placement of nuclear weapons in space. A US abrogation of this treaty could lead to the unraveling of all the arms-control agreements negotiated with such difficulty since 1963.
- Any complicated and expensive system, such as the x-ray laser, would be subject to a variety of countermeasures. For example, pieces of metal chaff near the target missile may give the same radar image as the missile itself.
- Reliance on new "defensive" nuclear weapons could lead to a false sense of security for the nation. Maybe these new ideas could be made to work after a few decades of expensive development, but for now they strike me as high-technology fixes that belong in "Star Wars" stories.

Finally, I want to point out that the new weapons systems give the weapons labs an additional strong argument against a test-ban treaty. If the third-generation weapons ideas are sold to the Reagan Administration and the Congress, then the weapons labs will need many years if not decades to develop them, and during that time a comprehensive test-ban treaty would obviously be impossible. This, in my opinion, is the main danger of Teller's new third-generation weapons.

Detectability

Sykes and Evernden conclude[8] that seismological monitoring techniques have become so good in recent years that compliance with a comprehensive test-ban treaty could be effectively verified. They state that present-day seismic monitoring methods are capable of detecting and identifying underground explosions in the Soviet Union down to yields of one or two kilotons. If an array of 15 unmanned seismic monitors were placed in the Soviet Union by treaty agreement—something the Soviets have already agreed to in principle[12]—then the detectability limit would be reduced to a fraction of a kiloton. Sykes and Evernden base these estimates on explosions in rock.

Decoupling by conducting explosions in cavities complicates the issue considerably. Sykes and Evernden say that with conceivable cavities in rock or in salt domes, the largest blast that the Soviet Union could mask in the presence of 15 seismic monitors is still only two or three kilotons. As one might expect, the weapons labs are quite disturbed by Sykes and Evernden's conclusions, and they dispute them. Milo Nordyke, who is in charge of treaty verification work at Livermore, says[13] that it is possible to decouple relatively small explosions. He suggests that in a large cavity, a 10-kt explosion may give the seismic signal of a 0.2-kt explosion. Such a decoupling by a factor of 50 would be a serious matter for treaty verification purposes—but note that the yields being discussed in 1983 are far smaller than the 300 kilotons that Teller in 1957 told Eisenhower could be hidden. There seems to be a healthy technical debate going now among seismologists in the nuclear-weapons labs and outside, and the Defense Advanced Research Projects Agency is making every effort to dispute and discredit the Sykes and Evernden work.[14] Whatever the outcome of this debate, it now seems clear that seismologists can detect quite small nuclear explosions and that this represents a serious threat to the weapons labs. If explosions above one kiloton were prohibited by a new treaty, the labs would be effectively out of business.

Clearly, the present 150-kiloton limit of the Threshold Test Ban Treaty is unrealistically high. Some future US Administration may resume test-ban negotiations with the Soviet Union. If the direction of future negotiations is simply to modify the 150-kt limit, then it will be necessary to consider a treaty based on either a yield limit or a detectability limit. A yield limit would have to be determined by what both sides agree is a yield large enough to be detected in spite of decoupling. This might be considerably more than 10 kilotons in salt-dome cavities, for example. Conversely, the negotiating countries could try for a treaty based on a seismic detectability limit that might, for example, correspond to a 0.2-kiloton explosion in rock. It is important to note that a yield limit would be much more favorable in the eyes of the weapons laboratories, because to be realistic such a limit would have to be at least 10 kt. The labs could then continue their work with explosions below that limit. A detectability limit of a fraction of a kiloton, however, would seriously restrict the weapons labs.

One problem in negotiating a limit based on seismic detectability is that it would require much discussion of the masking of larger explosions in decoupling cavities. One would expect that in such negotiations the American weapons labs will argue strongly that the Soviets might clandestinely cheat occasionally with explosions of a few kilotons in expensive cavities. At some point, the political leaders of the US and the USSR would have to come to some understanding as to whether there is any advantage to be gained from small-scale clandestine weapons programs that risk detection as seismological methods improve.

