The Comprehensive Test Ban Treaty: Next Steps

Roundtable Discussion

Stanford University

July 19, 2000

Sponsored by

the **Center for International Security and Cooperation** &

the **Lawyers Alliance for World Security**

THE COMPREHENSIVE TEST BAN TREATY: NEXT STEPS

ROUNDTABLE DISCUSSION
JULY 19, 2000
STANFORD UNIVERSITY

TABLE OF CONTENTS

Written Submissions

MESSAGE FROM THE SPONSORS

The debate surrounding the Comprehensive Nuclear Test Ban Treaty (CTBT) is as multifaceted as it is important. In addition to arms control and non-proliferation elements, it involves scientific and technical disciplines, military planning, international relations, and national security strategy. Sharing a concern that the debate prior to the Senate's rejection of the CTBT was insufficient to address fully the complex mixture of issues involved, the Center for International Security and Cooperation (CISAC) at Stanford University and the Lawyers Alliance for World Security (LAWS) set out to undertake a thorough examination of the Treaty.

On July 19, 2000 CISAC and LAWS gathered forty preeminent scientists, security experts, and political analysts for a *Roundtable Discussion on the Comprehensive Test Ban Treaty* at Stanford University. The day-long seminar was intended to explore the diverse set of topics that arose during the October 1999 Senate debate of the Treaty and to develop a consensus on steps that the United States should now take with regard to the CTBT. This booklet includes a transcript of that discussion along with a collection of short papers submitted by experts who were unable to attend. A series of Background Papers submitted prior to the Roundtable will form the basis of a LAWS White Paper on the CTBT to be published in October 2000. We hope that the discussion and analysis herein will prove useful to future consideration of this most important issue.

We are grateful to all of the participants. We would especially like to thank General Andy Goodpaster and Ambassador Jim Goodby for their assistance in shaping the Roundtable Discussion and Taylor Crawford Bucci and Damien LaVera for their work in putting it together. CISAC and LAWS would also like to thank the Ploughshares Fund. Their financial support made this Roundtable Discussion possible.

Dr. Christopher Chyba
Co-Director
Center for International Security and Cooperation

Ambassador Thomas Graham, Jr.
President
Lawyers Alliance for World Security

LIST OF PARTICIPANTS

Background Paper Presenters:

Ambassador George Bunn
CISAC

Dr. Sidney Drell
Stanford University

Ambassador Thomas Graham, Jr.
LAWS

Dr. Paul Richards
Lamont-Doherty Earth Observatory

Dr. Amy Sands
Center for Nonproliferation Studies at the Monterrey Institute of International Studies

Discussants:

Dr. Donald Cobb
Los Alamos National Laboratory

Dr. Christopher Chyba
CISAC

Dr. Gloria Duffy
Commonwealth Club

Senator J. James Exon
Committee to Support the Comprehensive Test Ban Treaty

Ambassador James Goodby
Department of State

Dr. Roger Hagengruber
Sandia National Laboratories

Dr. Raymond Jeanloz
University of California, Berkeley

Ambassador Stephen Ledogar
U.S. CTBT Negotiator

Dr. Michael May
Stanford Linear Accelerator

Dr. Wolfgang Panofsky
Stanford Linear Accelerator

The Honorable William Perry
CISAC

Mr. Bob Peurifoy
Sandia National Laboratory (Ret.)

General John Shalikashvili
Special Advisor to the President and the Secretary of State for the Comprehensive Test Ban Treaty

Dr. Wayne Shotts
Lawrence Livermore National Laboratory

Dr. Lynn Sykes
Lamont-Doherty Earth Observatory

General Larry D. Welch, USAF (Ret.)

Observers:

Mr. Zachary Bishop
Global Security Institute

Ms. Naila Bolus
Ploughshares Fund

Mr. Taylor Bucci
CISAC

Dr. Nancy Gallagher
Department of State

Mr. Seth Grae
LAWS

Dr. Henry Kelly
Federation of American Scientists

Mr. Daryl Kimball
Coalition to Reduce Nuclear Dangers

Mr. Damien LaVera
LAWS

Mr. Jack Mendelsohn
LAWS

Dr. Robert Rinne
Sandia National Laboratory

Dr. Scott Sagan
CISAC

Mr. Mark P. Schlefer
LAWS

Dr. Paul Stares
Japan Center for International Exchange

Mr. Tyler Stevenson
Global Security Institute

Ambassador James Sweeney
Los Alamos National Laboratory

Ms. Leonor Tomero
LAWS

Written Statements Submitted By:

President Jimmy Carter

Major General William F. Burns, USA (Ret.)

Dr. Richard Garwin
Council on Foreign Relations

General Andrew Goodpaster, USA (Ret.)

Senator Mark O. Hatfield
Committee to Support the Comprehensive Test Ban Treaty

Ambassador Max Kampelman

The Honorable Melvin Laird
Readers Digest

Ambassador Paul H. Nitze
Committee to Support the Comprehensive Test Ban Treaty

BACKGROUND PAPER PRESENTATIONS

Dr. Sid Drell: With the end of the Cold War there's been a major change in the U.S. nuclear weapons program, because the continuous cycle of developing and testing and deploying new warheads has ended. President George Bush announced in 1992 that we have no need for new nuclear weapons designs for deployment. It was this decision that, of course, opened the possibility of a Comprehensive Test Ban Treaty, which is why we now have a Stockpile Stewardship Program with the three requirements: we must maintain an enduring stockpile that's reliable, effective and safe for the indefinite future without nuclear explosive testing; we must maintain competence in nuclear weapons; and we must retain a technical capability and a manufacturing infrastructure in order to respond if required to any change in strategic circumstances. This will be one of the factors in our net assessment of whether to enter a CTBT.

My starting point in discussing this is defined by the following three of what I call facts that I'll state very briefly. The first is that our arsenal at the moment is in fact safe, reliable, and effective and will remain so for the foreseeable future. That's the way they were designed, that's the way they were tested, and that's the way – with fifty years of surveillance and experienced analysis – the stockpile was built, in which we have statistically significant confidence. In particular I would like to point out that somewhere on the order of 150 to 200 of the tests – of the 1,000 or more that we've done – have been on our modern arsenal – the one that is in the enduring stockpile.

The second point I want to make, when we think of testing, is that the overwhelming majority of our tests have been devoted to developing new warhead designs, which is what we are not doing now. Only a very small percentage of our nuclear tests – less than one per year, far less than ten percent even – of the 150 to 200 tests of the modern weapons conducted in the last 20 to 25 years – were devoted to stockpile confidence tests.

And the third point is that a Comprehensive Test Ban Treaty in no way limits most of the testing and analysis that we do on our stockpile. We still can test the operation of a warhead up to the moment of initiating the fission. We still can exercise the neutron generators, boost gas transfer system, flight tests, the arming firing and fusing systems, etc. Of the almost 6,000 parts that make up a warhead, these are all tested, they all should be tested, they must be tested and they will be tested under a CTBT. The CTBT stops only the testing after the device starts producing fission. The operation of the high explosives up to that point will go ahead.

So with that as background let me comment on what I said are the requirements of the Stockpile Stewardship Program. We start with number two, maintaining competence. The Stockpile Stewardship Program is a scientifically very exciting program. We are understanding the fundamental science underlying many of the processes going on in the weapons – how the materials behave under the extreme temperatures, pressures and whatnot during an explosion. It's just that no new designs are being developed for deployment. In fact, thinking of new designs is also going ahead. We're deepening our scientific understanding. This program is generating exciting science and in my experience at the labs is indeed proving a draw and a matrix for scientists to be excited, to be drawn, to stay involved in the work that in many ways I call a scientific renaissance. In my judgment as a scientist working on these matters, it is far more interesting to understand more deeply the science of nuclear weapons rather than the phenomenonology of blowing out the side of a mountain with an old design.

The Stockpile Stewardship Program is a difficult management challenge, which was emphasized in the report on maintaining nuclear confidence by Admiral Chiles's Commission, which I also served on. To run this program successfully takes enlightened leadership, but I think that with all the new diagnostic tools, with the effort to understand the weapons, this is a challenge that will and should serve to maintain nuclear confidence in this country. I also think that the leadership that my friend, whom I admire so much General John Gordon, will provide now as the new administrator of the NNSA will be an important component in the success of this program.

As for the challenge of maintaining confidence in the stockpile for the future, again you have to remember that data is the coin of the realm in science and that's what we are getting now with the diagnostic equipment that we have, that's being improved, that's being constructed. We are learning now, for example, how the plutonium – the fission material in a bomb – or uranium, but especially plutonium because it's so complicated, behaves under the extreme temperatures and pressures of an explosion. We are learning about whether the aging of plutonium because of the radioactive decay involved in any way compromises the integrity of its structure and the properties that it must have during the implosion process.

We are doing detailed forensics, diagnostic work on each warhead type in the stockpile. Eleven copies of each warhead are disassembled and studied for evidence of aging, for evidence of corrosion, for whatnot. Each year, on average, one of those eleven – sometimes we diddle with the numbers a little according to the labs' best wisdom, but typically one a year – is completely and destructively disassembled to go over in great detail what's happened so we can study whether there has been corrosion or other signs of problems. We can study whether the radioactivity in the plutonium is affecting the chemicals of the high explosive or its own structural integrity.

These detailed features in the enhanced surveillance program are giving us greater confidence in how the warheads are behaving, whether cracks are developing, etc. And indeed the data also allows us to determine by simulation what the effects of any small crack will be and when it is big enough that we have to worry about it. We can literally x-ray the primaries during the implosion up to what would be the initiation of fission.

We are doing underground sub-critical tests in Nevada, which are giving us direct evidence on the properties of plutonium, whether it is young or old, and whether spall or ejecta change, because all of this is important in understanding the boost process, and therefore whether the yield of the primary will drive the secondary. There is an enormous good science program going on and we are learning whether aging or changes to the manufacturing process are affecting performance. So far the answer is no.

ASCI, the Accelerated Strategic Computer Initiative, which has achieved speeds up to about three terraflops in our computers now on the way up to ten, allows us to develop three dimensional explosion codes to study in detail the effects of slight perturbations on the structure, and give us confidence that, in particular, the primary of the weapon remains strong enough in yield to drive the main stage, or the secondary.

I could go on and make a physics talk. I will spare you that, but I want you to know that this is the kind of work that is going on and that the new codes from ASCI are being benchmarked against old data, excursions in the past that we didn't understand, and against new data coming from the new facilities as (and when) they are completed.

It's a very sophisticated, technically challenging program with Livermore and Los Alamos competing against each other and peer reviewing each other's work. I think that we can be confident that if there are any warning bells to indicate that something is going wrong we'll hear them. And in fact I think the best argument right now for keeping two independent weapons labs – two physics device labs – going is to have that independent peer review.

We are learning about the lifetimes of the warheads: how long a lifetime we can expect for them; when we might find that there are defects that might come with age; etc. We must know how long we can count on the warheads and therefore at what rate we may have to refurbish or remanufacture them with time.

Here is an example of statistics on aging (figure shown). These are rates of actionable findings of warhead lifetime, the rate in the number per warhead. So this shows you that over a range of thirty years, which is the limit on experience, there is no evidence of decreases in the integrity of the warheads. Clearly one has to get more data out there, and that's what the program is doing.

Scientists will always welcome more data; it always is helpful to have more data that can be gained from experiments, such as underground tests. But the question at issue here is, is it necessary, or is it simply desirable. Is it useful? Because if it is necessary, it is necessary. If it is useful, you have to

weigh its value against other factors, political and strategic, that would be involved in allowing underground yield tests.

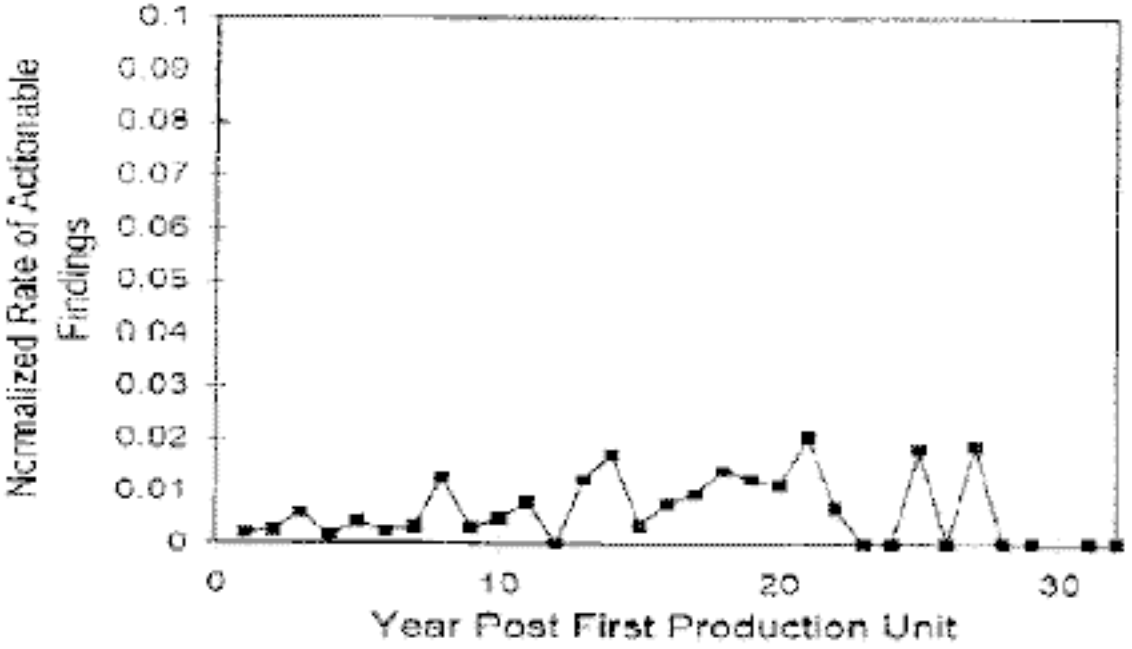


Figure 1. Summary of results on age-dependence of rate of actionable findings. The squares indicate the observed number of actionable findings divided by the number of samples, plotted against the cohort age. (SAND 95-2731; UC-700)

The situation at the moment is best summarized in the official DOE document dated June 12th of this year. The review of the stockpile headed up by General Thomas Gioconda, the Acting Deputy Administrator for Defense Programs, said, "At this time the weapons in stockpile are aging without detriment to their safety and reliability." And I think that's a fair summary. It is my judgment as well.

On the question of the need for data, refer back to the JASON study of 1995 done together with four of the leading designers of our current stockpile. One of them is sitting right over there, Bob Peurifoy, former Vice President of Sandia. It was the unanimous conclusion that, at low yields, underground nuclear explosions had little to contribute – and nothing essential – to what we are presently learning from a well supported, if it continues to be, stewardship program. Now certainly there are people who disagree, and that's why the Treaty wasn't ratified and we are here today still talking about it five years after it was signed.

It's important that we learn how long the warheads can be counted on. For example, do we have to rebuild the primaries? Here's a calculation from a recent JASON report which shows you how many warheads you would have to rebuild a year (see chart below). This answers the question, "do we have to build a big manufacturing structure for new weapons, for new primary pits?" This is the number you'd have to build per year, assuming a 4,000-warhead stockpile – 4,000, that's an assumption and everything scales with that – and this is the average age as a function of the year. The average age in the stockpile now is 20. If we started manufacturing warheads, ten years from now when the average age is 30, and

then we say we don't want the average age of the warheads in the stockpile to be more than 50 years, to just pick a number, then we would have to build 40 a year. If we don't want the oldest warhead to be more than 50 years, we would have to build 80 a year. If we don't rebuild of course, the average age goes up linearly with age.

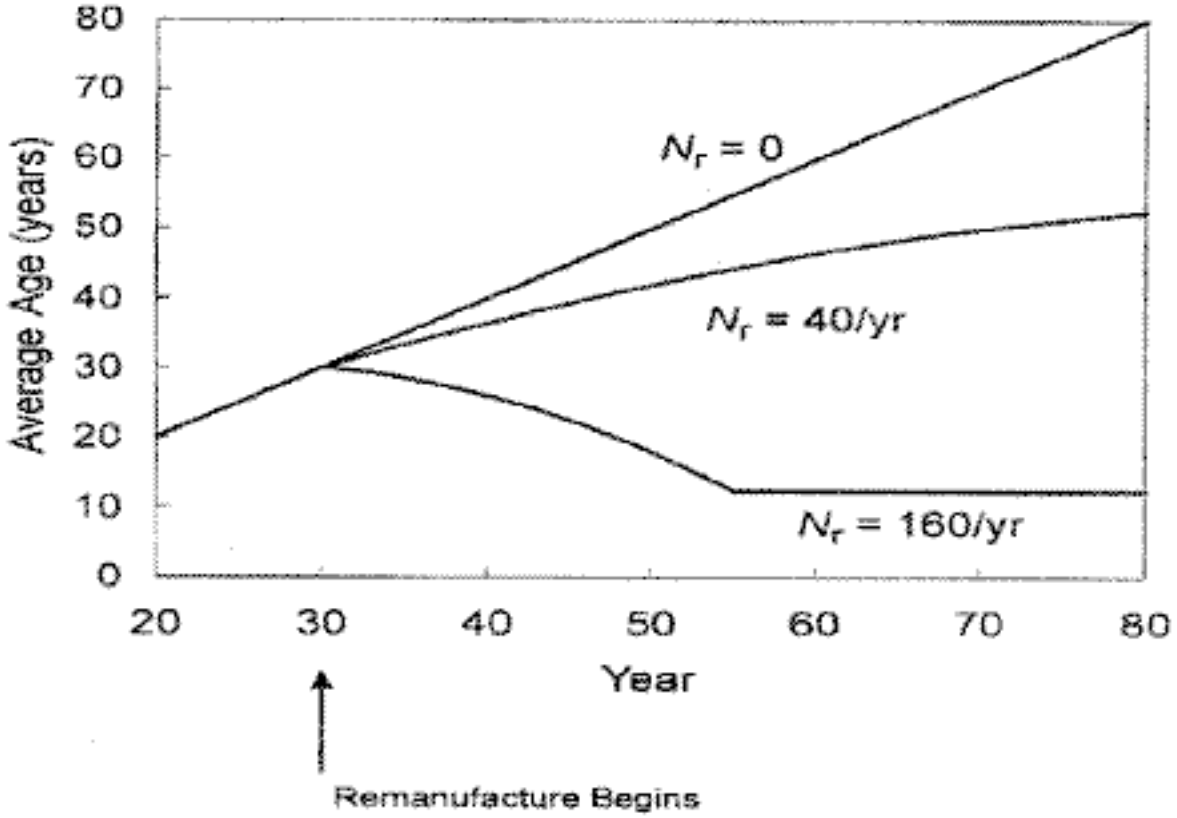


Figure 2: Sample calculations of average age of stockpile warheads assuming that remanufacture starts at a time when the average age is t_0-30 years. The average is calculated for a 4000 warhead stockpile, assuming replacement rates of N_r=0, 40, and 160 per year. See the JASON report on Remanufacture (JSR-99-300, October 1999).

