

**Nuclear Testing:
Technical Requirements for
and Implications of New Limits**

Moderator:

Gregory van der Vink, Senior Analyst, Office of Technology Assessment

Speakers:

Robert Barker, Assistant to the Secretary of Defense (Atomic Energy), U.S. Department of State

Thomas Cochran, Senior Staff Scientist, Natural Resources Defense Council

Thomas Cochran

On this, the 25th anniversary of the Limited Test Ban Treaty, we are once again witnessing a strong public and political demand to stop nuclear testing. Despite the Reagan administration's efforts to push a test ban as far into the future as possible, over the last several years, there have been several scientific and political achievements that have moved us closer.

Over the past decade, there has been a revolution in seismic capabilities as techniques for digitizing and recording seismic wave forms have permitted more rigorous analysis and provided better discrimination between nuclear explosions and earthquakes and other events.

Next, the NRDC-Soviet Academy of Sciences project installed seismic stations near Semipalatinsk, the first time American scientists were permitted to monitor arms control verification issues of any type in the Soviet Union. Subsequently, we have expanded that network to four stations at new locations, and a fifth one should be on-line by the end of the year.

The Incorporated Research Institutes for Seismology, IRIS, is negotiating with the Soviet Academy to expand that network to 20 high-performance stations. There has also been the Joint Verification Experiment (JVE). I will not elaborate on that, since Dr. Barker already has.

There was Secretary Gorbachev's announcement of a 19-month unilateral moratorium that demonstrated that he is serious about moving toward a CTB. When testing resumed, Gorbachev announced that the Soviet Union would stop testing again immediately if the United States would do so. The time is ripe for an analysis of verification requirements for a Low Threshold Test Ban Treaty or a CTB, and what benefits we can expect to get from them.

Nuclear tests with explosive yields above 10 kilotons can be readily monitored with high confidence. This can be done with an external seismic network and other national technical means, as described in the study Dr. van der Vink directed for OTA. Such a network is already in place, and so there is nothing to prevent us from verifying a 10-kiloton threshold without reliance on in-country seismic stations. (See Table 1.)

However, the 10-kiloton threshold would not stop much other than the introduction of new, high-yield secondaries. Given known distribution of U.S. tests, a 10-kiloton threshold would not cut off very many that were conducted over the five-year period from 1980 to 1984, so the technical impact would not be large. It would, however, have a sizeable political impact.

Where do we go from here if we have the political leadership that is willing to move to new thresholds? The next threshold to be considered is in the five to 10-kiloton range. This would prevent the introduction of high-yield warhead designs, and may have an impact on the x-ray laser.

As for verification below 10 kilotons, you have to start worrying about potential evasion scenarios. The only ones that deserve serious consideration are decoupling by testing in a large underground cavity, disguising the nuclear explosion as an industrial explosion, and hiding the explosion signal in the coda of an earthquake.

This last scenario is not very credible due to the ability of modern seismic instrumentation. You have digital records of the events and can use filtering techniques to look at the high-frequency versus the low-frequency energy in the spectrum.

So in the five to 10-kiloton range, we are really worrying about the decoupling scenario. There are reasons not to take the scenario as seriously as seismologists do, but we can rely on the seismic techniques alone nonetheless.

The OTA study draws the line at about five kilotons. Below that, you run into trouble distinguishing decoupled nuclear explosions from industrial explosions, but in the five to 10-kiloton region, decoupling opportunities are fairly limited. For practical purposes, you are restricted in the Soviet Union to salt domes, where a five-kiloton nuclear shot fully decoupled is about equivalent to a chemical shot that is 175 times smaller — on the order of 30 tons. There are not many industrial explosions of that size in the Soviet Union, especially in regions which are attractive for decoupling. The number is on the order of 20.

So you can verify in the five- to 10-kiloton range. You might need a dozen in-country stations. You would want these to be high-performance stations so they could record high frequencies — out to about 70 hertz — and you would want to install them around the salt domes of the Soviet Union.