Proof testing

As I see it, the nuclear-weapons establishment likes the protracted argument over verification of a comprehensive test ban or a low-yield threshold test ban because it focuses attention on the possible cheating capabilities of the Soviets. The seismic verification questions, as long as they sound alarming, serve the purpose of distracting attention from the really serious argument against a test ban that Anderson publicized. If the seismologists can make their case that verification of a test ban is really no longer a problem, then the labs will have to face the real question: Can dependable working bombs be manufactured in the future from today's proven designs? People at the top of the weapons-labs hierarchy say that bombs manufactured in years to come will not be dependable without continued nuclear testing. Other weapons experts deny this assertion. In August of 1978, when it seemed that

Treaty signing and toast, 5 August 1963. Top photo shows the signing of the Limited Test Ban Treaty in St. Catherine's Hall in the Kremlin. Seated are US Secretary of State Dean Rusk, Soviet Foreign Minister Andrei Gromyko and British Foreign Secretary Lord Home. Those standing include, from the left, US Senators George Aiken, William Fulbright and Hubert Humphrey, US Ambassador to the UN Adlai Stevenson, UN Secretary General U Thant and Soviet Premier Nikita Khruschev. Rusk, Home and Gromyko (below) are among the celebrants after the signing. (United Press International photographs.)

negotiations with the Soviets on a comprehensive test-ban treaty were close to success, three men from Los Alamos wrote President Carter a very significant letter concerning testing and the reliability of the stockpile. They were Norris Bradbury, director of Los Alamos from 1945 to 1970, J. Carson Mark, head of the Theoretical Division of Los Alamos for 26 years, and Richard Garwin, a consultant at Los Alamos since 1950. In their letter they argue that it is possible to have a reliable stockpile even with a comprehensive test-ban treaty. They pose the question,

> Can the continued operability of our stockpile of nuclear weapons be assured without future nuclear testing? That is, without attempting or allowing *improvement* in performance, reductions in maintenance cost, and the like, are there non-nuclear inspection and correction programs which will prevent the degradation of the reliability of stockpiled weapons?

Their answer is "yes," and they go on to address several problems that must be solved to maintain and manufacture reliable bombs, including the problem of materials acquisition mentioned by Anderson. They further point out that

> It has also been rare to the point of non-existence for a problem revealed by the sampling and inspection program to *require* a nuclear test for its resolution.

Livermore personnel disagree with the assessment of Bradbury, Mark and Garwin. Thus, as I quoted earlier, Livermore's director Batzel stated in September 1978 that continued nuclear testing is necessary to keep the US stockpile credible.

The disagreement among weapons scientists in 1978 may have provoked some further thinking about the problems of a potential comprehensive test ban treaty. In February 1980, Joseph Landauer, then assistant associate director for arms control at Livermore, wrote a classified report[15] titled *National Security and the Comprehensive Test Ban Treaty*. Later that year he released a declassified version[16] that is fairly close in content to the classified document. This report gives reasons for and against a comprehensive test ban treaty—primarily against—and is a rare example of what amounts to a publicly available policy statement from a weapons laboratory. As one argument against a comprehensive test ban treaty, Landauer raises the question of materials replacement, saying:

> We expect that all nuclear weapons will have to be replaced or remanufactured within a few decades of their original manufacture. More and more of our stockpiled weapons are approaching

> retirement age. No amount of good intentions or executive decisions will ensure the availability of exact replacement materials or prevent subtle changes in manufacturing processes.

The implication is clear that nuclear testing is required in the future to make sure that replacements or newly manufactured bombs actually work. There are also some classified aspects of current weapons designs that persuade people at Livermore that standard bombs built in the future must be tested to make sure they work. These design questions need to be examined by qualified scientists from outside the weapons laboratories.