We've learned that the plutonium pits seem to be healthy for at least 50, perhaps up to 60 or more years. That means that the average age is 30, so that the oldest one is not more than 60, we would have to build about 65 a year. This gives you a scale. This is why it is so important to have the stewardship program with the full panoply of activities including stockpile life extensions.

The fact that we can now say conservatively that plutonium behaves stably for 50 years is the product of what we have learned over the last 5 years from the Stockpile Stewardship Program. We didn't know that before. We have more confidence in our understanding of the effects of aging on the stockpile now than we could have had 5 years ago.

There are questions that still have to be answered more satisfactorily about the Stockpile Stewardship Program than they were during the abortive, politically driven debate of last October. We have to answer the critics and their allegations that, without testing, our cadre of nuclear weapons scientists will inevitably lose competence.

As a scientist who has worked in a laboratory and whose career has given some sense of what it takes to do good science, all I can say is that I contest that. Confidence will come from addressing

challenging scientific problems. With the new diagnostic instruments and the data being worked and detailed by the new computers, I find the stewardship program to be much more challenging for a good scientist than, as I said before, just blowing out the side of the mountain with an existing already developed bomb from 10 or 20 years ago. Even if you think there's an added excitement from blowing out the side of the mountain, there is an enormous scientific challenge associated with the Stockpile Stewardship Program and my sense is that scientists at the labs are in fact getting a great deal of satisfaction from that.

If I can find any problem in terms of competence or confidence in the labs, and I'll come back to this at the very end, it is the result of the political turmoil that's been caused in Washington as a result of the Cox Commission and the Wen Ho Lee report, which are having a harmful effect that has to be contained.

Are we already losing confidence in the deterrent? Again, I would answer this by repeating the argument that we can now be confident, more confident than we should have been five years ago, as a result of the annual certification process through which each year the lab directors and the Secretaries of Defense and Energy must certify to the President the performance of the stockpile.

Of course there are new problems and new challenges, but to my mind we have thus far been highly successful in meeting the scientific challenge and in showing that there is no reason to lose confidence in our deterrent.

There's a third problem which comes up frequently. This is the argument that we have in the past found through testing that some weapons already deployed in the stockpile had to be withdrawn and refurbished or redesigned as a result of problems that developed and were only detected subsequently – some of them, but not all – on the basis of test explosions.

This is a very serious issue. In the 1995 JASON study we went over in detail all the cases where this happened, where something had to be withdrawn, and we came to a very strong conclusion, a unanimous conclusion which is in my report. We can talk about it more but I feel that this is a very cautious and responsible and accurate statement. Namely, that the device problems which occurred in the past and which either relied on or required nuclear yield tests to resolve were primarily the results of incomplete or inadequate design activities. Many of them went back to the 1958-1961 period when we put new warheads in the stockpile without testing them, because that was during the period of a moratorium. We also knew much less, and so these problems were due to the more limited knowledge and computational capabilities of a decade or more ago.

In 1995 we were confident that these problems had been corrected. The weapon types in the enduring stockpile are safe and reliable in the context of explicit military requirements. That's the conclusion in a long, detailed highly classified study. That is our best way of stating our response to the concern.

As to concerns about the safety of the arsenal, as distinct from the reliability and effectiveness, this is an issue that really should not come up again. Congress asked for a review of safety in 1990. Johnny Foster, Charlie Towns – the inventor of the laser – and I were the committee that went over this issue in detail. We reported then to Congress our finding that the enduring stockpile did meet rigorous safety criteria. We raised some questions that have been addressed by a panel chaired by General Larry Welch. I think that there are no remaining safety issues and that bringing them up now is a diversion from the heart of the problem.

To close, in my judgment science can never guarantee the future. You can't guarantee with science that circumstances won't change in the future, certainly not political ones. And, as a scientist, one is always open to technical surprises that could come up as our weapons get older and older. Therefore we must maintain a refurbishing and remanufacturing program to meet potential requirements and enable us to be prepared to respond promptly as needed.

There also are safeguards associated with the Comprehensive Test Ban Treaty, including safeguard F, which explicitly calls for withdrawal with six months notice if need be.

The subsequent debate on the CTBT should revisit these three points of contention: confidence, competence, and the need discovered after the weapons are in the stockpile. They need a better answer. Perhaps, we need more safeguards to ensure for example that the certification process gets a broadly based, apolitical scrubbing every 5-10 years to make sure that we are maintaining confidence in the stockpile. We can make sure we satisfy ourselves by devising such a process.

We have to have confidence that there is no evasive work threatening to our security going on in violation of the Treaty, and we will talk about this more later when we discuss treaty verification, but we can in my mind add bilateral agreements with Russia or China in the record of ratification to add to our confidence. Relative to other countries, the United States, has a sophisticated Stockpile Stewardship Program with its instrumental sophistication that is the most advanced one with our diagnostics and simulation and capabilities and tools. That's an advantage for us, and I believe that the Stockpile Stewardship Program is adequate to the risk.

I will close with two concerns, one of which I have already hinted at. The political reaction to the events starting with the Wen Ho Lee accusations – in fact let me be clear, the false accusations of espionage against Wen Ho Lee that have been dropped – is something that I consider very serious. The political repercussions of the handling of this matter have made the laboratories less attractive places for our best young scientists coming out of the universities to work. It is discouraging young talent. They now have to worry more about whether they are going to be able to talk about their work with this new sensitive unclassified technical information category (SUTI). This means, for example, that inertial confinement fusion – how stars burn, as well as weapons – that Admiral Watkins heroically brought out from behind the curtain of classification, was able to be talked about so the scientists could benefit from discussion with colleagues outside the labs and get credit for their work. That's gone now behind pretty much the veil of secrecy. That's discouraging people. We have to balance science and security. That was the whole emphasis of our PFIAB report. We are not doing that very well, yet we hear more and more evidence of mistrust and concern and polygraphs galore. That is going to have a lasting detrimental influence if we don't control it.

And the other thing, the program has to set priorities. We are going to have to set real priorities for what we have to do for the immediate needs of our stockpile as well as the long term needs of the program. I don't believe that the program has found its priorities yet.

These are the issues which stand between today and a sustained, fully successful program that the country needs. Thank you.

Dr. Chyba: Thank you Dr. Drell. Next we will hear from Dr. Amy Sands from the Center for Nonproliferation Studies of the Monterey Institute of International Studies. Dr. Sands…

Dr. Amy Sands: Today, I will provide a brief overview of the verification regime for the Comprehensive Test Ban Treaty, or CTBT. I will have to move reasonably quickly through the different components of the Treaty in order to give you a general sense of what is involved. I hope to look not only at the goals of the CTBT, but also at how these goals have been reflected in the type of verification regime that has been developed. I will talk a little about the components of the regime, its effectiveness, and then at the end take a look at some of the obstacles and future challenges to the implementation of this Treaty.

The goals of the Treaty are rooted in its long history, which dates to the 1960's. There was in the Partial Test Ban Treaty the goal of discontinuing all nuclear test explosions for all time. What the CTBT is trying to do at this point is cap or limit the sophistication, that is to say the power, complexity, and size of the nuclear weapons. It is directed at those countries with nuclear weapons as well as those countries that might be interested in trying to obtain nuclear weapons. The idea is to deter the development of new nuclear weapon capabilities and in many ways should be seen as a symbolic commitment to lessening the salience of nuclear weapons over time.

It is important to realize that the success of the Treaty relies on a very robust technical verification regime. There were several questions that emerged when this Treaty was brought before the Senate in October 1999 that I think need to be fully fleshed out and explored.

In essence, the verification regime is based on what you might call a web of technologies. The idea is that there probably is not any single sensor system or capability that will do the job completely in all the environments that we have to worry about for nuclear testing. The Treaty establishes substantial verification capabilities, but in the U.S. case, national technical means would obviously remain at the core of our own activities. This web creates so many different complex interactions that it would be very difficult for a leader to feel confident that his or her country could conduct a test that would not be detected. The Treaty should in the long run make it much more difficult and costly to cheat, which will hopefully deter those countries that are uncertain about the utility of attempting to undertake deceptive test practices. They would probably see these activities as high-risk and be deterred from testing.

The verification challenge is enormous, basically trying to confirm the existence of nuclear explosions in different environments. The verification regime is designed not only to detect violations but also, as is true for all verification regimes, assure States Parties that all countries are complying with Treaty provisions. It is also designed to resolve questions over ambiguous events, which is probably one of its greatest assets. It gives you the capability and a place to address concerns about such ambiguous events, and it provides means of collecting needed data that can supplement a state's own national technical means.

These are not easy verification challenges. The verification regime took a fair amount of effort to assemble and is still evolving in many ways. The components of the verification regime include a very complex and extensive international monitoring system, also involving an organization that will be located in Vienna called the Comprehensive Test Ban Treaty Organization, or the CTBTO. The two primary organizations for the regime are the Executive Council and the Technical Secretariat. The verification regime also includes a set of clarifications and visits that can be used if there are questions before calling for an onsite inspection. And finally there are some confidence-building activities.

I should say that there are certain aspects of the verification regime that I will not be able to cover in such a short period of time. But I think this presentation will give a clear idea of what are some of the key components and strengths of this verification regime and also some of the concerns that we need to address as we try to implement the Treaty.

The International Monitoring System consists of four remote sensing networks: a seismic sensor network as well as radionuclide, hydroacoustic, and infrasonic ones. There is also an International Data Center, which will have a unique capability. A prototype International Data Center has been operating on a test basis for the last several years in Arlington, Virginia.

The expectation is that when this is in place, there will be more than 320 monitoring facilities in over 90 countries. There will be approximately 60 radionuclide stations located in a variety of countries, ensuring that this will have a very strong international component. Once it is in place, the system will have sufficient flexibility and strength to be used in an international context when concerns over an ambiguous or uncertain event arise.

I will not spend a great deal of time on the seismic network because I know that Dr. Paul Richards is following me with a much more detailed discussion of this, but this network is probably the core of the actual monitoring system for the CTBT.

I would like to spend a little bit of time on the other components of this regime that tend not to get much discussion, the first being the radionuclide collection network. This system is basically used to detect particulates from atmospheric nuclear explosions or to detect noble gases that might result from atmospheric tests or the venting of underground nuclear explosions. There are currently scheduled to be some 80 radionuclide monitoring stations, with 16 radionuclide laboratories that would be called upon to do further examination and validation of events that are considered to be suspicious, i.e. determine that these events are of concern. The radionuclide laboratories will have to be certified probably on a regular basis – not just once – by the Technical Secretariat of the CTBTO.

The detection threshold is expected to be less than one kiloton for above-ground explosions, but for underground explosions detection will depend on how much venting occurs. These stations will be located around the globe. They were chosen based upon meteorological calculations, existing monitoring capabilities, operational factors and, of course, geopolitical considerations. The effort here was to provide global coverage that would be useful if there should be an incident that warranted concern.

Taking a look at the hydroacoustic sensor system, this is a system that basically detects hydroacoustic signals that are propagated very efficiently in what is called the sound fixing and range channel, or SOFAR channel. These signals are essentially oceanic acoustic wavesguides that are somewhat – though not exactly – similar to the seismic signals that propagate through the earth during earthquakes and explosions. Under the CTBT, hydrophones will be positioned in the southern oceans where the distances are greater, and there is much less shipping traffic.

During the negotiations, it was agreed that the system would also employ five land-based T-phase stations. These are basically seismic stations to be located on coasts in the northern oceans, where they will detect seismic signals when hydroacoustic waves make landfall. Since there is more activity in the northern oceans, it was decided that it would be difficult to test in these oceans without being detected. The expectation is that the detection threshold will be significantly smaller than one kiloton.

I keep referring to a one-kiloton threshold because this was the target level during the negotiations. The negotiators agreed that the detection threshold should be at least as low as one kiloton, but, as is evident, in each case the threshold for detection is actually going to be significantly less than one kiloton.

Moving on to the infrasound sensor network, which, while not a new technology, is being applied in a new context for CTBT verification purposes. This sensor system will be used to detect changes in air pressure that are caused by low-frequency sound waves produced by atmospheric nuclear explosions. At the moment, this is the least developed network, but it could eventually be very powerful in terms of its ability to detect and identify nuclear explosions if they should occur in the atmosphere. Because it is the least developed in this context, there is the expectation that it will be able to detect in the one-kiloton range, but the threshold is very dependent on atmospheric conditions.

Data from these four different types of technical sensor systems, which are global in their context and coverage, will flow into an International Data Center (or IDC). The IDC is expected to be able to process over ten gigabytes of data per day, which is an enormous amount when you think about that happening everyday. The seismic, hydroacoustic, and the infrasound sensors will provide continuous data 24 hours per day, while the radionuclide network will provide information every 24 hours because of the type of technology involved.

The data from all of these sensor systems will be collected in the IDC, where the information will be authenticated, analyzed, distributed, and then archived. The data will be compiled into an Event Bulletin, which announces that a suspicious event has occurred and should be of concern. This Event Bulletin is not one in which the technical experts at the IDC are going to analyze and make a determination about an event. It will then be up to the States Parties to make any decisions concerning getting more information, a clarification, or an onsite inspection.

The United States will likely add this data to what it would have already gathered through its own national technical means, thereby enhancing its own verification capabilities and compliance analysis with the enormous amount of data coming into the IDC. The IDC is basically collecting and filtering in a coherent and transparent way some of its data, and will not itself provide any type of evaluation in terms of a verification assessment. It will simply provide the core data that would be needed to do such an assessment.

At the negotiations, there was a rather extensive discussion about national technical means. This debate was resolved with an agreement that national technical means would be included as a source of data, but that information gathered through national technical means had to be collected in a way generally found acceptable to the international community. While still somewhat vague, I do not believe that this will inhibit countries with relevant data from making the information available.

Another component of the CTBT verification regime is the provision for onsite inspections. I think of this as a particularly unique asset that will be useful in identifying the nature of an ambiguous or uncertain event. In such a case, an onsite inspection can be requested based upon data that is being collected by the IDC or by an individual state that has information collected through its own national technical means.

It is important to note that the onsite inspections can only go forward if 30 of the 51 members of the Executive Council decide that there is a justifiable concern sufficient to warrant an onsite inspection (or OSI). Also, a request for an OSI that comes in has to turn around with a "yes" or "no" answer within 96 hours of the request, so the discussion will not drag on indefinitely. During that 96-hour period, there can be preparations by the Technical Secretariat to ensure that once the inspection has been agreed to, a team can get onsite within a reasonable amount of time.

Trained experts would do the onsite inspection, but unlike the International Atomic Energy Agency, or IAEA, there will not be a standing group of experts. Instead, a pool of experts that countries have designated will be used to select the OSI team. The inspection can consist of two phases, the first one being 25 days, and the second one would be 35 days and would follow immediately upon the conclusion of the first phase. The second phase would go forward unless terminated by the Executive Council. The techniques to be employed in the first phase are designed to be less intrusive and include visual and photographic inspection, measurements of radioactivity, and environmental sampling. In the second phase, inspectors may opt for more intrusive measures, such as active seismology, ground penetrating radar, electrical conductivity, and drilling.

One last thing that I would like to mention is the set of Treaty-related confidence-building measures, or CBMs. These are critical to the effectiveness of the International Monitoring System. One CBM involves States Parties providing, in advance, information about mining activities or explosions, whether for oil drilling or other types of mining activities. The idea is to provide pre-notification of such events, or at least notification of events immediately afterward so that when data shows up at the IDC indicating an event has occurred, there will be some understanding of the nature of the event.

Also, the ability of the State Parties to work with the Technical Secretariat to perform regional calibrations for the different sensors is a critical CBM since it will provide background levels prior to an ambiguous event. While progress in this regard has been gradual, obtaining these regional calibrations will be central to the long-term effective functioning of this regime.

Very briefly, let me talk more about the Executive Council and the Technical Secretariat. The Executive Council consists of 51 State Parties that will be chosen from six geographic regions. The United States has a guaranteed position there. The Executive Council oversees the Technical Secretariat and plays the primary role in determining whether an onsite inspection will take place. The Technical Secretariat is the core of the actual CTBTO and is crucial to its effective implementation. It oversees the operations of the International Monitoring System, data collection at the IDC, and any onsite inspections. It also assists in any type of visit, consultation, or clarification process that would be promoted by the Executive Council.

This regime has a synergy resulting from all these different sensors providing overlapping coverage of the potential test environments. This synergy strengthens the capability to detect, locate, and identify nuclear explosions. For example, radionuclide data, which many people think of as a smoking gun, will probably not be used to detect or locate an explosion – the seismic or hydroacoustic network will be critical to that – but it will provide the data that could determine that an event was or was not a nuclear event.

A determined proliferator would probably not be very confident that it could get away with the sub-kiloton test because not only must it be concerned with the CTBT's sensor system, but also with the national technical means of every country. While such a country may fully understand the international system, it probably would not understand how states will integrate the CTBT verification capabilities with their own national technical capabilities. Thus a state considering testing probably would not fully understand what the lower thresholds of all these capabilities combined might be.

In terms of the benefits to the United States, from my own perspective having worked at the Arms Control and Disarmament Agency in the compliance area, this type of treaty provides us with extensive supplemental data that is internationally accepted. We would not have to go to the international community with only our own technical data, which is likely to be viewed with suspicion. We would have IDC information that will instead be authenticated by the CTBTO, an international agency. In addition, the CTBT verification regime gives us access we would not normally have to many areas of the world, and provides a forum for discussion of ambiguous events.

I believe that the CTBT verification regime is technically sound, but I also think that it is politically bold. It is a global verification effort that depends on States Parties and their commitment to its becoming fully operational. Let me just quickly mention some of the current obstacles to its full implementation. One such obstacle is the entry-into-force issue. The longer this goes on without being resolved, the less likely States Parties will maintain a strong commitment to the technical, financial, and political support needed for this verification regime. There are also technical and diplomatic hurdles. For each of the sensors that I discussed, there have to be agreements between the CTBTO and the countries in which they are located. Those agreements are in the process of happening, and a great deal of progress has occurred, but it will become increasingly difficult to get countries to agree to expend resources if they are not certain that the Treaty is actually going to come into force. Essentially, we have something of a self-fulfilling prophecy going on. Some opponents point to the fact that these systems are not completely in place as evidence of their weakness – and therefore as a reason not to bring the Treaty into force – while the reason these systems are not in place is because countries do not think that the Treaty is actually ever going come into force. A point will come when countries will need to demonstrate their full commitment to the whole process of the CTBT; the sooner such support surfaces, the more quickly the verification regime will become the foundation for CTBT verification issues.