With such a network, five kilotons seems to be a good place to draw the line. We have the stations in the Soviet Union now, and we can install others faster than the Soviets could build a test program based on decoupling. So there is really no technical reason not to move down to the five-kiloton level immediately.

Once you go below five kilotons, you start running into the problem of distinguishing tests from industrial explosions. The number goes up exponentially, and by the time you get down to one kiloton, you are looking at about 1,000 industrial explosions and counting earthquakes in areas favorable for decoupling. To move from five kilotons down to the one- to two-kiloton regime, you have to take additional steps on the basis of other verification techniques.

Table 1. Objectives of Lower Limits on Yields of Nuclear Tests

Threshold	Objective
5--0 kt	Halt the introduction into the stockpile of new high-yield strategic warhead designs and probably the nuclear pumped x-ray laser.
1-2 kt	In addition to the above, halt the introduction into the stockpile of some new tactical warhead designs, new primaries for high yield secondaries and possibly some third generation weapons.
0 kt (CTB)	Depending on the definition of a CTB, in addition to the above, it is possible to halt various physics tests, weapons effects tests and testing of third-generation weapons; and the introduction into the stockpile of new low-yield tactical weapons and third-generation weapons.

To move from five kilotons down to the one- to two-kiloton regime, you have to take additional steps on the basis of other verification techniques.

First, you have to understand that we have tested about 200 or 300 times more than the Soviets have. Do we have some great national security advantage as a result of having tested 200 times more than the Soviets? We have warheads that have better yield-to-weight ratio and better yield-to-volume ratio, but the Soviets have simply made up that difference with missiles of greater throw-weight. It is hard to see how the Soviets, through testing in the one- to five-kiloton range, are going to get a national security advantage. It could only come by some revolutionary innovation like third-generation weapons, not from marginal improvements in yield-to-weight or yield-to-volume of traditional warheads.

You are not going to get an advantage out of one or two tests in the five- to 10-kiloton range. In fact, you have to have a robust, clandestine, cavity-decoupling testing program. It is hard for me to believe that, with all of the other intelligence capabilities — photo intelligence, signal intelligence, human intelligence — that we cannot make the risk of getting caught very high.

Since the risks would be so high and the benefits would be pretty close to zero, there is not really any incentive for the Soviets to test. By that line of argument, we can draw the line below five kilotons. If we go down to one kiloton, not only would we halt the introduction of new high-yield strategic secondaries, but we also halt certification testing of low-yield weapons like atomic demolition munitions, neutron warheads, and the like.

You could still do a lot of physics experiments, and you could conduct a robust research program on third-generation weapons, and you could do some effects tests at two kilotons.

Now, when you try to find a place that is below one or two kilotons, it is difficult to find a logical place without dropping down to a comprehensive test ban or something very close to it. There have been a number of proposals.

Roy Kidder at Livermore has suggested a laboratory capable of containing one nuclear explosion up to 300 tons a week. We could draw the line there. Then, there is the Garwin proposal: permitting above-ground laboratory facilities, provided that workers could stand within 10 meters of the explosion. You would use the criterion of how close you could get without getting skin burn or neutron exposures. You could draw the line at eliminating all implosion physics experiments with fissile material, but perhaps allow inertial confinement fusion research to go forward.

Regardless of which of these techniques are used, you are really out of the regime where seismic technique is the basis of verification, so you have to rely a great deal more on on-site inspection. Finally, let me point out that the nonproliferation advantages of a CTB outweigh whatever risks are associated with cheating.

van der Vink: I think that is a new proposal: to limit testing not by a particular threshold, but by the distance that the administrators and designers are willing to stand away from an explosion. I think that that is an avenue we may need to pursue further.

(Laughter.)

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Question: Dr. Cochran, I have trouble figuring out where you are coming from. Dr. Barker states that it is necessary for this country to continue testing to maintain a reliable deterrent. You obviously do not share that view. I would like to know what your view of the relationship between testing and deterrence is.