Clearly, what has happened in the 20 years since the signing of the Limited Test Ban Treaty is that the weapons laboratories have produced sophisticated designs that are very efficient but so delicate that the labs seem to have no confidence that they can be manufactured reliably in the future. This raises two questions:

- Why have the laboratories been allowed to produce weapon designs that effectively preclude the US from ever signing a comprehensive test-ban treaty? Surely this is strange considering that such a treaty has been a US policy goal for 20 years.
- Can this situation be changed? That is, can the weapons laboratories quickly modify some of their designs so that bombs can be built reliably in years to come in the event of a comprehensive test-ban treaty?

Landauer makes another point that we have to consider seriously. He notes that Russian nuclear bombs are generally heavier, possibly less sophisticated, and possibly more dependable for manufacturing in the future. Thus he fears a serious degradation gap favoring the Soviets after a few years of a comprehensive test ban. He says

> We cannot assume that stockpile degradation will be symmetrical in respect to US and Soviet weapons. We do not know how Soviet weapons are made, what their remanufacturing problems are, or by what means the Soviets can maintain the skills of their weapon scientists.

It would be ironic indeed if the cruder and more robust Soviet bomb designs allow the Soviets to be better prepared for a comprehensive test ban. I believe—for whatever it's worth—that the Livermore and Los Alamos Laboratories are full of clever weapons scientists who can in a short time meet the technical challenge posed by a test ban, and can produce bomb designs that avoid stockpile degradation problems. Certainly this should be one of the duties of the weapons laboratories.

Nominally, the University of California manages both the Livermore and Los Alamos laboratories under contract with the Department of Energy. The University of California obviously cannot interfere with the nuclear weapons design work done at the two labs, but it does have some oversight role. Part of this role is handled by a committee, the Livermore and Los Alamos Scientific and Academic Advisory Committee, which reports to the president of the university and occasionally to the university's regents.

What should be done?

In February 1982, Ray Kidder, one of my colleagues at Livermore, made a formal presentation to the Advisory Committee concerning the question of the necessity of continued nuclear testing to assure stockpile reliability. He asked the committee to look into this question as a technical scientific matter and to try to resolve the conflicting claims of weapons experts. In July of last year, Kidder sent a letter to David Saxon, then president of the university, stating that

> The purpose of the report [of the Advisory Committee] would be to provide government policy makers with information that is of fundamental importance in the formulation of national policy concerning nuclear weapons, and that directly concerns the statements and activities of the two weapons laboratories under the stewardship of the University.

After some months of prodding, the answer finally came. It was *no*, the Scientific Advisory Committee would not be authorized to take up the question. Evidently this question impinges on national policy and is simply too difficult for the university to study.

To conclude, I will give my own opinions on what should be done.

- I think Congress or some part of the US Government should appoint a high-level committee of competent scientists, with members from outside the weapons establishment, to examine carefully the problem of bomb replacement and to figure out what needs to be done so that a comprehensive test-ban treaty will be possible.
- Congress, with the help of a group of qualified scientists from outside the weapons establishment, should examine carefully all the ideas for third-generation weapons, and make sure that they don't instantly become mammoth secret projects that attain their own momentum and destabilize the present precarious arms-limitation agreements.
- Technology for seismic verification of a comprehensive test-ban treaty appears to be sufficient already, and I am not convinced by the labs' arguments about the need for indefinite nuclear testing. The world needs to stop nuclear testing even more now than it did in 1963. Thus I hope that a more enlightened Administration in a few years will approach the Soviets again and complete the agreement that Kennedy and Krushchev tried to attain, namely a comprehensive test-ban treaty. Not everybody agrees that stopping continued nuclear-bomb development will reduce the possibility of nuclear war, but I think so.

Seaborg concludes his book with a strong recommendation for a renewed effort to reach agreement on a comprehensive test-ban treaty. The final words in his book reflect the urgency of this task: "The hour is late. Let us hope not too late."

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