In terms of future challenges, I think we all worry about international organizations becoming bureaucratized. We have seen this phenomenon at the IAEA, which I think has begun to address that problem in constructive ways, but it is nevertheless something to watch. The real challenge will be to keep the political, technical, and financial support in place in a way that lets this regime, which is so based on technology, be put in place and tested.

Clearly, the first time there is an ambiguous event, the international community's response to it and what information is used will be crucial to cementing the credibility of the CTBT regime. But my bottom line assessment of the CTBT is that by using national technical means and the CTBT's International Monitoring System, the Treaty is effectively verifiable, and militarily significant testing can be detected, identified, and located in a timely way.

Dr. Chyba: Thank you. Dr. Paul Richards from the Lamont-Doherty Earth Observatory at Columbia University will speak next.

Dr. Paul Richards: For most people in California, seismology is the study of local earthquakes. More generally, seismology is the study of how the ground moves – not only in damaging earthquakes, but also in ground motions that can be a billion times smaller and still measurable, caused by earthquakes and explosions that may have occurred on the other side of our planet.

Seismology became particularly important as a monitoring technology following the Limited Test Ban Treaty of 1963, because nuclear explosive testing by three of the nuclear weapons states moved underground, and was found to generate easily detectable seismic signals observed indeed all over the world. On average, about one nuclear test a week was conducted underground from the early 1960s to the early 1990s. It was during this period that seismology was built up, frankly from almost nothing, as the most practical way to monitor underground nuclear explosions.

Monitoring for nuclear explosions in violation of a CTBT will be carried out in three different ways:

(1) by the International Monitoring System of the new CTBT Organization (CTBTO);
(2) by National Technical Means; and
(3) by the loosely organized efforts of numerous institutions (international, national, private) – including those operating seismographic stations for purposes of geophysical research and earthquake hazard reduction.

I am going to emphasize the first of these methods – the monitoring that uses data contributed by the International Monitoring System associated with the CTBT headquartered in Vienna – since this provides a basis to which data and methods of analysis from (2) and (3) can be added. The Treaty itself recognizes that there are national technical means available to signatories, and all signatories have the right to use objective information gathered from NTM as a basis for requesting onsite inspection of a suspicious event. Concerning the type of monitoring carried out by numerous private or national organizations, each acquiring data of some relevance to CTBT monitoring, it is important to recognize that several thousands of seismic stations are operated around the world by hundreds of different institutions for one reason or another. Also with reference to (3), note that vast regions of North America, Europe, and the Western Pacific, parts of Central Asia, Northern and Southern Africa, and the Middle East are now being monitored very closely for earthquake activity down to magnitude 3 or lower on the Richter scale by organizations whose data and methods of analysis are freely available. It is from this work that we have acquired our knowledge of seismic signals in different regions and from which we have acquired a familiarity with the differences between signals from earthquakes and nuclear explosions, and from blasting associated with the mining, quarrying, and construction industries. Seismology is still very much a growing science, likely to be driven indefinitely by the need to understand and mitigate earthquake hazards. Thus the numbers and quality of seismic stations are increasing all the time for reasons having nothing to do with treaty monitoring.

But coming back to treaty monitoring, the practical work for monitoring for underground nuclear explosions using seismological methods first entails detecting seismic signals and grouping together all of those signals that might be associated with a particular source. The next step is to estimate the location and to identify the nature of the seismic source, whether it is an earthquake, a chemical explosion or possibly a treaty violation. As Dr. Sands has reminded us, the responsibility for identifying the nature of an event is left to the CTBT State Parties, but the International Data Center in Vienna does assist by carrying out a process called event screening, which I will briefly describe later. Seismology also plays a role in onsite inspections and in confidence building measures.

Let me say a little about these separate steps of detection, location, and screening, emphasizing the work of the IMS and the IDC since these provide a base upon which other types of monitoring can be built. We've heard a brief description of the International Monitoring System's 50 primary seismographic stations, which continuously send data to the International Data Center. These form the basis of the detection capability of the IMS. Supplementing that network is an auxiliary network of 120 stations, which operate continuously but contribute their data only on request for specific time intervals in order to help characterize seismic events of particular interest.

We've now had quite a bit of experience beginning in January 1995 with how a network somewhat similar to the planned IMS will operate. From January 1995 until February this year, when operations were transferred to Vienna, the IMS stations grew from about one-half to about two-thirds of the intended primary network, and they reached approximately one-third of the auxiliary network. During this five year initial period, in practice, an average of about 50 seismic events a day have been reported by the Prototype International Data Center in Arlington, Virginia, with about 100,000 seismic events having been documented over its first five years. Most of them were earthquakes, and a few percent were mining blasts. The nuclear explosions carried out by France and China prior to their signing the Treaty in 1996 were very well recorded by the IMS, as were the nuclear explosions of India and Pakistan in 1998.

So what then is an appropriate summary of the current detection capability of the IMS seismographic network? And what is its expected capability when that network is eventually completed?

The design capability of the primary network has not been formally specified, and the short answer, often given, is it can be expected to provide data adequate to monitor for nuclear explosions down to about magnitude 4 on the Richter scale. For an explosion executed in the usual way in most geographic regions without making special efforts at concealment, magnitude 4 corresponds to a yield of approximately one-half kiloton of TNT equivalent. I would go on to say in practice that the detection threshold, not the identification, but the detection threshold appears to be better than magnitude 4 in regions where the IMS is complete, and even in some regions where it is incomplete.

My conclusion here emerges from several lines of argument, going back to plans for a similar but earlier network associated with the Geneva-based Conference on Disarmament. That network was planned to have a threshold detection capability in the magnitude range below 3 for large parts of Eurasia and North America. We now find that, with the IMS stations as they currently operate, virtually all of Eurasia and North America have detection thresholds with magnitudes less than 4. And in certain areas of particular interest, including the test sites in Nevada for the U.S. and on one of the islands of Novaya Zemlya for the Russian Federation, the IMS seismographic network is now essentially complete and has a detection capability typically below 2.5 on the Richter scale.

Let me say a little about the ability to locate seismic sources. We would like to be able to locate them to within about 10 to 12 miles to end up with an area of uncertainty that matches what the Treaty indicates in the context of specifying an area for onsite inspection. It turns out that locating seismic events in large numbers to that level of accuracy is today quite a challenge. Particularly for earthquakes and explosions below magnitude 4, there may not be enough IMS stations that detect an event for an accurate estimation of the location to be made by the IDC using current procedures. But this challenge is being met by a series of international activities that have successfully demonstrated in Northwestern Europe, for example, how improvements in location accuracy can be obtained. These methods are now being systematically developed and applied to other regions of Eurasia, North America, North Africa, and the Middle East.

Concerning the discrimination of seismic sources (i.e. the actual identification of an event as possibly being a nuclear explosion, and hence a treaty violation perhaps warranting an onsite inspection), this entails judgments that bring in political as well as technical assessments. And this is of course why the IDC's role in event identification is limited to providing assistance to States party to the Treaty rather than actually making an identification itself. The Treaty protocol does state, however, that the IDC may apply what are called standard screening criteria based on "standard event characterization parameters." This refers to the identification of events that appear not to have features associated with a nuclear explosion.

The logic that underlies such screening work is a process of winnowing out those events that could not be nuclear explosions. We start out with numerous candidate events for which we have data. I mentioned that the IDC currently detects on the order of 50 event a day, but I would anticipate that as the IMS moves towards completion this number might on average even rise to about 100 a day. One examines how deep these events are. If they are deep then they can't be manmade explosions so they are screened out. If they're shallow, they are not screened out and one goes on to examine detailed features of the recorded waveforms. If they look very much like earthquakes, then the event is screened out. To the extent that they look more explosion-like, they are not screened out, and one goes on to investigate other attributes of those remaining events and so on.

The task of developing appropriate screens is today a vigorous area of operational work and one that requires continuing improvements. Some of the classical methods that were relied upon in the era that I spoke of earlier, from the 1960s to 1992 when nuclear explosions were happening on average once a week, relied upon measurements made as we say "teleseismically," that is, at great distance. But now, in order to monitor what is of course a zero yield treaty, the work of screening must be done at lower and lower magnitudes. This entails the use of seismic waves which travel only at shallow depths in the earth and that do not reach teleseismic distances. A number of different efforts are being made to look at these shallow traveling waves, to take so-called "spectral ratios" of different features measurable from the

recordings. The preliminary result of such methods when applied to the IDC data is that more than 60 percent of events with magnitude 3.5 or greater are now routinely being screened out, based on the characteristics of these shallow traveling seismic waves.

The seismic activity that is routinely recorded and has to be analyzed all the time includes not only earthquakes but also mine blasting, which presents its own set of special problems. Mine blasting can appear superficially similar to small nuclear explosions using criteria such as depth estimates, weak surface waves, and certain spectral ratios that look explosion-like, etc. But there are additional characteristic features unique to such chemical explosions because commercial blasting activity routinely consists of numerous small explosions, which are fired in a sequential manner with delays in between. Thus, the resulting seismic source is spread out in space and time, and therefore is physically very different from a single fired nuclear explosion.

Another potential discriminant of mine blasting is the infrasound signal. That is to say the low-frequency sound wave in the atmosphere, which would not be expected from a small underground nuclear explosion unless it vented significantly – which in turn would likely result in characteristic radionuclide signals. So here I agree very much with Dr. Sands' point that the synergy of different technologies enables us to characterize non-nuclear phenomena such as mine blasting activity, which may superficially in some respects look like a nuclear explosion.

I would like to say a little about evasion scenarios, though I do this with reluctance since this subject can be a tar baby. But evasion scenarios played a strong role in the discussion on the Senate floor last October. For example we heard the Senate majority leader stating in executive session that "a 70 kiloton test can be made to look like a one kiloton test which the CTBT monitoring system will not be able to detect." An explosion of such high yield of course would have great military significance.

The type of underground cavity – he was speaking of the cavity decoupling scenario – that would be needed to reduce the signal of a large nuclear explosion by a factor of 70 would have to be on the order of a kilometer underground and have a diameter of 200 meters. With the energy of a 70-kiloton blast, gas pressure in the cavity would be increased to about 150 times atmospheric pressure. The walls of such a gigantic (in my view, deep and impossible-to-construct) cavity would have a surface area on the order of 35 acres. The smallest cracks in that vast area would be pathways for the release of radionuclides, only 0.1 percent of which in this case would result in detection at great distance by the radionuclide network being developed for the IMS. The seismic network as well as the radionuclide network would be perfectly capable not only of detecting but also of identifying such a test.

In the Senate debate a repeated quote was that "while the exact thresholds are classified, it is commonly understood that the United States cannot detect nuclear explosions below a few kilotons of yield." I believe that might have been an accurate characterization of the state of affairs in about 1958 when CTBT negotiations began, but it is more than 40 years later. Unclassified networks of seismic instruments continuously and routinely monitor areas of the globe for earthquakes and explosions down to very low seismic magnitudes. For example, we are reaching down to about magnitude 2 to 2.5 on the Richter scale at Russia's nuclear test site. Such a capability in that particular case translates into the ability to detect down to about .01 kiloton of well-coupled yield.

As for mining technologies, again from the Senate floor, an exact quote: "advances in mining technologies have enabled nations to smother nuclear tests allowing them to conduct tests with little chance of being detected." But in practice, the overall trend of modern methods of mine blasting has resulted in general in smaller seismic magnitudes than were prevalent a few decades ago. There are only a limited number of mining regions where signals from a small, let's say .1 kiloton nuclear test could be masked by a simultaneous mining blast without taking additional steps of putting that nuclear test in a cavity, and the attendant complications. But perhaps regions of mine blasting – and there are some with unusually large seismic signals – to the extent that they are of concern, could be made the subject of special monitoring on the basis of bilateral or multilateral agreements.

In concluding, it must be acknowledged that this is a zero yield treaty. To speak of the thresholds down to which monitoring can be done, is an implicit acknowledgment that below some threshold,

monitoring cannot be done. Monitoring has to be good enough, to drive that threshold down to military insignificance.

The work of monitoring the CTBT by seismological methods will be demanding because of the technical difficulty and the scale of organizational effort that is necessary, and because of the need to interact with political and bureaucratic decision making. A review of nuclear explosion monitoring has not been carried out in the U.S. political arena since the 1980s. There was an Office of Technology Assessment report in 1988, much of which is still very relevant today.

The work of treaty monitoring is greatly helped by the existence of major seismological resources other than the IMS primary and auxiliary networks. I believe then that seismology is continuing to provide new methods of data acquisition and data analysis, is giving useful information that will improve the work of the IMS, and is assisting in the attainment of national and international goals for monitoring the CTBT.

So to summarize my whole talk, I believe seismology is an enabling technology for the CTBT. Thank you.

Dr. Chyba: Thank you Dr. Richards. That brings us to Ambassador Thomas Graham, Jr., President of the Lawyers Alliance for World Security. Ambassador Graham…

Ambassador Thomas Graham, Jr.: Thank you, Chris. I'm going to speak to the question of Russia and China and the CTBT. Stemming the proliferation of nuclear weapons is unquestionably the greatest challenge facing the United States now and for the foreseeable future. As President Chirac of France, Prime Minister Blair of the United Kingdom and Chancellor Schroeder of Germany noted in an October 1999 *The New York Times* opinion piece, "as we look to the next century, our greatest concern is proliferation of weapons of mass destruction, and chiefly nuclear proliferation. We have to face the stark truth that nuclear proliferation remains the major threat to world safety." The costs and benefits of the CTBT should thus be weighed in the context of this overarching U.S. national security objective – preventing nuclear proliferation.

Preventing nuclear proliferation is not the only benefit of CTBT entry into force, however. Moscow and Beijing, and more importantly the nature of US relations with both, will clearly remain of great significance for the next century. Thus, it is also critical to consider the impact that a CTBT will have on China and Russia and the effect that this will have on U.S. national security. Russia and China are and will continue to be the only potential adversaries that could challenge U.S. interests around the globe. Despite the ongoing debate over whether the United States needs a national missile defense to address the possible future missile/ WMD threat from "states of concern" (formerly known as "rogue states") such as Iraq, Iran and North Korea, it is important to recognize that Russia and China are the only potentially hostile nations with the capability to strike the US with long-range nuclear-armed ballistic missiles.

The ability of Russia and China to maintain and modernize - and in the case of China, significantly increase - the capabilities of their strategic nuclear arsenals and the impact that the CTBT would have on those efforts should be a central element of the US debate on Treaty ratification. A strong case can be made that the United States should ratify the CTBT and aggressively promote its entry into force in part in order to constrain advances in Russian and Chinese nuclear capabilities.

The United States currently has a significant advantage over Russia and China, and indeed the rest of the world, in terms of the sophistication of its nuclear arsenal and the depth of knowledge related to nuclear weapon technology possessed by its nuclear scientists. This advantage was developed from 1945 to 1992 by the conduct of well over 1,000 nuclear explosive tests – a number greater than the combined total of nuclear tests conducted by the rest of the world – and translates into a U.S. nuclear deterrent of unmatched effectiveness. The Soviet Union and Russia by comparison conducted 715 tests and China only 45.

Modern nuclear weapons, with at least some 4000 parts in any typical design, are complex. There is no substitute for a nuclear explosive testing program involving full-scale tests to provide confidence in the reliability of a new design of a second-generation nuclear weapon. No reasonably advanced state, no competent modern military authority, and no nation depending on nuclear weapons for a credible deterrent, could be expected to deploy a modern lightweight two-stage, thermonuclear weapon without a full-scale test program. For its part, the United States typically used on average six explosive tests before certifying its new weapons designs and France reportedly used as many as 22. Thus, the CTBT would keep new designs for advanced weapons out of the stockpiles of Russia and China. This will ensure that the U.S. arsenal would continue to consist of the world's most advanced weapons.

Also, in terms of maintaining the reliability of nuclear weapons in a non-testing environment, no nation is better prepared to do this than the United States. The information gathered by U.S. scientists through the nation's extensive nuclear testing program contributes to the effectiveness of the Department of Energy's Stockpile Stewardship Program, which if properly funded will be able to ensure that the safety and reliability of the U.S. nuclear arsenal will not erode over time. U.S. global leadership in the realm of supercomputer development, which is essential to the success of stockpile stewardship efforts, further ensures this advantage. In effect, under a CTBT, no other nation – including Russia and China – will be as capable of maintaining its arsenal without testing as will be the United States.

The current moratorium on nuclear testing essentially amounts to a political commitment to refrain from testing. When the CTBT comes into force, it would make this political commitment legally binding and thereby legitimize a range of actions by the international community in support of the ban and, if necessary, in response to a potential Russian and Chinese nuclear test. The establishment of this international norm against testing, together with the monitoring network that would be in place, would come at little additional cost to the US. This is because, whether or not the CTBT enters into force, political realities are such that unless the other major nuclear powers resume testing, the United States is unlikely to ever test nuclear weapons again. Thus, the US would be much better off in a world of no nuclear tests and therefore it would be a gain for U.S. national security if Russia and China were bound by an international agreement not to test as well.

With regard to verification concerns, the CTBT will ensure that the United States will have considerably more information about what is happening at Russian and Chinese test sites. The International Monitoring System (IMS) established by the CTBT will augment U.S. efforts to monitor international nuclear explosive test activities. The new system will consist of more than 320 monitoring stations around the world, including 31 in Russia and 11 in China, augmenting existing U.S. capabilities. It will also establish a regime for onsite inspection as well as the first truly high-tech arms control treaty verification regime, which relies on seismic monitoring, radionuclide systems (i.e. environmental sampling), a hydroacoustic network (to monitor underwater wave patterns produced by nuclear tests), and an atmospheric infrasound network (to detect sound pressure waves in the atmosphere).

Nevertheless, a concern among opponents of the test ban is that nations will be able to hide nuclear explosive tests by testing them in environments that will decouple their seismic signatures or otherwise prevent their detection. However, this is a concern that can realistically only be directed toward Russia and China. Only nations with advanced nuclear testing programs have the requisite technology to conduct such deceptive tests. This rules out India, Pakistan, Israel as well as the so-called "states of proliferation concern". The United Kingdom and France would not be of concern in this regard either since the UK cannot conduct any tests as long as the U.S. test site is closed and France does not test on its own territory and could not expect to test abroad in the wake of international reaction to its 1995 tests. However, whatever the shortcomings of the IMS in this regard may be, the United States will be better able to monitor suspicious activities at the Lop Nor and Novaya Zemlya test sites and elsewhere in these countries with a CTBT than without.

This is not to say that detecting tests of very low yield will easy. Indeed, no matter how thorough and effective the verification regime is the potential for cheating remains. Some have argued that sub-kiloton tests by Russia and China will not be detectable by the CTBT verification system and that they

will benefit from these activities. Since it is assumed that the United States as an open society would not be able to do such tests, it is argued this could translate into a strategic disadvantage for the United States under the test ban.