Cochran: That debate is well developed, so I would refer you to the papers by Ray Kidder on whether testing is needed for reliability purposes. For example, we have had the B-53, which has a 10-megaton yield, in the stockpile for a number of years, and we have certainly relied on it since the 150-kiloton limit without a great deal of worry. I do not think that you need to test for reliability purposes. The objective of reducing the yields is to put some brakes on the introduction of new warhead designs into the stockpile.

Question: Do you believe it is necessary to have reliability in order to maintain a deterrent?

Cochran: It is useful to have reliable weapons, yes, and the weapons are reliable. They are much more reliable than the delivery systems. The degradation in the reliability of the weapons at these various threshold levels will not be significant compared to the degradation in the reliability of the delivery systems.

Question: But will the Soviets believe it? They are the ones whom we have to impress.

Cochran: Well, one nice thing about this is the Soviets are in the same boat.

Barker: Maintaining the reliability of the weapons that exist in the current stockpile is but a small part of the reason why nuclear testing is necessary to maintain a credible deterrent. We have accepted the limitation of 150 kilotons because we believe that we can maintain the reliability of the existing stockpile at that level and at a level not much lower than 150 kilotons. Tom claimed that we have not tested the B-53. He is right in that we have not tested the B-53 at full yield, but he does not know whether or not we may have tested it at a yield below 150 kilotons, and thereby have assured ourselves that we can remain confident in its performance.

Cochran: Have you?

Barker: We do not discuss that issue.

Question: Dr. Cochran, you said that the net effect of the negotiations we are now having and the JVE would be to put off significant testing limits. Given that, and given the apparent Soviet interest in going to a Comprehensive Test Ban, what do you think the Soviet motive has been in going along with these rather elaborate delaying negotiations?

Cochran: We can only make some guesses about what their motives are. One possibility is that the Soviets made a political judgment that they were not going to get relief through congressional efforts and were going to have to work with the Reagan administration. Perhaps they thought Bush would be elected, and there

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was some benefit to getting this issue resolved so that political and public attention would focus on lowering the thresholds. In the negotiation with the United States, it was agreed that once we ratified the Threshold Test Ban Treaty and the PNET, the next step would be to begin formal negotiations of reductions in the threshold and implementation of quotas.

Question: Dr. Barker, can you tell us what new weapons we will be unable to deploy under a CTB?

Barker: Nuclear testing is relevant to the maintenance of reliability of the existing stockpile, but a far more important reason is the ability to respond to a changing Soviet threat by deploying weapons systems that are more survivable than the ones they replace, both in terms of the way in which they are based and in the Soviets being convinced they could actually get to a target.

Over the last decade, we have moved in the direction of enhancing the survivability of our stockpile by adopting weapons systems that impose harsher conditions on the warhead. A nuclear warhead is like any other piece of hardware in that you have to look at the temperature environments — how hot it could get, how cold it could get, what kinds of vibration loads it sees. One of the reasons why nuclear designs change is because we change the designs in order to accommodate these new environments.

Along the way, we may change the yield, but over the last decade, modernization has been primarily a repackaging of technology, as opposed to any great change in the technology.

We will shortly be deploying a new warhead aboard Trident submarines. That warhead will have to travel greater ranges than the system that it has replaced. It will have different shake, rattle, and roll environments. In this case, there is an additional military effectiveness requirement over and above the system that it replaces. We are going to a B-1 bomber whose weapons see a different environment than those weapons that were mounted aboard a B-52. We are talking about tactical weapons which see a different environment than those which they replace.

So the modernization process has replaced technologically obsolete systems or systems whose effectiveness is in question because of steps the Soviets have taken to make the older systems ineffective. For those new systems we have developed new warheads. That process is going to be perpetual, because the things which have threatened the survivability and credibility of existing forces are not Soviet nuclear developments. They are developments in the Soviet conventional weapons area like antisubmarine warfare and anti-air warfare. Those are the things which pose threats to our existing deterrent, and the new weapons systems and the new nuclear weapons that go along with them are a response to a changing threat that often comes from the conventional area in Soviet weaponry.

Question: I am surprised that you didn't mention the earth penetrators and third-generation weapons that are cited in the literature.

Barker: Directed-energy weapons is an area of research at this time. One of the challenges given to our nation's nuclear weapons laboratories is to understand the potential threat that can be posed to the United States. At this moment, work on directed-energy weapons is a technology effort in this area. There has been no

decision on the part of the United States to deploy that kind of technology. After all, the president's objective in the Strategic Defense Initiative is a totally conventional system, a system without nuclear weapons as a part of it.

Cochran: Bob indicated that the primary purpose of testing in recent years has been repackaging, and that is how he defines modernization. We do not change the design of our astronauts when we "repackage" them. What is done ensures that the environment is the same throughout their flight, or at least within the limits of human endurance.

If you had a test ban, and some assurance that the weapons that you presently have will remain reliable, then your modernization would be restricted to changing the packaging of the delivery system.

With respect to directed-energy weapons, he says that the research is designed to ensure that we understand what the Soviets are going to throw at us. Well, if we have the test ban, the Soviets could not develop new weapons or introduce them into their stockpile. Then, there seems to be less need for a research program to see what they are going to deploy. One of the main purposes of moving quickly to lower thresholds is to curb the research on third-generation weapons.

Barker: I did not mean to imply that the only reason one does research on directed-energy weapons is because of a potential Soviet threat. That is one of the reasons. If the technology is ever proved feasible, the United States might determine that it was in its national security interest to deploy such technology.

Question: Dr. Barker, is it true that some of the more modern safety and security designs require underground testing? And if that is true, what can be done to better educate both the Congress and the public as to the implications of the ban for modern safety and security?

Barker: That is correct. One of the challenges which is given to nuclear weapon designers is to improve an already very safe nuclear weapon to make it even safer, and to improve our ability to ensure that a nuclear weapon can be used only under authorized circumstances. This has led to the inclusion of security features as a fundamental element of nuclear design. One of the things that has happened as the stockpile was modernized was that those new weapons which were built incorporated the latest safety and security features.

It is important to remember that there are still elements of our nuclear stockpile that are virtually 30 years old and represent the technology of that time. As these systems are retired and replaced, these modern safety and security features are incorporated, but we have a long way to go before the entire U.S. stockpile will be equipped with such features. Nuclear testing is critical to our being able to incorporate this technology into our weapons.

Cochran: That is not the reason he opposes a test ban. When the language of the Senate bill, which would stop testing above a kiloton, allowed provisions for a few reliability tests and some modernization, the administration still opposed the bill. The real reason the administration does not want a test ban is that they want to continue development of new nuclear weapons.

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Barker: The short form is that the administration wants a reliable deterrent.

Question: Dr. Barker, it would seem to me that it would be advantageous for the United States to have a test ban to constrain the development of further nuclear powers.

Barker: The issue of the influence of test limitations on proliferation is an interesting philosophical argument that has been made for decades, and I never quite understood the technical foundations for it. Technology has certainly advanced to the point where a country that chose to proliferate could probably develop a primitive stockpile without testing, so a test limitation is not a great inhibitor to non-proliferation.

I think we have a higher responsibility to maintain the security of this country and our allies. Today in 1988, much more than in 1948, nuclear weapons play a very important role in security, and I cannot see abandoning that crucial element in exchange for the possibility that a cessation in testing might somehow deter some unnamed country from developing or deploying an untested stockpile.

That is one of the great things that is missing in this debate. There has been an awful lot of discussion about nuclear testing limitations over the years, but the side of the argument that is totally undeveloped intellectually is the argument that a cessation in testing will have the kinds of benefits that people attribute to it. It is more often than not a simple statement that is supposed to be viewed as true on its face without a sound foundation.

Cochran: Do you believe that we have a treaty obligation to seek a CTB?

Barker: We indeed are committed by the Limited Test Ban Treaty to seeking —

Cochran: You do not sound committed.

Barker: If you go back to the earliest references to a CTB, you will find it mentioned in the same breath with general and complete disarmament, and I think that that is exactly the place for it to be. As long as we must depend upon nuclear weapons, we must depend upon nuclear testing to ensure that our deterrent is a reliable one.

Cochran: Is the administration position, then, that they will seek as a goal the complete abolition of nuclear weapons? Is that your philosophy?