Of course, the same situation would apply today under the moratorium, the only difference being that we cannot avail ourselves of a developed CTBT verification system that is up and running. And, as the 1995 JASONs Report makes clear, while testing at one-half kiloton could confer some benefits, it would only be meaningful if testing extended over a long period of time. Russia and China might be able to conduct a few low level tests and evade detection, but a long series, which is the only way military benefits can be achieved from such very low yield tests, will not be possible to hide. Six IMS stations detected the Kara Sea event near Novaya Zemlya in 1997, a magnitude 3.5 on the Richter Scale, which would correspond to a nuclear explosion with a yield of less than one kiloton. This demonstrates that the global monitoring system, which has further improved in the three years since, can detect very low-level seismic events.

Some have argued that prohibiting nuclear explosive tests is a meaningless step because the CTBT contains no enforcement provision. This is an argument without merit. No international arms control treaties, whether bilateral or multilateral, have real enforcement provisions. If a CTBT were in force, conducting explosive nuclear tests would be a violation of an international treaty obligation and Russia and China would be risking international condemnation and certain political repercussions if they were to be caught.

It is the case that some international arms control treaties establish implementation organizations such as the Standing Consultative Commission associated with the Antiballistic Missile Treaty, the Organization for the Prohibition of Chemical Weapons associated with the Chemical Weapons Convention or the CTBT's Comprehensive Test Ban Treaty Organization, but these are not enforcement bodies. While the United Nations Security Council may be utilized to enforce multilateral treaty obligations, as was the case when North Korea threatened to withdraw from the NPT in 1993, these treaties have never included enforcement mechanisms. This is for two reasons; first, there is no world government and therefore no world police force to enforce its rules, and, second, the U.S. Senate has never been willing and would not now be prepared to allow international enforcement provisions to apply to the United States. The CTBT is no exception in this regard, but one should remember that, as with other highly effective arms control treaties such as the NPT, the lack of specific enforcement provisions has little bearing on the effectiveness of the Treaty. Potential violators are kept in line by the threat of sanctions and a range of international reactions from the UN Security Council and from Treaty members. Like it or not, for Russia and China to play a role in the development of the security framework of the 21st century, it must be a member in good standing of the various treaties that comprise the international arms control and non-proliferation regime.

U.S. ratification and subsequent entry into force of the CTBT would clearly benefit U.S. national security in relation to Russia and China. The test ban would strengthen the NPT regime and promote greater transparency at the Russian and Chinese test sites. It would augment the United States' already impressive global monitoring system for detecting nuclear tests and make it more difficult for either nation to conduct undetected nuclear explosive tests. This would in turn hinder modernization of the Russian and Chinese nuclear arsenals and help maintain the U.S. advantage in nuclear weapon technology. In short, the CTBT would enhance U.S. national security by locking Russia and China into a legally binding, verifiable international ban on nuclear testing and more firmly into the nuclear non-proliferation regime.

Dr. Chyba: Thank you Ambassador Graham. Our last background paper will be presented by Ambassador George Bunn.

Ambassador George Bunn: I'm going to speak about the Comprehensive Test Ban and the nuclear nonproliferation regime: what concrete effect will failure of the United States to ratify the Comprehensive Test Ban Treaty have on the proliferation of nuclear weapons?

First, if the U.S. does not ratify, the CTBT by its terms cannot go into effect for any country. If the CTBT went into effect it would certainly inhibit the nuclear weapon development of India, Pakistan and any non-nuclear weapon Non-Proliferation Treaty (NPT) party, such as North Korea or Iran, that wanted to withdraw from the NPT in order to acquire nuclear weapons. Withdrawing from both treaties would be that much harder politically than withdrawing from the NPT, particularly, I think, given the widespread international condemnation of new testing that will be likely if this treaty goes into effect.

Crude "beginner's bombs" like that dropped on Hiroshima, can be made without testing. But American weapons designers have concluded that more sophisticated missile warheads and more portable weapons of diameter of, say, one or two feet and a weight of, say, a hundred to two hundred pounds, require testing for newcomers. Thus, the CTBT would prevent its parties that have not already tested from making anything but "beginner's bombs" that were too large to be carried by missiles.

Second, the Senate's action has already caused a devastating blow to the implementation of the International Atomic Energy Agency's more intrusive, post-Gulf War safeguards, for which the U.S. has pushed so hard for so long. I refer to the IAEA's "93+2" additional protocol for strengthening the safeguard provisions of all non-nuclear weapon NPT parties. These provisions permit much more intrusion by International Atomic Energy Agency inspectors looking for clandestine nuclear weapon activity. In the past, as Iraq taught us, these inspectors mostly looked only at nuclear facilities declared by the country being inspected.

In June 2000, the Director General of the IAEA said, and I quote, "The Senate vote against the ban on nuclear testing was a devastating blow to our efforts to gain acceptance of more intrusive inspections of nuclear facilities around the world." I've just come from the annual meeting of the Institute of Nuclear Materials Management where I raised this question in a conference meeting with the IAEA Deputy Director General for Safeguards. He said that fifty-four countries had signed the additional protocols – authorizing more intrusive inspections – fairly soon after the IAEA approved them in the spring of 1997. But only fourteen have ratified. The Senate vote had a very bad effect. Of the fourteen, Japan is the only one with major nuclear facilities that has ratified so far. The EU countries have not yet done so. They may go ahead – some of them have approved it individually, but they have to come in as a group of fifteen under their way of doing things now. They may do so later on, but many non-nuclear weapons states are asking why they should assume additional nuclear arms burdens if the United States, the leader in the area of nonproliferation, will not do so.

The NPT countries in the Middle East except for Jordan have also refused to do so. North Korea has refused even to sign the protocol. Many non-aligned countries are delaying. The IAEA is disappointed in the results in the three years since 93+2 safeguards were approved and attributes many of the refusals to ratify to the Senate's action. It's very hard to judge, but the Director General said it was a devastating blow and his Deputy Director General for Safeguards agrees.

Third, and most important, failure to ratify greatly reduces U.S. leadership and bargaining leverage in enforcing the NPT regime. For almost forty years the U.S. has led nonproliferation efforts. Certainly, that was true in the negotiation of the Nonproliferation Treaty in the sixties. And certainly it was true in getting the International Atomic Energy Agency to achieve a consensus for the safeguards that were to implement the Nuclear Non-Proliferation Treaty in the seventies. And it's been true in many individual cases since then; we watched it not so long ago with respect to the former Soviet republics of Belarus, Kazakhstan, and Ukraine which assumed they had inherited the Soviet nuclear weapons that were left on their soil. When the Soviet Union broke up they finally gave them up. It was our leadership which, I believe, was most important.

India and Pakistan announced after their tests in 1998 that they would not prevent the CTBT from entering into force by staying out if the other necessary parties joined. On the President's recent trip to India and Pakistan, however, he could not get a promise from either one to even sign the CTBT. He

announced after he got home that the U.S. had "lost all leverage" to persuade the two countries to sign when the Senate had voted against the CTBT. The CTBT cannot go into effect without the U.S., and the U.S. is not persuasive in asking others to do what it will not do itself.

If India and Pakistan resume testing, will China be far behind? If China tests, what will be the effect on North Korea? South Korea? Taiwan? Japan? We don't know, but we will surely have a harder time persuading these countries not to withdraw from the NPT and begin testing, if that is their choice. North Korea, South Korea and Taiwan all once had nuclear weapons programs, and the U.S. talked all three of them out of continuing those programs – so far as we can tell today.

In the Middle East, Egypt, Iran, Iraq and Israel have all signed but not yet ratified the CTBT. Egypt, Iran and Iraq likely will wait on Israel, and the U.S. will have great difficulty persuading Israel to ratify if the U.S. has not done so itself. If the U.S. ratifies, however, I believe that Israel could be persuaded to do so, particularly if the Middle East peace process continues successfully.

Fourth, failure of the U.S. to ratify the CTBT will weaken the NPT over the long pull, even though it did not produce a bad result at the recent NPT review conference. Many expected that conference to fail because of the U.S. Senate's action on the CTBT, U.S. plans for national missile defense, and the stalemate on the START negotiations. But the P-5 (the five nuclear weapons states who are parties to the NPT and also permanent members of the Security Council) agreed to a joint statement that called for early entry into force of the CTBT and averted condemnation of either the Senate's action or U.S. plans for National Missile Defense. The other conferees apparently accepted that the Senate action was temporary and not the fault of the Executive Branch. U.S. representatives made it clear that the failure of the Senate vote did not mean that the U.S. could not ratify in the future if there was another Senate vote. The NPT Review Conference simply called for early entry into force of the CTBT and a moratorium on testing until the CTBT did enter into force.

But over the long pull, failure of the U.S. to ratify will be criticized by many non-nuclear weapon NPT parties as a violation of the NPT Article VI promise to negotiate in good faith to end the nuclear arms race at an early date. This promise was made in 1968 and included the Comprehensive Test Ban Treaty. The link between the CTBT and this commitment was clear from the preamble of the CTBT and from the first agenda agreed at Geneva after the NPT was signed on July 1, 1968. The first agenda agreed in Geneva had the CTBT as the first item listed under the pledge to negotiate in good faith to end the nuclear arms race at an early date. So it's been a promise of the United States to achieve such a treaty since 1968, a promise approved by the Senate when it gave its consent to the NPT.

Achieving a CTBT by 1996 was the single most important promise the U.S. made again in 1995 to gain the consent of a large majority of NPT members to indefinite extension of the NPT. By frustrating this 1995 promise, as well as the repeated NPT promises to negotiate further nuclear arms reductions, the U.S. will be perceived by many as violating Article VI of the NPT. We agreed to this provision of the Treaty, which was ratified by the Senate. It says that we will negotiate in good faith to end the nuclear arms race at an early date to achieve nuclear disarmament. If the United States does not ratify the CTBT, those that want to withdraw from the Treaty will have a ready excuse for doing so.

Thus, U.S. adherence to the CTBT is essential for the Treaty's entry into force and necessary to renew U.S. leadership and bargaining leverage for efforts to stop the spread of nuclear weapons. Thank you.

REMARKS BY DISCUSSANTS

Dr. Chyba: Thank you George. That concludes the first part of this roundtable – the presentation of the background papers. We'll proceed now to presentations by discussants. This session is on the record. Each of the speakers this morning, or at least most of the speakers this morning, is limited to 5 to 10 minutes. If there is time left within that 10 minutes, I will encourage questions to the speaker so that we can have some on the record debate this morning. But I will have to keep us moving along after 10 minutes for each speaker, and I will remind the speakers when they approach the end of their 10-minute time if they need to be reminded. The first speaker this morning is going to be General John Shalikashvili. I think we're very pleased that he is able to join us for this Roundtable and he'll describe to us his current role in the CTBT discussions. General, I think that there's a sense that this Roundtable is designed to be as helpful as possible for you, and I hope that we'll succeed in that regard.

General John Shalikashvili: Thank you very much Chris. First of all I would like to thank the presenters of the papers this morning for the very, very thoughtful and very useful information. As you know, for the last couple of months in response to a request by President Clinton, Ambassador Goodby, Ambassador Ledogar, and Nancy Gallagher and I and others have been engaged in a quiet, hopefully non-partisan dialogue with Senators from both sides of the aisle, with members of the scientific community, with pertinent NGOs, with other influential individuals in and out of government, to find out what the real issues were, away from the television spotlight and away from the politics of the issue, that caused people to vote against the Treaty in October.

And I thought it would be useful if at the beginning of this next phase of our discussion, I would give you a very brief outline of what it is that I have so far heard that caused this reaction in the Senate. I will tell you at the outset that you will see absolutely no surprises, and that the issues that we've discussed so far are by and large the issues.

Why did people vote against this treaty? First of all, clearly, there are those who would vote against any arms control treaty no matter what. And I think we need to accept that there are those who voted against the Treaty because President Clinton proposed it.

But beyond that, I believe there were serious people who in fact raised serious questions that require serious responses on our part if in fact we wish to have a different outcome next time this treaty comes up for debate and eventual vote in a Senate, whenever that might be. Those are the issues that I would like to address with you.

There are essentially four issues. The first is one that you hear repeatedly: that the case has not been made why the CTBT is important to national security. Unlike most other treaties, they say, the value of this one is simply not that obvious, and certainly the case has not been made how this treaty fits into this broader, all-encompassing strategic outline for dealing with proliferation. Unless the case can be made up front, I am told, then don't bother me with all the other details.

The second issue that I hear has to do with what I call uncertainty, and the question goes something like this: Why in this period of uncertainty, in a period where science moves so rapidly, should I sign up to a treaty of indefinite duration? The administration, as you know, had tried to answer that question partly through Safeguard F, which said that at any given time, if the safety and reliability of our stockpile could no longer be assured, and the Secretary of Defense and Secretary of Energy so reported to the President, then the President, in consultation with Congress, would consider leaving the Treaty. The argument that you hear in response is that that is simply not credible, particularly now that we have watched this debate about potentially leaving the Antiballistic Missile (ABM) Treaty, to say that because one or more of our warhead types have some serious problem we would leave such an important international treaty. A different way of dealing with this uncertainty issue has to be found.

Most opponents of the Treaty say that the duration issue is reason enough to renegotiate the Treaty. When you confront them with arguments about how difficult it would be to renegotiate the

Treaty, I hear that as a minimum, you need to do something significantly different in terms of an understanding or some other such mechanism that would bring greater certainty about the circumstances under which this country would walk away from the Treaty if we could no longer certify the safety and reliability of our nuclear stockpile without nuclear testing.

The next issue has to do with the science-based stewardship program. There the basket of concerns is really quite extensive. It is clear that many people who voted against the Treaty, and also many people who voted for the Treaty, do not really understand the science-based stewardship program. They don't understand its pieces. They don't understand what each one of those pieces is supposed to do. They don't know what it is that we have today or what it is that we expect to have in terms of capability when we're finished with this program.

But they do understand that there is no agreement on what the program should include and that there is no agreement on the funding required. In short, we do not have plan nor a multiyear funding stream that has been agreed to by the administration and the leadership in Congress. And consequently, some senators have very little confidence that they should place their faith into a program about which they understand so little and that has so little coherence to it.

Furthermore, I think they don't understand what this program will give us vis-à-vis what nuclear explosive testing gave us. I know from the remarks here this morning that it's obvious to all of us sitting around this table, but I can assure you it is not to everybody up on the hill. I have pledged from the beginning of this process not to report to President Clinton or to speak to anyone about what any individual Senator told me, otherwise I would lose all credibility in those discussions, and I won't break that. But I will tell you that just the other day, I had a discussion with a very strong supporter of the Treaty, and when I raised the issue of the science-based stewardship program, he stopped for a minute and asked me, "what is that?" Now I mention that to you only to suggest that there are people on both sides of the aisle who understood it that little and who are therefore not willing to sign up to the termination of testing in perpetuity.

The final issue that I want to raise is no surprise to you; questions about monitoring. That is perhaps the most difficult issue to come to grips with. What I hear right away from those who oppose the Treaty is that President Reagan had it right. You trust but you verify. They say, here you are asking me to sign up to a treaty that prohibits testing when I know that we cannot monitor all testing activity below a certain threshold.

As has been discussed here, you can have debates whether that's 2.9 on a Richter scale that we can detect, and whether that's equivalent to one kilotons, or .9 kilotons. But I think we need to be clear on those issues, because there is an awful lot of confusion on it and on those numbers. But there is no confusion that there is some level below which we cannot detect.

Usually the supporters of this treaty respond by saying that the testing that could be accomplished below that level is not militarily significant. I want to tell you in the strongest possible terms that I have not seen any opponent of this treaty, or at least I have not had a conversation with any opponent to this treaty, who is satisfied with that answer. It simply will not fly. We have to explain much better than we have been able to do so far, why testing at these levels is not significant. You have to be able to differentiate between how significant it is or is not when you discuss Russia testing at these low levels, as compared to when you discuss China testing at these low levels. The same is true with North Korea, Iran, Iraq, or whoever you wish to address. It is sort of a net assessment of the United States vis-à-vis each one of those countries both with and without the Treaty.

By the way, it is also important that we make clear something that one of you stated this morning and a number of people in the Senate are now beginning to understand. On verification, if the lack of our ability to detect tests at certain levels gives us heartburn with the Treaty is in effect, it should give us the same amount of heartburn without the Treaty. So, this concern is really treaty-independent. And the same thing is true of the science-based stewardship program. If you're uncomfortable about the science-based stewardship program when we are in a treaty, you ought to be uncomfortable about the science-based stewardship program without the Treaty. Both the science-based stewardship program and ability to

monitor, as well as to explain what is militarily relevant and what isn't, are equally important without the Treaty as they are with the Treaty.

This point is not clearly understood, so people tend to say "I will vote against the Treaty because you have not explained one thing or another" and then they think national security no longer requires that they worry about these other things, or fund these other programs. But if we are truly interested in national security, we ought to be just as worried about whether there's funding for science-based stewardship programs now and whether there's funding for the monitoring system now, not only if the Treaty goes into effect.

So where do we go to from here? It is my intent, probably sometime in the November time frame, to publish a report I intend to give to the President. It will contain a very concise articulation of the issues that we need to address and contain specific recommendations as to what needs to be done if we wish to change sufficient views on the Hill to have a different outcome next time this Treaty comes up to vote, whenever that is.

And it is also my understanding that the President, after reviewing that report, will turn it over to the president-elect for him to use to make a more informed judgment as to how to proceed with this treaty. Obviously, in my judgment, there will be a different situation whether Governor Bush is elected or Vice-President Gore.

I think that whatever the judgments are, for those who support this treaty we then enter into a probably extensive period of public education, continued awareness programs of the importance of the Treaty, and what not. This still has to be worked out, but I think the first step is to offer to the next administration our best judgments of what we have been able to find out and what recommendations we have, so that it can make a more informed decision. And I hope that during the remainder of this discussion we will be able to explore in some more detail those issues that I raised here and ways that we can address in more depths those particular points that seem to bother people. So with that, I thank you very much.

Dr. Chyba: If there are specific questions of clarification to General Shalikashvili's remarks, I'll take one or two of them now. Otherwise, we'll proceed. General, thank you for that clarifying presentation. Let's proceed. Our first discussant today will be Dr. Donald Cobb of the Los Alamos National Laboratory.

Dr. Donald Cobb: Thank you. I want to thank the conveners of this Roundtable for inviting me to speak on a topic that's of a great deal of interest to my laboratory at Los Alamos and our sister laboratories. The 1992 moratorium on nuclear testing, the August 11, 1995 decision by the president to have a true zero CTBT, and subsequent events over the last 5 years have had a major effect on our laboratory and its operations and its core mission, to sustain our nuclear deterrent. The CTBT, as everyone here agrees, and as the background papers presented, is a complex treaty. It involves a complex set of policy and technical challenges. We find at the laboratory that these challenges clearly have an impact on how we see our future and the future of our enterprise.

I personally think that there are a number of issues that need to be addressed for a successful ratification. I doubt that I can make them clearer than General Shalikashvili. I'd like to quote a comment from a person that I admire, Senator Lugar, and his reasons for not voting for ratification. He said, "I have little confidence that the verification and enforcement provisions will dissuade other nations from nuclear testing. Furthermore I am concerned about our country's ability to maintain the integrity and safety of our own nuclear arsenal under the conditions of the Treaty."

For me this suggests that there are major issues. The first one I would like to talk about is the Stockpile Stewardship Program, the second is verification and monitoring, and the third is a topic that I think is also central to the discussion, the differences, the asymmetries among nations who either have nuclear weapons today or desire to have them in the future.

Under stockpile stewardship, I agree with Ambassador Graham. No nation is probably bettered prepared than the United States. No nation has a more sophisticated or technologically advanced nuclear deterrent than the United States. It's our ultimate deterrent to those who would threaten our security or that of our allies. We'll need to maintain this deterrent for the foreseeable future. It's been said by the President that it's a supreme national interest to do so.

The Stockpile Stewardship Program is the key to maintaining a safe and reliable nuclear deterrent without testing. I want to quote from the statement by our director, Dr. John Browne, who has the responsibility to do the annual certification of the weapons that were originated in Los Alamos. This is his testimony to the Senate Armed Services Committee last October: "Maintaining the safety and reliability of our nuclear weapons without nuclear testing is an unprecedented technical challenge. The Stockpile Stewardship Program is working successfully toward the goal, but it is a work in progress. Los Alamos has been able to certify the safety and reliability of its nuclear weapons since the cessation of testing. On the basis of our experience over the last four years, I am confident that a fully supported and sustained program enables us to continue to maintain America's nuclear deterrent without nuclear testing. However, I am concerned about several trends that reduce my confidence level each year that I have to do the certification. These include annual shortfalls in the planned budgets, increasing number of findings in the stockpile that need resolution, augmented work beyond the original plan of the program, and unfunded mandates that can cut into the program. We must have a national commitment if we are to succeed in certifying the stockpile without nuclear testing." And I personally would also add that in the last 18 months, many of the events that Sid Drell mentioned about the political environment have made it more and more difficult for us to attract and retain the people that we need to do this program at the laboratories.

The second topic that I want to talk about is verification, specifically monitoring. As was mentioned [by General Shalikashvili], with or without a Comprehensive Test Ban, the U.S. needs a reliable and effective system to monitor for nuclear explosions. For the past 50 years the requirement to detect nuclear explosions anywhere by anyone at any time has been an integral part of our national security requirements. The atomic energy detection system is necessary and is mandated to detect, locate, identify, and attribute nuclear explosions underground, underwater, in the atmosphere, or in space, and provide this information to our national authorities in a timely manner.

There are additional U.S. requirements for monitoring a CTBT that have been laid out in presidential statements and directives. These requirements are more challenging than for any previous treaty limiting nuclear testing. Meeting these requirements requires major enhancements to existing national technical means of monitoring for nuclear explosions. While I agree that the IMS will provide substantial additional capabilities that are complementary to our national technical means, unfortunately the program designed to enhance our own capability has fallen significantly behind the projections that were made for this program only a few years ago. Funding and program priorities seem not to have kept pace.

Even with these enhancements in place, monitoring alone can't be the whole story for a true zero CTBT. I think most people here understand cooperative measures among the nuclear weapons states are needed, including possibly reciprocal visits to our respective nuclear test sites. To date there has been progress in bilateral lab-to-lab work between our laboratories and our Russian counterparts, for example, in developing onsite inspection measures that could be useful under the Treaty's IMS and broad verification provisions. However, the thought that there would be reciprocal and transparent visits to our test sites still remains an elusive prospect.

Finally I want to discuss the differences and asymmetries among countries. As I said the U.S. stockpile is the most technologically advanced in the world. Therefore the Stockpile Stewardship Program is uniquely tailored to maintain the U.S. stockpile. The Russian stockpile is widely reported to depend on regular re-manufacturing, the replacement of new components or new weapons. At the same time, it is clear that, and this is quite different from the U.S. stockpile which is to be maintained indefinitely, the activities that are going on at Novaya Zemlya are extremely important to Russia's

Stockpile Stewardship Program. There's no way they would invest the level of resources that they are unless it was a major element. Our full understanding of why it is that important is at this point not clear. It seems to me that this means that any treaty regime, including a successful CTBT, must take account of these and other differences.

Finally, as you all know, the path to proliferation is only limited by the ingenuity of the people who are thinking about how to do this, and those pathways, many of them don't include nuclear testing. South Africa and Pakistan are good examples of that. So, with or without a CTBT, we have to continue to be vigilant. We have to continue to maintain our net assessment of what's going on in the rest of the world. Thank you for the opportunity to comment.

Dr. Chyba: Thank you Dr. Cobb. We have time for one or two questions or comments, and I think I'll get us started. You mentioned that the CTBT must take into account asymmetries among different countries. I am curious as to how you would like to see the CTBT do that.

Dr. Cobb: I don't know if I can give you specific answers of how to do it. I am not sure that I have any recommendations that would be specific in a formal sense to the Treaty. I just think it's important for the people who have to make this policy decision to understand what those differences are and what their significance might be.

Dr. Chyba: Thank you.

Dr. Drell: I'd like to go back and try to understand John Browne's statement a little better. He said that he has confidence that, fully supported, we could maintain confidence in our stockpile. Now, I understand concerns about the budget. If one wants to fight for budget in that program, with proper priorities, we can do what needs to be done. But there's sort of an implication, as I understood it, in John Browne's statement when he made it, that we're learning things that are reducing his confidence. –Not just a question of resources. To my mind, and I tried to make it clear, we're gaining confidence. We were worried whether a pit with plutonium could last for 20 years. You people raised that question 4 or 5 years ago. Now we're saying plutonium is good for 50 or more years longer. We've been learning things. We've been learning how to deal with our findings. I have more confidence because the lab directors each year have certified to the president that they have confidence in the stockpile. So what's hidden in that losing confidence, if I take out resources and the political side of it?

Dr. Cobb: I would not like to speak for [Dr.] John [Browne] on the details of what he has in mind, but I think that from the general discussions that we've had, we are finding that maintaining the stockpile without nuclear testing is a challenging enterprise and that there are technical issues that continue to arise. And if you put this in the context of questions about whether you have the right people and whether you are able to attract them and move ahead with the program, then maybe some of these eventually over time will begin to erode confidence that the program can succeed.

Dr. Chyba: Thank you. We should move on to the next discussant, Dr. Gloria Duffy from the Commonwealth Club.

Dr. Gloria Duffy: Thank you very much. I am so happy to be here among so many old friends and colleagues. Very briefly, what I would like to discuss is not on the technical level, but rather the importance of symbolism in the international arena, and particularly symbolism with regard to the importance of nuclear weapons. What we do in our policies and our behavior as a country signals to other countries what we believe about whether nuclear weapons continue to be important instruments of national security. We signal that those weapons either do or do not confer great power and influence on a nation.

There was a positive trend from the mid-1980s through the mid-1990s toward de-emphasizing and minimizing the importance of nuclear weapons for national security. South Africa and Argentina abandoned their nuclear programs, Russia and the United States made progress in constraining and reducing their strategic nuclear weapons and Ukraine, Belarus, Kazakhstan decided to be non-nuclear. We signaled a desire to reduce the number of weapons, reduce their influence and their importance. All of this was important symbolism to countries which were evaluating the nuclear option for themselves.

Since the mid-1990s, that symbolism has reversed, and the action by the U.S. Senate to reject the Comprehensive Test Ban Treaty has been a particularly destructive addition to the negative symbolism the U.S. has been communicating. The CTBT, in my view, is one of the most important, concrete barriers to proliferation that we could have. And I think it is well to recall that had the CTBT been completed and brought into force at an earlier time, and had India and Pakistan been persuaded to sign, their 1998 tests and movement towards full nuclear status might have been averted. Such was the price of delay. But the U.S. rejection of the CTBT, together with our lackluster performance until quite recently, along with Russia, on START and other arms control objectives has sent an important and negative symbol to potential proliferators that nuclear weapons continue to be very valuable instruments of national security.

The CTBT, in my view, is a viable treaty. Any uncertainties about verification and the viability of the U.S. arsenal that are embodied in the Treaty, in its current form, are in my view well within the range of acceptability in trade for the nonproliferation benefits of the Treaty. They are similar to the necessary, relatively minor uncertainties that we have always accepted as part of all arms control treaties. We shouldn't be applying new standards that cannot be met by arms control agreements.

The symbolism of the past five years that nuclear weapons continue to be valued elements in the arsenals of the U.S. and Russia has not been lost on potential proliferators. Were the costs of nuclear weapons, the resources required to develop and maintain them, the reactions that would be stimulated among one's neighbors, and so many other factors, seriously considered by India, for instance? Did we hear those negative aspects in the debate in India? These same questions were considered just a few years ago by South Africa, Argentina and Ukraine and these were reflected in their decisions to be non-nuclear. A number of us who were involved in the discussions in Ukraine had conversations with the Ukrainian government about the costs and the downside of nuclearization.

In the debates in India and Pakistan, I did not hear these negative aspects considered because this has not been the tenor of the international discussion about nuclear weapons led by the U.S. over the past few years. Even the Russians seem to understand the importance of symbolism better than the U.S. does, as evidenced by the Duma's ratification of START and the CTBT at the time of the NPT Review Conference earlier this year. The U.S. should be talking about and acting as though we understand the cost of nuclear weapons, thus conveying the appropriate symbolism to possible proliferators.

In my view, at this point a number of U.S. actions would begin to reverse the negative symbolism that we've created over the past few years. These include possibly a new nuclear posture review for the U.S., a review of NATO's nuclear doctrine, and further strategic arms control progress with Russia. But of course the most powerful symbol would be timely Senate ratification of the CTBT. And let us just hope we elect a president and a Congress in November that can provide the leadership to make it happen. Thank you.

Dr. Chyba: Thank you Dr. Duffy. We have time for questions and comments on Dr. Duffy's presentation. I will again ask the first question, and I'm really directing this to General Shalikashvili. I wonder, General, whether you see tension between Dr. Duffy's comments, which to some extent echo some of Dr. Sand's comments about the CTBT being viewed in the context of de-emphasizing the role of nuclear weapons in national security. I wonder if you see a tension between that and your very first point with respect to reactions on the Hill, that those in favor of the CTBT need to make a case for the role of the CTBT in national security.

General Shalikashvili: I am not sure that I have a simple answer, but I will tell you my view. I think there's a significant number of people who believe strongly that nuclear weapons will be an important part of ensuring America's security for some time to come. They feel uncomfortable with the notion that we will forego testing, which in this uncertain world will take away the opportunity to improve our remaining nuclear stockpile. And certainly they are not a group of people who think that nuclear weapons no longer have a role in deterring, under certain circumstances. They worry that if you forego the ability to conduct testing, you potentially forego the ability, in this uncertain world, of having a more effective deterrent. This gets at the issue of being able to, for instance in some future timeframe, develop smaller, more effective deep penetrating warheads and whatnot. The issue is clearly one that has reached the Senate floor and has been debated there recently.

There are also some people who believe that the CTBT put us on a slippery slope towards the elimination of nuclear weapons, because without testing sooner or later we will have to give up these weapons because we no longer can maintain them in a safe and reliable way. And so there is a great tension, I think – not an insignificant tension – between those who look at the CTBT as counter to their objective of retaining nuclear weapons for the foreseeable future as a significant and important part of America's deterrence, and those who they see as using the CTBT as a backdoor towards eliminating nuclear weapons from America's arsenal.

Dr. Chyba: I wanted to ask Dr. Duffy if she wished to respond. Ambassador Graham?

Ambassador Graham: I just want to make a short comment on this subject. My experience has led me to believe that at least many non-nuclear weapon states around the world, some of them not necessarily close friends of ours, see the NPT as a bargain between the nuclear weapon states and the non-nuclear weapon states in broad terms – nonproliferation on the one hand in exchange for disarmament progress with the ultimate objective of elimination on the other hand. And further, they see the CTBT as the litmus test – as they've said many times – of the commitment of the nuclear weapon states to live up to their half of the bargain. So, I would argue that if we take CTBT off the table by not ratifying it for a significant period of time, increasingly many of these states may see this as a breaking of the bargain, especially given, as Gloria has discussed, the very important symbolic status of the CTBT. This over a number of years would be to the serious detriment of the NPT, leading to the eventual widespread proliferation of nuclear weapons which, at least in my judgment, would damage our security more than anything else that I can think of.

Dr. Chyba: Thank you. I think we'll have to move on. The next discussant is Senator James Exon from the Committee to Support the Comprehensive Test Ban Treaty.

Senator J. James Exon: Thank you very much. I want to not only thank you, but I want to take this opportunity to thank the Lawyers Alliance for World Security for holding this conference, which I hope will kick off a better understanding of what this is all about. For those of you who do not know who I am or from whence I come, I am no shrinking violet. I was known hawk in the United States Senate, served 18 years on the Armed Services Committee, and I was brought along very carefully by such noble hawks as Barry Goldwater, John Stennis and Sam Nunn. I was a lieutenant to each of those great leaders in the Armed Services Committee.

When I think of nuclear weapons I go back to my personal experience with them, which happened at an early age. It was in Clark Field in the Philippine in August of 1945. We had just taken back Clark Field from the Japanese, and I was a member of the Army Signal Corps. I took the message via Morse code about the dropping of the first atomic bomb on the Japanese. At that time we were planning an assault on the Japanese mainland when we were officially told that we could expect 38 percent casualties. With that event we knew that the war would be quickly coming to an end, and we

wouldn't face those casualties, and I knew also at that time that I would be going home soon. So I've had a personal relationship with nuclear weapons, the good and the bad.

I want to tell you how pleased I am to be invited here among all of you who have contributed so much to the understanding of what this is all about. I am sure glad to be here, to be back with some of you that I worked very closely with during those 18 years as a member of the United States Senate. I am here because the CTBT is clearly one of the most important treaties affecting the future of mankind negotiated in the last century. I am here to help ensure its eventual success.

In addition to what I think it can do for mankind, it locks in the superiority of the United States of America. John [Shalikashvili] that's what we've got to convince those people in Washington that you're working with. I reviewed with great interest and great appreciation the excellent presentations by the five speakers that we had this morning, all tremendously well done. I think if we could get those who are opposing this Treaty in the United States Senate just to sit down for an hour and a half, and read through carefully what you presented it would answer all or most all of their questions, if they want their questions answered. Some of them in my opinion do not.

I noticed with great interest, Dr. Drell, your opening statement. You said the continuing cycle of developing testing and deploying nuclear weapons has ended. As announced by President George Bush in 1992, the U.S. does not need to develop new nuclear warheads designed for deployment. It was this decision that opened the possibility of the CTBT. I wish that he would converse about this with his son.

I also noted with great interest, and I think strictly to the point, the excellent comments by Ambassador Graham, and I am going to read them again: "U.S. ratification and subsequent entry into the force of the CTBT will clearly benefit U.S. national security relations with Russia and China. The test ban would strengthen the NPT regime, and promote greater transparency at the Russian and Chinese Test sites. It would augment the United States already impressive global monitoring system for detecting nuclear tests, and make it more difficult for either nation to conduct undetected nuclear explosive tests. This would in turn hinder modernization of Russian and Chinese nuclear arsenals and make permanent the U.S. advantage in nuclear weapons technology. In short the CTBT would enhance U.S. national security by locking Russia and China into a legally binding verifiable international ban on nuclear testing, and [more closely] into the nuclear nonproliferation regime."

We have to say some of these things that I am about to say so that people understand. The fact of the matter is, and we shouldn't be ashamed of it, we are the biggest bullies on the nuclear block. Certainly not since the Roman Empire has a single country been so dominant as we are today. Yet, we all know what happened to Rome. It seems to me that we've got to renew our intensity. Certainly John, the work that you are doing in Washington, is excellent. Certainly I think the President has hindered our chances somewhat by his suggested changing of the ABM Treaty. Still, we must persevere.

I would suggest that most of you here have not been in the political trenches I have. I was there in 1992 on the floor of the United States Senate twisting arms to get two or three votes [for a moratorium on testing], and the very people that were trying to defeat it then are trying to defeat it again now.

I suggest that we have got to not only expand our horizons, but the people that are working on the horizons. And I think maybe we should try and organize some kind of bipartisan group of politicals who could help and assist John and the others in doing what they are doing. That list of politicals we need must be heavy with Republicans, and I think that certainly when we talk about those that we could get, we could certainly pick up Mark Hatfield, who was a close and valued ally all during those times when this all started. It seems to me that if had some kind of bipartisan committee, heavily Republican – because there's where the votes are, there's where our problems are – it might assist you John in what you're trying to get done. Thank you.

Dr. Chyba: Thank you Senator. Are there comments or questions for Senator Exon?

Dr. Drell: Right on.

Ambassador Bunn: I'd just like to say I watched what you and Hatfield did in 1992, and I want to congratulate you.

Dr. Chyba: I think will move on to the next speaker, Ambassador James Goodby from the Department of State.

Ambassador James Goodby: My only question is why I always follow such a speaker as Senator Exon; it seems to be my fate in conferences like this.

I want to address a few points, which are more micro than macro, but I do think they need some attention as we begin to dig into these issues in a serious way. I am going to base my questions and my comments on what we heard this morning and on my own reading of the papers that were circulated, which I think do deserve a very careful reading. There's much merit in each of them.

First, three questions I would address to Sid Drell. Performance margins: Sid you make a very powerful statement saying that enhancing the performance margins would do more for our national security than underground testing. That's a powerful statement. I wondered if you could elaborate on that, and if the lab people here would like to comment. That would be interesting, because I have not heard that much about this issue, and your statements suggest that it is one that deserves a lot of attention.

Second, the Stockpile Stewardship Program and making it a national commitment to it: I think we all want to do this whether or not there's a treaty. I think we have to pay attention to this because we must have the resources and we must recruit the most able people into this field in the future. That, of course, is a legitimate worry that the laboratories have. My guess is that this would require a modest increase in funding. I doubt very much we are going to double or triple the bill, which is already fairly significant given other things that we need as well. My guess is that we would need as, General Shalikashvili suggested, a more coherent program, and a 5-year program, as in the Defense Department. Given those kinds of conditions I should think that prioritization of specific projects would be an almost inevitable result, what needs to be done first in order to guarantee the reliability and safety of the stockpile.

You mentioned spreading the priorities across the areas of validation, remanufacturing, and research and development. I don't know whether one needs to be or should be at this particular point more precise than that, but if you had any thoughts or anybody else had any thoughts about how to prioritize these several programs, and on what basis does one prioritize, I think it will be very useful.