Barker: I would be happy to read for you the statement that the administration has used for several years: "A comprehensive test ban remains a long-term objective of the United States. We believe such a ban must be viewed in the context of a time when we do not need to depend upon nuclear deterrence to ensure international security and stability and when we have achieved broad, deep, and effectively verifiable arms reductions, substantially improved verification capabilities, expanded confidence-building measures, and greater balance in conventional forces."

So what happens in the conventional forces domain is very important to any determination of when we can cease nuclear testing, and that is why the next great push in the arms control arena must be in the conventional weapons area. And the latest signals are that we and the Soviets will be able to agree to a common agenda

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That the administration has as a long-term objective of reducing in the context of a time period to ensure international stability, deep, and effectively verification capabilities, exercise in conventional forces.”

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and may be able to start serious negotiations before the end of this year on the reduction of conventional weapons.

van der Vink: If there is not much merit in further restrictions on nuclear testing, I do not understand what the role is of these negotiations that are intended after ratification of the Threshold Test Ban Treaty to pursue further verification methods for future treaties. Could you explain the motivation for the negotiations, considering some of your statements?

Barker: Both we and the Soviet Union were optimistic that we would be seeing substantial progress in the arms control area in limiting and reducing nuclear weapons and conventional weapons. The statement that the two sides agreed to on September 17, 1987, makes it clear that we would pursue further reductions in nuclear testing in the context of an effective disarmament process. That was the exact language that both sides agreed to. The U.S. statement is a little bit more expansive because it talks about step-by-step reductions in nuclear testing as accomplishments are achieved in these other arms control areas.

van der Vink: In other words, the negotiations which Ambassador Robinson is leading are intended to start improving verification for a time when we no longer need nuclear weapons.

Barker: Well, it is difficult to predict progress in these various areas. As I mentioned, the conventional arms talks are going to be starting in December; the Strategic Arms Reduction Talks are under way. Whenever the Senate finally ratifies the Threshold Test Ban Treaty and the Peaceful Nuclear Explosions Treaty, Ambassador Robinson and his counterpart will have to sit down and see if they can agree on a concrete objective. Verification capabilities may very well be a very important part of those discussions.

This is one area where the nuclear testing talks have set a precedent. The two sides have demonstrated the verification capabilities they are talking about before they have been incorporated into a treaty.

van der Vink: So this is sort of a “coal in the fire” for some future, as-of-yet undefined, or even determined further restriction.

Barker: Certainly, the United States and the Soviet Union have not discussed, let alone agreed to, what the next objective would be for the nuclear testing talks. Verification would be an important part of it, but I am certainly in no position to predict what the next specific goal will be or how long it will take to get there.

Question: I think it is important to point out that, in a letter to Congress a few weeks ago, the Reagan administration changed U.S. policy.

Barker: That is a misstatement. I have the document right here, and it does not say that.

Cochran: I know what he is talking about, but it is not in there.

Barker: The president's statement was issued several weeks ago. I encourage all of you who want to understand the administration's position on nuclear testing to get hold of it. It is a White House press release dated September 8, 1988. It is a

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transmittal to the Congress that went along with two classified reports, one from the Department of Energy and one to the Department of Defense. These reports were required by the Congress. Only the president's cover memo is unclassified, but there is no change in U.S. position in that paper.

Cochran: You have made references in the congressional testimony to the OTA report. I would like to know what specifically in the OTA report you think is incorrect, because the OTA is going to be the base line for future debates, at least for the next few years. If there is something in there that the administration thinks is flatly incorrect, we ought to know what it is and know the scientific basis for the argument.

Barker: As I told Congressman Fascell (D-FL), the chairman of the House Foreign Affairs Subcommittee, the best people to explain the deficiencies to OTA served on the panel of experts that OTA had turned to for a critique of their report. The concerns that I expressed in the hearing were a result of conversations with several of those people who felt that the report had, in tone, misrepresented views that they had expressed, and that the OTA report was, in general, too rosy about the ease with which thresholds lower than 150 kilotons could be verified.

I am not a seismologist. I think the right people to address the deficiencies of the OTA report in detail are on that very list of people whose names appear on the inside front cover of the OTA report.

Cochran: So the administration does not have any specific issues. It is a matter of tone. There are no specific scientific mistakes in this report. It is not the administration position that this is wrong.

Barker: I do not have a line-in/line-out critique of the report. One of the problems with the report is probably best underlined by a statement that you made earlier when claiming to quote the report, Tom. You said that a threshold of greater than 10 kilotons can be monitored with high confidence. I do not know what you mean by the word "monitored." I do not know any seismologist who does not believe that he will probably see a seismic signal from an explosion in the neighborhood of 10 kilotons. However, a 10-kiloton threshold requires much more than that. It requires detection, clear identification as a nuclear explosion, and measuring the yield to an accuracy sufficient to protect U.S. interests under such a treaty.

Right now, we do not have in place the mechanisms to verify a 150-kiloton threshold. Nor do we have the capabilities to verify a 10-kiloton threshold to adequate accuracy.

van der Vink: I need to make a comment. You said that the proper technical people did not have the opportunity to comment.

Barker: No. They had comments that were not incorporated in the report, and they are the people whom should be consulted by Congressman Fascell for any detailed criticism of the report.

van der Vink: I do not want this to get sidetracked into an argument about the OTA report, but that also came up in your testimony, particularly in the discussion of hydrodynamic methods. In fact, we did send copies of the report to the

appropriate people at Los Alamos for review through three iterations, and they did send comments to us at both the classified and unclassified level. Furthermore, I noticed on all of their letters that copies had been sent to your office. To say that we did not consult with the proper people would be an unfair criticism.

To say that the report presents a more rosy tone than you feel is appropriate is a criticism we have heard. We have also heard, to a greater extent, the criticism that the report presents much too dark and bleak a forecast about what could be accomplished. One of the difficulties in writing a report like this is that you try to compress the technical debate as much as you can by eliminating any technical opinions (both optimistic and pessimistic) that were demonstrated to be untenable. However, if you want to get something that all people with all points of view will agree on, both in philosophy and tone, you end up with nothing.

While it is true that there are a few people who feel the report was too optimistic, there are a greater number of people who feel that the report was too pessimistic. To us, this is one of the signals that indicates that we did a good job in accurately putting our finger on the consensus.

We would be happy to hear any criticisms of the technical arguments of the OTA report; in fact, we are still waiting for those from you. All that we have received is a flood of letters from seismologists who were involved in the study (one or two of which were written to you) that defend the technical merit and the process and the substance of the OTA report against your allegations.

Question: Would the panelists comment on their interpretation of Soviet attitudes on the whole issue? The moratorium did last 18 months. The Soviets seem to be open to any kind of mutual moratorium. They have supported the activities of the NRDC.

Presumably, the Soviets feel that they could maintain an adequate deterrence. If the panelists think the Soviets are wrong, why are they wrong?

Barker: I certainly am not in a position to definitively say why the Soviets take the positions they do with respect to nuclear testing agreements. Maybe they do not depend upon their deterrent as much as we do. All the more reason to be frightened.

Sakharov implied that he believed that the Soviet Union was quite capable of maintaining the credibility of its nuclear weapons without testing. The best advice I can get says the United States cannot. That explains our reluctance to undertake such a limitation.

You asserted that the Soviet Union observed their declared moratorium. That may very well be, but we always have to point out the fact that we did not have the verification mechanisms to ensure compliance.

Maybe the Soviets did have a moratorium, but we do not know, because we did not have the technical capability to determine whether they did or not, and we cannot do it today, either.

Question: Dr. Barker, the administration on several occasions has said that past Soviet testing practices constitute a likely violation of the Threshold Test Ban Treaty. Last year a team of experts from Lawrence Livermore, reviewing both the

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classified and unclassified data, concluded otherwise. So did the OTA study. Does the administration still hold to that charge, and if so, on what evidence?