And a third point, again addressed to you, Sid. You make the assumption that President George Bush's statement about no new nuclear weapons designs being needed will carry on. And yet we all know that there has been a lot of discussion recently about the need for a new nuclear weapon of some type, or maybe just a reconfiguration of something existing, to deal with hardened deep underground shelters. I think we need to have some clarity about whether this assumption about no nuclear weapons designs is solid and is going to hold for a time in the future.

I also have a question for Richards, Sands and Graham collectively – not that they all address this issue, but I think it is within their competence and interest to address it. That is the decoupling problem, which does not go away. It's been around a very long time, and there are numbers associated with it like seventy, or some say a hundred. I think it's probably true that you cannot scale up this thing indefinitely. As Paul Richards said, the idea that seventy kilotons could remain undetected is unrealistic, but nonetheless under some conditions, some decoupling is going to present a problem. Can we think about a profile of the kinds of tests that certain types of countries could do? I read in Tom Graham's paper, for example, that the proliferant countries are unlikely to do that kind of thing because they are not able to test reliably at these very low-yields – let's say 5-10 kilotons or something like that – as they first enter the testing field. But is there something in all of this that suggests a certain category of countries that in fact might be capable of decoupling tests and getting away with it and what would they get as a result?

Finally, a couple of questions addressed to George Bunn, Tom Graham and Amy Sands addressing asymmetries. This is a remarkably important issue that we cannot overlook, and it comes in

different forms. One is this: there is an assumption (and it's been alluded to already today) about a lot of activities going on at test sites in Russia and China. There are some who say without much evidence, they admit, that perhaps there is some experimentation in the hydronuclear area going on at Novaya Zemlya. We can't prove it one way or the other, nor can we tell from the surface whether it's hydrodynamic, which is permitted, or hydronuclear, which is not. There may be walk-throughs of tunnels that we can get as a side deal that would help with that, but the real question really was alluded to by General Shalikashvili as well as by Tom Graham in his paper. If there is cheating going on right now under a moratorium – cheating under a moratorium in the sense that there is hydronuclear experimentation going on – are you better off without a treaty or with one?

If that kind of cheating is going on under a moratorium, are we simply to accept that that is going to be the case and not do much about it, or are we going to join a treaty which gives some leverage in dealing with it? If we have a test ban treaty should we assume more cheating of the type that is allegedly present today under a moratorium, or less?

And finally, a question about enforcement and punishment, which I think can't be dismissed. Senators who are well-disposed toward international cooperation in general have raised this with us and the question I have is this: the argument is made that the United States has never withdrawn from a treaty –witness the ABM Treaty and how difficult it is to get out of that – even if we wanted to get out of it. Therefore, a condition that says that the United States would exercise its supreme national interest option and get out of this treaty under some circumstances, as some Senators argue, is not credible. The question, particularly for the lawyers in the group – and we is do we have many distinguished attorneys present, including a couple of them who have occupied the position of General Counsel of the Arms Control and Disarmament Agency – is this: if there is a situation where a material breach of the Treaty occurred (let's say for the sake of argument Russia or China conducted three nuclear tests and, while they denied it, we can document it with defectors, radionuclides, etc.) is there something short of complete withdrawal from the Treaty that could be done? Can one temporarily suspend American observance of certain provisions of the Treaty in order to redress the situation (which might of course include conducting three tests of our own)? Now that of course puts a lot of pressure on a president, but probably less pressure than getting out of the Treaty altogether. Is this something that should be thought about? Is there any standing for that kind of argument in international law? Thank you.

Dr. Chyba: Thank you Ambassador Goodby. I'd like to suggest that we spend five minutes now with individuals who might want to respond briefly to each of your points, and I'm sure that we'll return to each of those points throughout the discussion. Sid, would you like to respond first?

Dr. Drell: Let me make this brief response, which I am sure will be amplified. There are two individuals here – Bob Peurifoy and Raymond Jeanloz, who have worked with me on these issues of performance margins and priorities who might jump in and correct me if I'm wrong. But on performance margins, let me make sure everybody knows what it is. For those of you who are not weapons physicists, thermonuclear weapons have two stages: a primary drives the main stage, or the secondary, where most of the energy comes from. The primary in a modern weapon, to be very light and small, can still have enough of a punch to drive the secondary, if it is boosted. That means as you start the implosion you also heat up some gas – deuterium and tritium – which produces more neutrons which then drives the fission to a much higher yield, and it's critical.

Now what we have said in 1995 and more recently is that the boosting and therefore the output of the primary can be enhanced by making a more robust boosting system within the parameters of the weapon and without testing. This is the kind of work that can be done, and while specific steps are different for different weapons, such changes will be more important than low yield nuclear tests. This has been quantitatively worked out in the 1995 [JASONs] report which is summarized in the quote Jim gave. Obviously we can't talk the details about too much, but I believe it is a very important activity. It

is consistent with the Comprehensive Test Ban and I am disappointed that five years after we've made the first comprehensive analysis of this, it still does not have the priority it deserves.

Which brings me to the second question, that with or without a CTBT under the Bush policy we need a multiyear commitment to and prioritization of the stewardship program. That indeed is true. The labs have to know that the country is behind them. There has to be a long-term commitment to maintaining the credibility of our stockpile. The government has to do its best, both the Congress and the administration, to do that. I complained about prioritization by pointing to the fact that we're not doing what we could and what I believe will be important to do to enhance performance margins so that whatever doubts creep in over time, we will have a greater margin of confidence by making a more robust boosting system.

As to how priorities are made between a short and long term needs: for example, the Defense Department wants to know that the weapons we have now are going to work 5 or ten or more years from now and whether we need to make some more pits to replace those taken apart by our diagnostic program. These are immediate needs. They cannot be put off to pay for the multi-hundred million to billion dollar facilities projects we would like to have for the future at all of the laboratories. We are struggling with these kinds of priority choices, but I am not satisfied we've come to grips with them. That's a worry.

My final comment is on no new nuclear weapons being needed. Again we can design and think about new nuclear weapons [under a CTBT]. What has been said is that we won't develop one for deployment. I would never deploy a new weapon without testing it, but one can think about it. I find the rumblings that are coming out of some places back in Washington about that new low yield deep underground penetrator ominous, but let's save that for a longer discussion this afternoon, because it needs a longer one.

Dr. Chyba: Thank you Sid. We'll take a few more comments and then we will have to move on.

Mr. Bob Peurifoy: Enhancing margins is straightforward. It's inexpensive. It is a matter of interpolation among test points already conducted. There is no serious risk of screwing things up. It's highly desirable. Why isn't it being done?

Dr. Richards: I heard Ambassador Goodby say specifically that decoupling is a problem, and he asks if there is something to say on what particular countries can get away with here. I wrote that down. There is a lot of further work that is going to be done this summer, and we are going to try to attend to that question.

Ambassador Graham: I would like to briefly address two of Ambassador Goodby's points. The first is the one that he referred to as the asymmetries of cheating under a moratorium. Should we assume there would be more or less cheating under a CTBT? I would submit that the likelihood of evasive low yield tests, it would seem to me, would be less, I would not say zero, but less, under a CTBT than under a moratorium as we would have a more complete verification system in place and the costs if you are caught politically are much higher. So that would be my answer to that question.

Secondly, with respect to a material breach where a country, let's say Russia, does three tests. Is there an option to suspend rather than withdraw in response to a material breach such as that? I hope Jim will forgive me if I say before I give a complete answer to that, I would like to look at a couple of books, but my understanding is under international law, when a material breach takes place, the aggrieved party, which would be all of the CTBT parties, have the option to suspend for themselves against the violating party the Treaty in whole or in part as opposed to withdrawing from it, which they also have the option to do if there is a material breach. So I believe the option does exist and it can apply to part of the Treaty, the part that has been violated, which in this case would be the central part of course, or suspend the Treaty in its entirety until something is worked out. That, I believe is an option.

Dr. Chyba: Ambassador Bunn, and then Dr. Sykes has a comment, and then we will move on.

Ambassador Bunn: I just wanted to add a footnote to what Tom talked with respect to material breach of the CTBT. Under the accepted riles of international law as enunciated by the prestigious American Law Institute in the Third Restatement of the Foreign Relations Law of the United States, a party "specifically affected" by a "material breach" of the CTBT, such as three Russian tests, can invoke that breach as grounds for "suspending the operation" of the CTBT "in whole or in part in the relations between itself and the defaulting state."

Dr. Lynn Sykes: I have a question for Dr. Drell related to his comment about increasing performance margin. Richard Garwin has said that we should resist making improvements in the nuclear explosive itself. Would [Dr. Drell] disagree?

Dr. Drell: Absolutely not. He was part of our study. In fact, when you talk about resisting changes that includes not changing the amount of plutonium, which I feel is very important, or the kind of high explosive, or the geometry. What you can do is enhance the boost gas system by making it richer by increasing the relative amount of tritium to deuterium. That is the kind of thing that has nothing to do with the dynamics of what is going on.

Dr. Chyba: Thank you. I will take the Chair's prerogative to ask one more question, which is going to be directed at General Shalikashvili. Is that a number of the discussants have talked about the extent to which we are better off with respect to verification if the choice is between the CTBT or a regime in which we simply agreed not to test, without the formal treaty. And while it may be the case that candidates for the presidency have indicated that they would continue not to test, I wonder whether if in the Senate that's the way the issue is seen, or whether the issue isn't seen as a choice between a CTBT and no testing or a return to a testing regime. I would be interested in your comments on that.

General Shalikashvili: There are different views in the Senate. Generally however it is agreed that you are probably marginally better off with the Treaty than without it, but that is not enough of a persuasive argument for those who are already predisposed not to support the Treaty. Let me give you specific examples. On the issue of verification, it is generally and grudgingly admitted by those who voted against it that you have a slight improvement when you add the international monitoring system to the national means, but they doubt that is as significant as some of the papers this morning imply. There's also a grudging acceptance that there is a marginally greater chance that people would not cheat if they are members of an existing treaty than if they are not members of an existing treaty. But again they say if a nation has made the decision that it must conduct low level testing in order to gain some advantage, whatever that advantage is, that a treaty in itself would not deter them. They would take the risk of getting caught. So I think it's an argument we need to continue making, but so far, I have not found a persuasive argument where someone said, "now I understand, now it's easier for me to support it."

I will make one other comment, which is only tangentially to this point, but it is important to understand. Such arguments, had they been made sufficiently before the first vote in October would have carried much more weight than they will now with people already on the record, in one way or the other. I believe that the onus on all of us who support this treaty now is to be able to demonstrate that during this period between October and whenever this next vote occurs, we have done something, not to the Treaty, but external to the Treaty, to make it materially stronger for the United States, more advantageous to the United States to be a member of this Treaty, so that someone who voted against it can look himself in the mirror and say I am glad I voted against it because as a result now the United States is better off. And I would guard against smoke and mirrors or believing that if we just say it in a different way, it will sway people. We really need to show what I call a material change, to persuade enough people to support the Treaty.

Dr. Chyba: Thank you. We will move on, conscious of the fact that some of the discussants will not be with us after lunch, I'll make sure that those of whom I know need to leave will have a chance to speak before we break for lunch. So we'll deviate from the alphabetical order as needed. If there are others of you whom I haven't heard from who need to leave at lunch, please make sure I that know about it so that you have your chance to make your remarks on the record before we break. The next speaker is Dr. Roger Hagengruber from the Sandia National Laboratories.

Dr. Roger Hagengruber: Thank you. I would like to start by saying that Sandia's President, Paul Robinson, provided comprehensive testimony on CTBT to the Congress this year. His testimony was too lengthy to summarize today. And, while I am not here representing Paul, I want to associate myself with all of his remarks because I share his views. But, I will never be able to get into as much detail in my remarks. I'll try, then, to add to those views by looking at the CTBT topic perhaps somewhat differently. I'll try to end with some suggestions about how we might proceed with the current proposed Treaty in terms of things that we could consider.

I came to Sandia almost 30 years ago to work in the arms control area. I spent most of my career associated with intelligence work at the Lab, and had the privilege from late in the Bush administration through last year of being responsible for the nuclear weapons program at Sandia. So I suppose one would argue that I'm thoroughly experienced. I might argue that this experience probably makes it easy to be confused in the complexity of issues like the CTBT.

As a young staff member at Sandia I remember working on test ban language that we were asked to comment on. So I was making a comment that I thought a CTBT made a lot of sense to one of my colleagues (in fact, my boss who is currently in the CTBTO). We had a debate as he raised the complex issues involved. My career has since involved many debates around a collection of complex issues such as those that have been raised here. Issues such as monitoring, which I spent much time on – the question of what the Russians can do and what other people have done – and the issue of holding yourself accountable for a creative and thoughtful stewardship of nuclear weapons. (The term stewardship here is not science-based stewardship but rather that which includes the possibility that a deterrent may have to evolve in time in order to make it possible to have a smaller deterrent.)

Now, I would have preferred a policy to keep a long-term goal of a CTBT, but one that emphasized working on reducing the importance of nuclear weapons to a point where we might retain the same inherent deterrent value we experienced for the past 50 years, but with a very small stockpile. Now that's a very pragmatic view, by the way. It's not idealistic. But, had it been my choice, I would have proposed a movement from the 150-kiloton threshold, perhaps, to 1.5 kiloton. And that's because there would be much less controversy around the question of decoupling, decoupling factors, etc. And we clearly knew, through the work of the JASONs and others, that at that level or in that vicinity there's plenty that you can do to sustain the stockpile. And, if there were an evolution towards a much smaller stockpile that included high accuracy weapons, some testing would be valuable. (That's been completely discounted here. But if you look at it, the effectiveness equation is enormously sensitive to precision of delivery and the target sets are no longer cities. We're talking about chemical, biological facilities or other issues that may arise where highly accurate small weapons might be the best deterrent.)

Without advertising or advocating new weapons, the idea that there are not new pathways that countries would find valuable in the evolution of nuclear weapons is questionable. In fact, we have open literature from the Russians (as authoritative as Mikhailov himself) talking about the value of mini-nukes.

Had my choice, I would have reduced the yield by a factor of a hundred with an agreement to limit the number of tests. The tests would also not be allowed to be associated with a larger yield weapon or significantly different types of weapons. There would be major transparency exchanges, including open discussion of intent and detection. Agreements would be scheduled for review and an eventual reduction to zero We would have a better match to the technical capabilities associated with verification, the available intelligence, recent experience with proliferation, the emerging bipartisan consensus, etc. But, we are not there. And our problems, in effect, arise in part with zero-yield, which is an unverifiable

stipulation. In fact, it's not even scientific in its nature. It is interesting that when we discuss our positions with the Russians in formal discussions, there is humor at the working level about the use of zero because of the difficulty of defining it.

Now, in a way I would've said that this problem that we're running into now is the collision of two faiths. One faith assumes that the CTBT is a good idea based in part on their belief that there is a symmetry of weapon design, technical approach, and program impact of restrictions between the United States and Russia. This assumption is highly questionable. This side of the issue would also lean in the direction that would require a high standard of evidence to believe that a violation occurred. The issue of whether monitoring occurs to detect non-compliance or to observe compliance is both subtle and important. Those who view a better world as depending on this country's proactive posture in arms control often have a different perspective on risk that those of the other faith. The clash of the two faiths happens powerfully over the interpretation of arms control monitoring data. The question becomes whether the monitoring is to prove a violation or to prove compliance. A graphic illustration of this difference occurred during the Reagan Administration when compliance questions were always, "the glass half-empty" versus "glass half-full."

But that situation has changed. It was an aberration of the Soviet Union that continued to make agreements possible, automatically balancing risk takers with skeptics. We also know that the details of monitoring are problematic. An ACDA Assistant Director for Verification once warned against stipulation of detailed and numerous engineering units in treaties because they become, in fact, a cancer on the Treaty. An example was the 15% on the diameter restriction for missiles (in the SALT agreements) that was not really observable and that caused such a strong debate over Russian compliance. In our nuclear stewardship program, we will be tightly bound by the strict interpretation of a technical specification (such as zero yield), yet we have no real means to monitor or verify symmetric behavior by the Russians.

The other side of the CTBT issue (i.e. the other faith) involves questioning every one of the assumptions about symmetry of objectives and impact, as well as other assumptions about the world in general. This is the divergence of views that we heard about so elegantly from General Shalikashvili. The current congressional environment is relatively unique in a historical sense. Interestingly, this is the first time when an agreement like this has come into an environment in which it has to be effectively passed rather than opposed. It's really striking to see the standards of evidence shifting in this way. And the debate reflects this.

As always, an agreement on nuclear testing will happen only when the two faiths or models of the world can be bridged. At this point, that has not occurred. Either you will redo this treaty (e.g. fix the zero yield, modify the period before you come into compliance or the role of reviews, and so on), reconcile yourself to a stalemate, or hope that some safeguards can bridge the gap of faiths. The current set of safeguards actually was a pretty good reflection of an effort to try and do that, but it appears not to be enough. So in the end, you have two approaches.

As Senator Exon pointed out, in the (Senator) Hatfield period (moratorium), which occurred about the time I took over the weapons program, there was a bipartisan lack of enthusiasm for testing. There was also a lack of ability on the part of Defense and Energy to find any convergence on what kind of tests they wanted to do. There isn't much enthusiasm for testing today either.

So in the end, it's probably the safeguards that need to bridge the gap. I would only appeal to people to accept the importance of safeguards and make a commitment to them with the same degree of diligence and faith with which they accept the value and importance of the Treaty. That has not been done. People appear who have a commitment in faith to the Treaty and have been unwilling to accept, on faith, the true importance of strong safeguards. It is an intellectual hypocrisy that has not helped the CTBT.

I'll finish by saying there is a set of existing safeguards. My sense of their status is as follows. The stewardship program was consistently "light in the pot" by about 150 million dollars and no one thought that was critical. Yet, it was. The cultures of the laboratories and program were encouraged to be

constantly creative for 40 or 50 years. They regularly found new things to do, to invent, to prove, and now to fix. It was expected. It generally meant more money each year not less. Charging them to do without testing and development was certain to raise some new needs hence costs. Expecting them to find clever ways to get cheaper or less inventive was almost without precedence. Doing all of this at the same time that the budget was going down was something that was highly questionable. We see the stresses of these conflicting forces today.

The second safeguard was about maintaining strong labs. However, the real safeguard must deal with the Complex as a whole. It is in dismal shape. It's 10 billion dollars away from being a complex that would sustain a small and modern stockpile, just because of the age of the buildings, the amount of clean-up that needs to be done, etc. The laboratories are in the best shape and the plants are the most stressed. The resources needed for a modern complex are not in the budget; hence the safeguard is not there. So whether the Treaty passes or doesn't pass, the fact is that maintaining modern capabilities and facilities is a lot more challenging than simply writing it down on a safeguard and then forgetting it in the budget.