Barker: The Livermore report said that, in their view, the seismic signals that were observed could be consistent with a test program which did not include tests above 150 kilotons or with signals that came from a program in which some tests exceeded 150 kilotons.

The data in the OTA study are also consistent with a program in which some tests exceeded 150 kilotons, so from that study you cannot tell whether or not the Soviets were in compliance based upon seismic data. However, based on this, if you want to be very critical, you can say the administration went overboard, because in true fact, you cannot tell whether or not the Soviets were in compliance.

I must point out that the president's statement on likely noncompliance by the Soviet Union is a very long statement. It points out that there are significant uncertainties associated with that assessment because the verification mechanisms of the Threshold Test Ban Treaty are deficient. We are now in the process of trying to make those provisions better.

We are doing so with the full cooperation of the Soviet Union, and I hope that next year we will have in place a verification mechanism which will remove the kinds of doubts and uncertainties that we have had over the last several years about Soviet noncompliance with the TTBT.

Cochran: Why did Livermore not say "likely" and the administration say "likely"? Surely Livermore had access to the same classified data.

Barker: I have no idea whether Livermore had access to the totality of information that was available to the administration when it made that study, but you make a good point. The administration conclusion was not based solely on seismic evidence.

Question: The Livermore people do have access to other than seismic information, and it is also well known that if you apply the same seismic criteria to our explosions, you would also find that you could draw essentially the same conclusion that it is consistent with the threshold, but you can also say that there is a possibility that some were carried out above threshold.

The situation is actually amazingly symmetrical, and it is really a stretch of the word "likely" to mean "possible." It is possible to have some outliers. The imprecision of measurement of 100 kilotons is something which we all know exists. It used to be factor of two with 95 percent confidence at the signing of the TTBT and has been narrowed down.

But how a systematic violator could exploit such an uncertainty has never been adequately addressed by the administration. Uncertainty means uncertainty, and we can be off one way or the other. Therefore, a systematic exploitation for weapons development of that uncertainty is clearly, from the violator's point of view, an extraordinarily difficult thing to do. Whatever fuzzy data there are above the threshold, they surely do not indicate a systematic effort by the other side to exploit the uncertainty, nor is it possible for the other side — or our side — to exploit the uncertainty.

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Barker: At one point you said that the uncertainty in seismic estimates was a factor of two at the time when the Threshold Test Ban Treaty was signed. That is what the seismologists said then. Unfortunately, they were wrong.

We have had to change that formula several times since then because of "improvements" in seismic theory as to how to better estimate Soviet yields. If I took at face value your statement that seismic estimates were good to a factor of two in 1974, there would be no doubt that the Soviets have violated the treaty. We have changed the formula substantially since 1974. If today's formula is true, in 1974, we were dramatically overestimating the yield of Soviet tests.

So there is a significant uncertainty. I have to be leery about seismologists' estimates of their accuracy in the absence of any calibrated yield data from the Soviet Union. We do not know the yield of any test that occurred in the Soviet Union up until the one that took place last month. We now have one data point that we can trust from the Soviet Union, and until we get a lot more data points, we will not have a technical basis for knowing the accuracy of seismic yield.

Cochran: Does the problem lie in the bias factor, or in the dispersion around 150 kilotons once you select the bias factor?

Barker: My view is that, with CORRTX as part of the Threshold Test Ban Treaty, we will have our own dependable measurement of the yield of Soviet tests. At the same time, we will be making seismic estimates of those yields. As we gather these data points, we will measure the bias, we will measure the dispersion, and we will finally, for the first time, know what the uncertainty is in the seismic yield estimate, something that now is based totally on theory.

Cochran: That is just not scientific. You will have a second set of measurements which will have their own uncertainties, and you will be able to improve on the uncertainty of your overall estimates of the yield, but right now, you have some scientific measurements of the yield of Soviet tests.

Barker: One test.

Cochran: You have a host of seismic data, and you can assign some uncertainties to your estimate of the bias. You can assign some uncertainties associated with the dispersion of the data.

Barker: Absolutely, you can do that. Feel perfectly free to do it. Someone else can do it, and yet a different person can do it, and I am not sure the numbers are going to be the same. What I am saying is, make a measurement and then you will know.

Cochran: The government has done it, and the government has asserted on the basis of those measurements that there is a likely violation, and now you are refuting the whole basis for the science.

Barker: Because it is the only thing we have had, and we have had to make the best judgment we could based upon the data we had, as bad as those data were.

Cochran: How could you make an assertion of a violation of a treaty on the basis of a scientific technique in which you have no confidence whatsoever?

Questions and Answers

Barker: We have already covered the point that more than seismic issues were considered in the judgment, but I really believe that a more productive course of action is to get on with what is happening in Geneva right now, one which the Soviets have agreed to. Don't forget that part of the equation, that the Soviets' ability to estimate the yield of U.S. tests by seismic techniques was bad enough that they questioned our compliance with that treaty.

Question: Dr. Barker, there is a perception in some policy-making circles that the Bush administration would want to proceed vigorously with the START negotiations so they wrapped up in about 12 months. The question is, if that happened and the political force fields took over, what would be the prospects in this country for a Comprehensive Test Ban?

Barker: There is no technical basis to believe that a Comprehensive Test Ban is verifiable. Tom did a good job this morning listing the significant uncertainties associated with verification of a Comprehensive Test Ban. We are a long way away from that.

Does the accomplishment of the START Treaty and the reduction in weapons associated with it automatically lead to some kind of further reduction in nuclear testing? For the long answer to that question, I refer you to the president's report, because it points out that the reason why we test is to maintain a credible deterrent. That really is a function of the number of different weapons systems the country must maintain, not the number of weapons deployed.

Question: I will not go into specific refutations. Suffice it to say that there is a valid, detailed technical counterargument to every point that Bob raised.

The need for testing every system in the future to meet survivability requirements, for example, is nonsense. This notion that the appropriate response to a Soviet ASW threat is to redesign American nuclear warheads is just silly.

Bob uses the same phrases over and over again, very imprecise phrases where the words glide into one another and you cannot separate them from the technical arguments "reliable, credible deterrent." Now, a lot of the politicians hear that phrase mentioned, "Oh, testing is essential to maintain the technical reliability of the stockpile." But that is not true on a factual level. He is saying "a reliable deterrent." That is something different than a reliable weapon. Or a credible deterrent. That is something different than a weapon that is certified to work under given environmental conditions.

The whole problem in this debate has been the unwillingness to disaggregate the problem into its broader political components. It is simply untrue that we need, in a technical sense, to modernize the stockpile to respond to threats to the survivability of the deterrent. There are many old technical alternatives out there. It is simply untrue that the only way to improve the safety and effectiveness of our weapons systems is to install PALS. There are many other kinds of improvements that we can make.

Barker: One of the issues is the credentials of the people making the statements. Along with credentials obviously comes suspicion. Twenty years ago, I was a nuclear weapons designer. I designed nuclear weapons for 10 years. I know the

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fallibility of a nuclear weapons designer. I know I made mistakes; I suspect my current-day colleagues make mistakes.

It is the nuclear test program that enables this country to know that the weapons that they have designed really work, really do what the designers say they will do. I say that from personal conviction. Now, I am at the Department of Defense, at the receiving end. Now I am the customer, and at the Department of Defense, our weapons systems carry these weapons.

Every other piece of hardware that is delivered to the Department of Defense undergoes rigorous testing before we will accept it. When we do not do it enough, the Congress beats us up about inadequate testing before we have bought the product. The amount of testing that a nuclear weapon undergoes is minuscule compared with that which we put tanks, airplanes, shoes through.

We are dependent upon nuclear deterrence. If you do not believe in nuclear deterrence, the argument does not hold. If you are willing to accept the fact that we are dependent upon a nuclear deterrent, we need to test the most critical element of that deterrent. That is what we do today.

What has been missing today is a description of what benefits are to be associated with nuclear testing. What is it that is so important, that so overrides the contribution of nuclear testing to our nuclear deterrent, that we should turn our back on it?

Look at the literature. It is hard to find a tight, coherent, cogent argument that is not based on whimsical theory.