Now, the business about being ready to test – we know from our experience with the safeguards for the atmospheric test ban (LTBT) that safeguards last or are funded only for a very short period of time. For example, today, the time needed to return to testing is adjusted to be longer almost every year. The safeguard says we must stay ready, but "ready" gets redefined every year to match the lack of budget priority for test readiness. Safeguards seem essential to agreeing on a treaty, but are easily forgotten once the deal is made. Our historical record here brings little confidence and our recent history with stewardship does nothing to change that.

Monitoring R&D has increased somewhat, but it is nothing like the proposed plan that was put together by DOD and DOE in terms of what was expected to be invested. And yet, among the safeguards, it is probably the one that has been most supported.

Now, I'll finish by saying that there has been no discernable change in nuclear intelligence capabilities from the deficient state that they are currently in. In the Post Cold War period when there are 150 countries and issues are biological and chemical, not just nuclear, the resource base is stressed deeply. Nuclear intelligence capabilities have largely been considered to be adequate, but this is in an environment when they have been discounted in terms of importance. Yet the CTBT and the safeguards raise to a much higher level the need for good nuclear intelligence. And there's hardly even a scintilla of evidence of any real meaningful investment or thoughtfulness around that issue. We suffer right now about the question of what the Russians can or can't do under a CTBT. We often ask what Pakistan or Israel or someone else has done or might do. We take positions on the CTBT or make statements based on some assumptions about evolutionary pathways that really aren't supported by the intelligence data. Yet, this safeguard is largely ignored.

There are some things that need to happen if we are to get on with the CTBT if that is the choice made by Congress. Full, meaningful, and continuing support of safeguards must happen.
We need to have increased cooperative monitoring with the Russians. We will have to have regular onsite transparency and we'll have to have instrumentation onsite. At the least, we must get down into the few hundred pound range of yields in the monitoring capability at their test site.
We may have to put some instrumentation on their test vessels (and they on ours) to assure that certain classes of neutrons, for instance DT neutrons, are not emitted in the tests.
There are also other things that could be done to increase the openness and reduce the risk significantly. I do agree with a number of the technical talks presented here that there are also valuable things to be done to improve our ability to monitor worldwide. They are simply not enough.

One could look at some additional involvement of Congress on certification of the stockpile or adjusting of the timing of coming-into-force and review of the Treaty and so on as a potential help.

The last thing I want to say is that we need more time for NNSA, science based stockpile stewardship, and diplomacy to work. I think pressing them too early to see if they will be successful just feeds right into the middle of the conflict.

So if we are in fact required to move forward with the CTBT there are some things that can be done. Whether they are sufficient or not, I don't know. But I think they are clearly necessary. Thank you.

Dr. Chyba: If there is one short reply or comment, we will take it. Otherwise, we will move on.

Dr. Sands: It does seem that at least there is one grave concern, and this goes back to Senator Exon's earlier comment about what is really at risk here. It is not whether this is a slippery slope to the elimination of nuclear weapons, but really whether U.S. superiority in the capabilities that we have can be maintained. So I am very curious, and this does not need to be answered now, but I think it would be useful to understand what types of new advances in designs or military capabilities occur when you can do testing at below five or ten tons? Because that is what seems to be the concern with the Russians and I suspect with the Chinese – that they can create a new threat to the United States. I am just curious as to how advances resulting from testing below ten tons would affect us?

Dr. Hagengruber: That question has never been really put to the designers – by saying, if you had that capability, and you could do anything you want to do, and you had spent months thinking about it, what you can you do? In the U.S., that question has never been put to them. I don't want to. I don't believe we should ever trade our stockpile for the Russian stockpile or our capabilities for theirs. So let me just start by saying that.

I think that my comment would be that there are things of military significance that can be done at lower yields. In places where, in fact, (I would just argue and I suspect that Sid and others here would argue the same) some of these things don't require going nuclear in order to develop things.
I would only – since it may be something we can come back to later and we can't talk about it too much at the unclassified level – say to you that the things to take into consideration are the fact that our stockpile was designed around a series of stipulations. One of them was that nuclear materials were rare and precious – and that we needed to build thousands of weapons so they had to be very sparing of nuclear materials – that the accuracy's of the systems were evolutionary. At the time that we moved to missiles, the classes of accuracies were kilometer-class accuracies.

The target assumptions in the early days were area targets, and the damage expectancy was often people and softer targets. A lot of that changes as you put the modern equation together, but without saying that I believe that the United States will be in serious jeopardy in term of national security by these types of developments. That's not the question posed alone in a CTBT. It's whether or not it does effectively stop proliferation, both horizontal and vertical. Whether it allows asymmetries of pathways and capabilities on both sides. I only raise the question of whether those were correct. Whether they are meaningful or not is a question that goes back to the issues of faith and what your perception is.

Dr. Chyba: Thank you.

Dr. Sands: There has just never been symmetry of development. This probably gets into a longer discussion, but I am concerned about some assumptions underlying the technical discussions that get generated.

Dr. Hagengruber: Again, I have the unfortunate sense that I am reporting something as opposed to advocating something. I am raising an issue not supporting it. Again, it's one of the questions associated with whether the Treaty has to be passed. These kinds of questions come up where the standard has to be to ask the question whether these can occur because the Treaty exists or whether they can't occur. And whether under the Treaty, things can happen? Whether they are militarily significant or not? Again, it depends on the perception of people. Whether a persistent ability to cheat or an ability to have a component of development that's not symmetrically received – whether these are significant or not?

I don't have a strong view. I have problems on both sides of that issue, so I don't have a strong personal view. But I think these are the types of issues that have to be dealt with if you are going to get a consensus or a majority of people to support the Treaty.

Dr. Chyba: I think we need to proceed. Dr. Raymond Jeanloz of the University of California.

Dr. Raymond Jeanloz: Concern about the future state of the United States' nuclear deterrent is one of the central issues that has been raised in the national debates on the Comprehensive Test Ban Treaty. Is the Department of Energy's Stockpile Stewardship Program (SSP) up to the task of ensuring a safe and reliable stockpile of nuclear weapons? What are the chances that loss of confidence in the current stockpile or that evolving military requirements will force the development of new designs, which would then call for nuclear-explosion testing?

These questions are answered by evaluating the processes – both those being implemented and those already in place – that are designed to monitor the stockpile. If the processes are up to the task, they will provide sufficient forewarning of any deleterious changes in the weapons, such that appropriate corrective steps can be taken either through repair or remanufacture of the necessary components.

Others are furnishing a broad overview of the Stockpile Stewardship Program. Suffice to say that it is now coming into focus, with priorities being set (and already being adjusted upon further analysis). It is an expansion of the surveillance and experimental activities that have been in place for several decades, but now extended to account for the fact that no new designs of nuclear weapons are being created and therefore no nuclear-explosion tests are being contemplated.

To complement the broad overview, the goal of this presentation is to describe an example of the SSP in some depth. This example illustrates the potential for detailed scientific analyses to track the health of a key element in the stockpile, and therefore its reliability into the future.

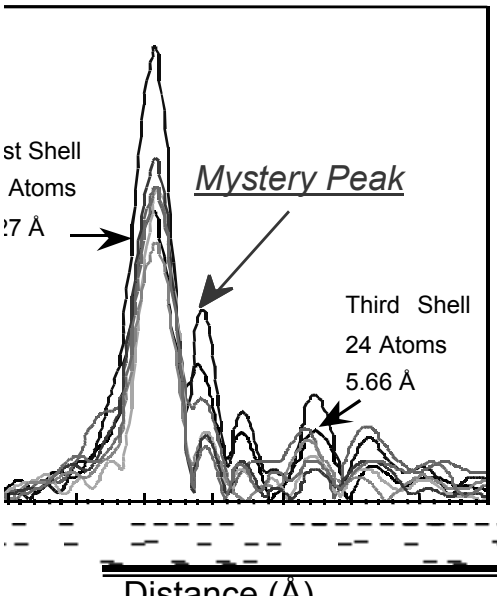
Plutonium, one of the crucial materials within the primary stage of a nuclear weapon, is notoriously complex: its properties are highly variable, both intrinsically and as a result of self-irradiation damage. Most of its known forms are not stable at ambient conditions, they are metastable. Metastability does not necessarily mean that a material will fall apart, however. It is a matter of timing: diamond is well known to last effectively "forever" (millions of years) even though it is metastable relative to the graphite form of carbon.

One Unit

-Plutonium

sity of Atoms vs Distance

Ga Alloys vs. Composition & Age



The structure of the relevant form of plutonium is face-centered cubic (Fig. 1). That is, the packing of atoms within the crystalline structure can be thought of in terms of a unit described by one atom placed at each corner of a cube plus one atom placed in the center of each face of the same cube. The edges of the cube are just under 4 Å (~16 billionths of an inch) long, such that each "unit cell" is repeated millions of times in all three dimensions, even for a tiny speck of material.

Figure 1. Packing of atoms in the crystalline "delta" form of plutonium, schematically shown for one unit cell (*top*), is characterized by 12 nearest neighbors (e.g., the central atom in front is surrounded by 4 atoms behind, 4 around, and 4 – not shown – in the next cell front), 6 next-nearest neighbors, and so on. The experimentally measured density of neighboring atoms as a function of distance (*bottom*), determined for several plutonium samples containing less than 1-2% gallium, shows the expected peaks from nearest (first shell, at 3.27 Å), next nearest (at ~4.5 Å; not marked) and further neighbors (e.g., third shell at 5.66 Å), but also an unexpected peak at ~3.8 Å. Data of S. Conradson (Los Alamos National Laboratory), obtained at the Stanford Synchrotron Radiation Laboratory.

One can go well beyond the artist's depiction, however, as there are methods available for directly measuring the positions of atoms with respect to each other inside a crystal. Measurements obtained by x-ray spectroscopy, for example, resolve the density of neighboring atoms as a function of distance. Such experiments clearly reveal the succession of peaks expected for the face-centered cubic structure of plutonium, yet also show the presence of an unexpected "mystery" peak due to the occurrence of atoms in additional locations (Fig. 1). These extra locations represent local patches of disorder, a deviation from perfect crystalline packing of the atoms, presumably due to the fact that the delta phase of Pu is not entirely stable at ambient conditions.

A natural concern is that these defective regions might grow with time, destabilizing the delta phase and causing major changes in the properties of the Pu "pit" within the primary stage of the weapons. It is further known that self-irradiation associated with radioactive decay of the plutonium, causes nearly 1 percent of the atoms in a sample to be displaced each month or two (each decay of a Pu atom violently releases a light helium as well as a heavy uranium nucleus, with the latter causing

extensive rearrangement of the neighboring crystalline structure). Could self-irradiation help trigger the destabilization of delta-phase Pu?

Theory is unable to answer this question at the present time, so the only option is to examine experimental results. In fact, some of the measurements in Fig. 1 correspond to new samples, whereas others are from samples that have been aging for many years. In order to home in on the specific effect of aging, Figure 2 shows how the anomalous extra peak – and therefore the related disordering inherent in delta-plutonium – evolves with time. Rather than becoming more disordered, it is evident that both samples exhibit a more nearly ideal atomic packing upon aging. Rearrangements of atoms associated with self-irradiation apparently serve to "heal" the crystal structure, such that it becomes less defective with time over the course of these studies.

Independent measurements obtained with other methods reinforce this finding. For example, high-resolution observations by transmission electron microscopy show a lack of defects accumulating in aged versus new samples, and precise electrical-resistivity measurements likewise reveal that the plutonium is not deteriorating with age (work of J. Kass and colleagues at Lawrence Livermore National Laboratory).

One would not want to conclude that delta-Pu is actually improving with age. However, for the way that it is packaged in U. S. weapons, it is evident that the plutonium is not showing the deterioration that had been expected as a potential problem, at least not over time periods of several decades. Because of the remarkable ability now available for precisely tracking changes at the atomic scale, across relatively large (macroscopic) samples, there is reason for confidence that any hints of deterioration can be observed well before they become problematic.

In addition to the metal, there has been concern that the high explosive (HE) which surrounds the plutonium may become less effective with time. Numerous measurements demonstrate that there are measurable changes in various properties of HE, first over month-long periods and ultimately (more slowly) over years. So far, none of these changes represents deterioration, however. In fact, key properties that determine the performance of the HE show improvements with aging. Therefore, as with the case of Pu, legitimate concerns about possible problems that might accumulate with age have been shown to be insignificant – for the time being.

It is on the basis of detailed studies such as these that a consensus has emerged about the effective lifetime of "pits" within the U. S. stockpile: they are no doubt stable for periods of a half-century or perhaps longer. It should be acknowledged that the detailed studies described here have required considerable effort, involving collaborative measurements among researchers at several DOE Facilities, Los Alamos National Laboratory, Lawrence Livermore National Laboratory, Sandia National Laboratory and the Stanford Synchrotron Radiation Laboratory (SSRL).

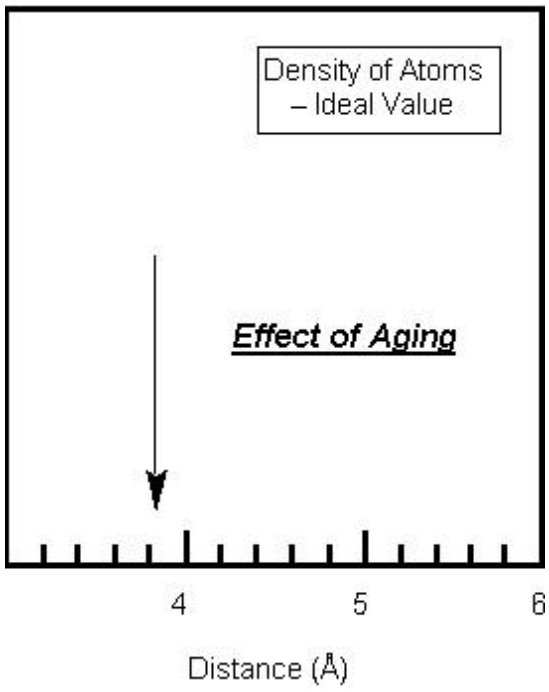


Figure 2. Four density distributions from Fig. 1 are shown after subtracting the distribution expected for the ideal crystal structure: solid and dashed curves represent new and aged samples, respectively. Results are given for two different concentrations of Ga within Pu. Plotted this way, the "Mystery Peak" of Fig. 1 stands out at a distance of 3.8 Å, and can be interpreted in terms of small patches within the sample of body-centered cubic arrangements of Pu (upper inset); it clearly decreases in height with aging (arrow). Curves for the ideal crystal structure (inset at right) should lie along the bottom horizontal axis, as is approximately found for aged samples.

There have been many speculations about the possibility that new military requirements may emerge for the nuclear weapons stockpile in the future. It is impossible to know if changes in international relations may require the development of new designs of nuclear weapons. This is why the CTBT explicitly allows the maintaining of a capability to design new weapons. However, it is possible to assess the likely trends in military requirements, for the future that is currently foreseeable.

The simple fact is that the current military requirements for the U. S. nuclear arsenal emerged from the Cold War period. Key scenarios that were then deemed as possibilities, perhaps under extreme conditions, are now considered far less plausible. In particular, the detailed requirements associated with "hostile environments" likely need to be revisited. This issue is relevant to the U. S. stockpile because it sets standards for weapons performance that are highly demanding in specific ways that may no longer be realistic, let alone optimal, for the current state of affairs (e.g., size and distribution of enduring arsenals).

Detailed technical analysis is required to fully evaluate this topic, but there is an emerging sense that past military requirements may need to be updated in a way that effectively enhances the performance margins of the existing stockpile. There is no intention to lower the standards to which the U. S. stockpile is held. Nevertheless, by focusing on the existing and foreseeable threats, rather than on threat scenarios that are no longer relevant, it is possible to further enhance the Nation's confidence in the safety, effectiveness and reliability of its nuclear deterrent.

Dr. Chyba: Thank you Raymond. We can take one short question or comment on this talk. If there is none, then I suggest that we jump ahead in the order and ask former Secretary of Defense William Perry to make his remarks.

Dr. William Perry: Thank you very much Chris. I want to go back to about 1995 to review the debate that occurred when the Department of Defense was asked to support the Comprehensive Test Ban Treaty, because I think that is instructive to today's debate. At the time, I was persuaded that there were important benefits for our ongoing security relations with China and Russia, a point which was made quite eloquently by Tom Graham this morning, and to our nonproliferation goals, a point which was made very clearly by George Bunn, and therefore concluded that I should support this if three objectives could be achieved. Let me list these for you because they were very explicit in our consideration at that time. First, that we could sustain for the foreseeable future high confidence in the deterrence force. Nobody at that time, or for that matter today, was willing to give up on the deterrent force. Therefore, we wanted to be able to sustain high confidence in it. Second, that we would be able to respond to unexpected changes, either in the reliability of the nuclear force or unexpected geopolitical changes. And third, that we have a reasonably high confidence that no significant breakout could occur without detection. Those were the three objectives we had.

I was concerned, and the joint chiefs of staff were concerned, about whether those objectives could be achieved particularly with a Comprehensive Test Ban Treaty which did not allow low yield testing, and that was the nature of the debate that was going on at that time. I would have to say that both General Shali and I were apprehensive about recommending to the President to sign this treaty until we could get these questions answered to our confidence. To say how those concerns were allayed, I will go back in history.

What were the four significant inputs that allowed us to have these concerns allayed if we were to recommend to the President to go ahead? The first of those was a scientific judgment that was given to us in a definitive briefing by Sid Drell and Bob Peurifoy. I am getting to the lab's view in a minute, but the first point was the JASON input from Sid Drell that the science-based Stockpile Stewardship Program could maintain confidence in the reliability of the system. That point has actually been strengthened I believe in the years since then and I thought the discussion on that this morning was very instructive in that point. The second point to come out of the JASONs study was that this stewardship program could sustain the high quality of the technical staff that could respond to unexpected challenges, and again that point is addressed today with some confidence.

The next factor that was influential in our judgment was the technical and managerial judgment expressed by Bob Peurifoy and the other lab directors. They not only made the same points about the stewardship program, but also argued that the enhanced surveillance of the Treaty would give us good confidence in being able to detect break outs. I though that point was discussed quite thoroughly today by Dr. Sands and Dr. Richards, and we have even a better feeling for that today than we did in 1995.

The fourth point that was quite important in our judgment and was made quite convincingly by the lab directors at this time was that low yield tests did not add significantly to our confidence. And I must say that this judgment was definitive in causing myself and General Shali to back off the view that we should hold out for low yield tests. And everything that we have learned since then and the points made this morning have reinforced that point.

Well those were the judgments that swung us around, and before we made our final recommendation to the President we asked for one more factor, which I still think is an important factor here. We were concerned about this point of whether the politics would allow our withdrawal from the Treaty – Sid mentioned that point again this morning – and we thought that in order to provide the right environment for that decision, if it ever had to be made, that we should ask for a requirement that the lab directors make an annual report certifying the stockpile. There has not been much discussion of that, but I thought then and I still think that is a very important factor. I do not believe that any president in the face of a failure to certify would shrink from his obligation to take whatever action was required, including either suspending or withdrawing from the Treaty. I think it's a very different circumstance than the ABM Treaty. So this was a very significant part of our judgment that we should go ahead and recommend it to the President.

Well, we did make that recommendation, believing that if we did not, the ratification of that treaty would be doomed. There would be no chance of getting it through the Senate if the Secretary of Defense and the Chairmen of the Joint Chiefs of Staff would not support it. What we did not understand then is that even with the enthusiastic support of Defense Department, the ratification would in fact fail. That is of course where we are today. The Senate vote in my judgment was a catastrophe, and the big question now is can it be turned around next year. We have had some discussion on that. I was particularly impressed with Senator Exon's points on that subject. Turning around the Senate vote is going to be a critical judgment for all of the reasons we've talked about today. Shali, I wish you well in the task you have ahead. You are doing the work of the Lord.

Dr. Chyba: Thank you Secretary Perry. I would like to ask Ambassador Stephen Ledogar to please make his remarks.

Ambassador Stephen Ledogar: Thank you. A number of informed or articulate people who argued against Senate consent to ratification of the CTBT – the serious people that Shali talked about earlier – claimed that if only the U.S. had clung to its original positions in the negotiations, the resulting Treaty text might have been acceptable to them. While the CTBT incorporates a number of provisions that the U.S. strongly advocated including for onsite inspections, the use of national technical means for verification, and no exemption for so-called peaceful nuclear explosions, it's also true that in the course of the two and a half year CTBT negotiations, original U.S. positions on several issues were revised in the give-and-take of negotiation dynamics.

Some Republican senators and the experts that advised them have focused on three issues where the U.S. negotiating position changed.

1. the yield threshold of banned nuclear explosions;
2. the duration of the Treaty; and
3. the trigger mechanism for challenge inspections.

Specifically we moved from our call for a nuclear yield limit of no more than four pounds of TNT equivalent down to "zero yield", or no threshold whatever. We dropped our original duration proposal from ten years followed by automatic renewal unless parties opted out, and joined the consensus of all other participants for a treaty of unlimited duration. And we shifted our onsite inspection trigger approach from a request being acted upon unless the majority of the Treaty's 51 members Executive Council opposed it to a request being acted on if 30 of the 51 approved it.

Several treaty opponents have suggested that the United States should call for renegotiation of the text that the Senate considered last October, with a view towards regaining the original U.S. preferences in these matters. (To my knowledge no other state party candidate is calling for renegotiation of the existing text, which has been signed now by over 150 states and ratified by over 50.)

Indeed all official allied and other friendly reactions to the October 1999 Senate rejection of the Treaty have, as I've seen them, revealed exasperation, a sense of betrayal, and in a few cases hints of vindictiveness. Some expressed hope against hope that the setback for CTBT is only temporary. Some have gone as far as to declare that U.S. leadership in disarmament and non proliferation endeavors is not to be trusted in disarmament forums such as the Conference on Disarmament and the recent NPT Review Conference, some friendly countries have even worked against and voted against U.S. positions in an arbitrary fashion. Of course the imbroglio over non-payment of U.S. UN dues has not helped.

Even if there were enough signatories who might be inclined to reopen the Treaty text, a number of procedural questions would present themselves:

1. Renegotiate with whom? Just the declared nuclear weapon states, or would you have P-5 plus India and Pakistan, both of whom have not signed. Add Israel? Others?

2. In what forum would you do it? Go back to the CD and renegotiate with some states that have not signed, but leave out some non-CD states that have already signed and ratified? Or would you create a new forum?
3. What would be the declared objective of renegotiation? To revisit and rewrite a few specific provisions, or to start all over again?
4. Would you have full participation and international reconsideration, or an ultimatum? Would the United States reengage in give-and-take negotiation, or would the U.S. only try to take back the positions we had previously agreed to or sacrifice in order to get things we had determined were more essential to our interests? What incentives, if any, would we offer to persuade others to reopen issues identified by U.S. Senate critics? Just the prospect of U.S. ratification with no possibility of gain for others?

No, I don't think it will work that way. Among the first things others would try to reopen would be the basic obligations of the Treaty as embodied in Article I. Their objective would be to expand prohibitions to include banning simulations, sub-critical experiments and so forth. China and a few others could be expected to again seek exemption from the scope of prohibition for so-called "peaceful nuclear explosions". Surely Pakistan, India, and a host of neutral non-aligned followers would try to eliminate references to evidence gathered by national tactical means being considered in evaluating an expressed compliance concern and a request for onsite inspection. Perhaps the surest counterclaim to a U.S. request for a renegotiation would be renewed attempts to write into the CTBT more immediate nuclear weapon states' commitments to begin international negotiations on nuclear disarmament within a time-bound framework.

Now, I can go into the substance about how we got to zero from four pounds, how we got away from the so-called ten-year easy out duration proposal to unlimited duration, and how we compromised on the onsite inspection trigger mechanism, but I don't have the time. The point I'd really like to close with is that as with any big international treaty negotiation, the result is replete with compromises. There are no thick layers of negotiating fat remaining, efforts to reopen just a few favorite issues with the hope of recouping negotiating capital already spent to purchase compromises are, in my view, unrealistic.

Now, am I prejudiced in saying this because I have a pride of authorship? No. Neither I nor my delegation have any responsibility as authors. We were but the points on the drafting pen for this text. Rather, I think that we have a certain realism, gained from first-hand experience, about the strong views of others. Does that mean there's no possibility for renegotiation? No it doesn't. What I'm trying to suggest is there's no realistic possibility for renegotiation internationally. But there's plenty of possibility for renegotiation within the United States between the Executive Branch and the Legislative Branch. And I will refer you to the statement of Melvin Laird, which is in your folders, and end there. Thank you.

Dr. Chyba: Thank you Ambassador Ledogar. We have a few minutes for questions. Please.

Senator Exon: Ambassador, since you've had so much experience in this area, I'd like to have you answer a question that I have. There are some people that are thoroughly dedicated in their opposition to this Treaty. I can understand that. I don't agree with them, but I can understand where they are coming from. But these people who are saying we should renegotiate the Treaty, I have no respect for them whatsoever because they don't seem to understand. Another way of putting that is that I am quite fearful that some people who are definitely against this treaty, but don't want to appear as dedicated opponents are merely using the idea of possible international renegotiation as a way to kill the Treaty. I take it from the remarks that you have just made that you feel that there is absolutely no sense whatsoever in a position that's being taken by some, that we can renegotiate this Treaty on an international level. I took it from your remarks that you said that would be impossible.

Ambassador Ledogar: Yes it would be highly unlikely; that's the point I wish to convey. If I may Senator, though, I wanted to raise earlier in connection with Dr. Duffy's statement a concern that I have about the difference between the period in which you were so important in 1992 when your legislation, which incidentally some people forget, called, with the force of law, for the United States to enter into a CTBT negotiation and to complete it by a date certain, and we made that date in September 1996 by a couple of weeks as you know. What Dr. Duffy said is that now there seems to be a loss of public sentiment against nuclear testing. I had a sense that in 1992 it was fairly strong, and now in a time with the moratorium, people have lost interest. They don't see it as an urgent requirement and I wonder to what extent that is a phenomenon that we collectively might have a chance to address this afternoon.

Dr. Chyba: Thank you Ambassador Ledogar and Senator Exon. We will have one more presentation before we break for lunch, and that will be given by Dr. Michael May, former Director of the Lawrence Livermore National Laboratory and Co-Director of the Center for International Security and Cooperation at Stanford.

Dr. Michael May: I will limit my comments mainly to the question of the reliability of the stockpile under a CTBT since that is the area where I have done some work and may have something new to add to the discussion. The other questions on which I will comment briefly is the continued US need for deterrence.

In 1996, I was asked by the Assistant Secretary of Energy for Defense Programs to assess what answers could be given to two questions:

1. What assurance could the Science-Based Stockpile Stewardship Program give that the stockpile would continue to be safe and reliable and what changes should be made in it to improve that assurance?
2. How would the responsible parties in Washington know when and if the program failed?

Those are difficult questions to answer with any degree of quantitative meaning. To respond to that charge, I formed a small group mainly composed of former nuclear weapons designers and we further broke the original questions down into more specific questions. Those questions, together with unclassified version of our answers, and some or our recommendations, will comprise what I have to say today.

Our general approach was to focus on what would be the effect on reliability and safety of two kinds of changes, those caused by normal deterioration of the weapons and the need to remanufacture them somewhat differently than they were manufactured originally, and those caused by changes in design stemming from changes in military requirements. Both types of changes were expected to and in fact have occurred.

The data to assess the effects of such changes come from the nuclear test history, other measurements, and calculations relevant to the present, so-called enduring stockpile. These data must then be evaluated in the light of having the new experimental and calculational tools slated to be provided by the program if funding holds up, but without tests. Obviously, our little group, even though ably assisted by laboratory personnel, could not do anything like a complete evaluation of these data and calculations in the time available, or probably at all. We did a preliminary evaluation and supplemented it with recommendations regarding what the laboratories should do in our view. Our goal was to point to an approach that would take advantage of the data and lead to some criteria that would help answer the original questions.

Key to assessing the effect of changes is an examination of unexplained differences between the relevant past test results on the one hand, and what was calculated before and after the tests, using the best tools available, on the other. That is, we focused on how actual results differed from what could be explained with calculations assisted by non-nuclear experiments, and what that implied for the ability to

predict the effects of both kinds of future changes. It is natural that such differences should exist. Calculations and non-nuclear test measurements do not permit the prediction of yields and other nuclear test results from first principles. Rather, together with the test results, they help set limits on empirical factors that are embodied in the predictions. In addition, small deviations from specifications inevitably occur. The differences between pre- and post-calculation results and actual test results provide a handle on how sensitive a particular design is to the inevitable uncertainties in the empirical factors as well as to the small deviations from specifications. As one would expect in the course of designing any complex piece of equipment, the predictions tend to be more reliable when they pertain to interpolations between test models, and less reliable when they do not. Also as one would expect, the predictions became more reliable with the years, but the margins within which the results had to lie for the weapons to work also became narrower. Our job then was to compare predictability of the effects of changes in the weapons to the margin those weapons' performance had to lie within.

With this background, here are some of the questions and answers we came up with. They are much abbreviated from the unclassified version of the original document. Actual numbers and weapons and test designations remain classified, but the general thrust of our conclusions was declassified. In what follows, by "reliable," I mean likely to give close to the expected result if detonated, and I will subsume safety under reliability.

1. How reliable are the weapons in the present stockpile? Our answer there is the same as everyone else's. The weapons are either tested or sufficiently close to tested versions that they are quite reliable according to all past test experience.
2. How reliable will the weapons be after any initial changes due either to deterioration and remanufacture under different conditions, or to purposeful changes in design? No general answer can be given in the absence of knowing what these changes are, obviously, but the changes that had occurred or were contemplated at the time we did this work did not seem to affect reliability significantly, though more detailed calculations and enhancing margins mentioned in the unclassified version of the JASON report quoted earlier, while useful, is not a cure-all. In particular, it would not have helped allay some of the potential concerns raised by the actual anticipated changes we looked at.
3. How reliable will they be as further changes are made down the road? This is what is harder to answer. The further one departs from the tested design, the more uncertainty there is in the outcome. We examined in a preliminary way how close to the edge the various designs in the stockpile are. They vary significantly from one to the other in this respect.
4. What difference will the new experimental and calculational tools to be provided by the program make? They should have two effects. They may help account for empirical factors and explain hitherto unexplained anomalies in test results, and they should help attract and retain competent scientists and engineers. This latter effect of course is crucial to any Stockpile Stewardship Program. The former effect, the explanatory power, is a two-edged sword. It could give designers of the future misplaced confidence in making changes, since empirical factors and anomalies are typically due to a number of unknowns so that any explanation would need to be checked with reality, especially if the changes contemplated take the design outside the range of tested parameters. Our group particularly feared basing changes on theories derived from apparently consistent non-nuclear experimental results and calculations, especially in the hands of people with no test experience.
5. How will we know if the stewardship program is failing? To deal particularly with that question, we supported a program designed to establish limits on permissible changes dubbed the rebaselining program. The program should involve both the best among the new scientists and such experienced scientists as remain, and should utilize the new experimental and calculational tools as they become available. Its goal would be to establish criteria limiting future changes using the best available experience. Should these criteria be violated

afterwards or should requests for deviations become frequent, that would constitute at least a warning signal that the stewardship program was becoming inadequate and testing might be needed.

On the basis of these conclusions, we recommend the following, again much abbreviated:

1. The rebaselining program should be carried through at high priority as soon as possible. In our view, it was better to do without some of the new capabilities that to do without the help of retiring and aging by experienced scientists. Even at high priority, we anticipated that at least five years would be needed to do the program. Given the other obligations of the laboratories, it is likely to take longer.
2. The top management priority, in addition to supporting and protecting the program noted above, should be to hire first-class scientists. The best guarantee of an effective program is good scientists. It would be better to have a cadre of first-class scientists available to help make key technical recommendations even if these scientists only worked on nuclear design part-time or occasionally, rather than to have less able scientists on a full-time basis, although the latter would be needed also.
3. While rebaselining was going on, changes should be made with extreme caution. The laboratories should be set up so that there is a minimum of pressure to accommodate new requirements. The dynamics of the system have historically gone the other way. After rebaselining is complete, and criteria for permissible changes established, changes should be made with even more caution, since test-experiences designers will no longer be around.

The test ban is a real impediment to weapons development, one that increases with time. It was designed to be such an impediment, and it should be treated as such. Our group fears that the time-honored dynamics of providing the military with the best weapons possible, together with the availability of improved non-test capabilities, would lead to less rather than more caution in making changes. The talk about the stewardship program and its computers "replacing" testing gave those of us who had designed weapons little comfort in this regard. In our view, the new capabilities are there to help understand better the consequences of inevitable changes, not to permit more drastic changes. This is a tough message to accept both for the labs and for the political establishment supporting them.

In conclusion, I am more worried about the internal effects of the CTBT on the US defense system than on it effects abroad. The system we have for providing ourselves with nuclear weapons was not set up for this situation and may be inadequate to deal with it. It may be argued that these weapons should never be used and from that argument, that it doesn't matter whether they work or not. There are at least two problems with that argument. In the first place, our wishing that they may never have to be used does not mean that we know they won't be. Certainly the effect of decreased reliability on deterrence, though marginal at first, are in the direction of decreasing it. Second, US foreign and security policy has generally been dynamic and expansionary, oriented to advancing our military assets and alliances, and often to internal change in the governance of other countries, including, but not limited to, potential strategic rivals. US defense policy puts the highest priority on improving already superior offensive strike capabilities. In carrying out this policy, crises may well occur and nuclear deterrence may well play a role. Not only our possible opponents, but our own government and people must at that time be fully confident that our deterrent is reliable if it is to be a force for stability.

Over the years, the need to certify the reliability of weapons which have been the subject of more and more changes, with the tests more and more distant in the past, and the new tools more and more expensive and needing justification, all this may eventually have a corrosive effect on laboratory leadership and scientific personnel. The best scientists may stay away from that situation. I don't know how future military leaders responsible for procuring new weapons systems will respond. Changes are still being called for. The history of procuring untested weapon systems is not conducive to optimism.

This culture must change. The stewardship program is just what the words imply, a program to maintain what exists, not a program to replace nuclear tests for the purpose of further weapons development. It could not do the latter now and it will be even less able to do it in the future.

Dr. Chyba: Thank you Michael May. We'll need to break for lunch now. We had originally scheduled 45 minutes for lunch, but I would like to suggest that we break for 15 minutes, gather our lunches in the other room. And bring the lunches here to the table, and we'll continue while we eat lunch in about 15 minutes time. Thank you.

Dr. Chyba: Please return to your seats. We are going to resume the on the record part of this Roundtable. I would think that we should be able to complete that in about an hour and move onto the off the record discussion. We'll begin with Doctor Wolfgang Panoksky from the Stanford Linear Accelerator.

Dr. Wolfgang Panofsky: I would like to make a few more general remarks. First, I am sure that this does not need reemphasis, that the United States has the greatest interest in promoting the nonproliferation of nuclear weapons. Our nation is by far the most powerful, measured in conventional military strength and in economic and political power. Nuclear weapons are the great equalizer among powerful and less powerful states just as firearms equalize combat strength between physically strong and weak individuals. The United States will lose the most if nuclear weapons spread.

Note, however, that achieving nonproliferation for military purposes of a new technology has never worked in past human history. It is essential to United States and world security that we make it work now, but we must admit that this has never succeeded in the past.

The linkage of a CTBT to the nuclear nonproliferation of weapons is both political and technical. It is perhaps not surprising that the political linkage in the minds of most may be motivation for supporting the CTBT or for opposing it. One reason for this is the major symbolism as Gloria has indicated, associated with nuclear explosions. Such explosions are the most energetic event which human kind has ever released. The control of such man made events symbolizes to some the question of whether technology controls man or whether man controls technology.

While fully recognizing the political and symbolic linkages, let me summarize here the technical bargain which bringing the CTBT into the force would accomplish. Other speakers have enumerated the political factors and the negotiating history extensively. We should not naively look only to what limit the CTBT might impose on our own military, but we should make a net assessment by comparing the military status of the world with or without the CTBT. Now, the United States currently has the world's most technically advanced stockpile of nuclear weapons, and I will not repeat here the arguments as to the extent and the value of the science-based Stockpile Stewardship Program in maintaining the safety and reliability of nuclear weapons.

According to the policy initiated by then President Bush in 19962, the U.S. need not and will not develop new types of nuclear weapons. In contrast, the nuclear arsenals of the other nuclear weapon states would require improvement if they were to aspire to match the performance attained by United States weapons. Non-nuclear weapon states can develop simple gun type and simple implosion weapons without nuclear tests, but two stage thermonuclear weapons require tests and the yield of so-called boosted weapons would be highly uncertain without testing.

Thus under a CTBT, the technical superiority of the U.S. stockpile will be preserved while at the same time non-nuclear weapons states are prevented from developing any but the most primitive nuclear devices. Thus the CTBT bargain preserves the strong technical advantage of the U.S.

However, one must agree that, speaking purely technically, the CTBT in itself does not avert proliferation of nuclear weapons. The nuclear weapon states can engage in proliferating nuclear weapons designs already in their arsenals and non-nuclear weapon states can develop primitive nuclear devices without testing.

But on balance, I conclude that enactment of the CTBT increases international security by significantly impeding nuclear proliferation and, at the same time, advancing U.S. national security by preserving the advanced technical nature of our nuclear weapon stockpile.

The reliability of nuclear weapon systems depends on the whole chain of delivery, starting from the human element to the delivery system – be it missile, aircraft or other device – and finally to the nuclear explosive.

Of these at this time, the nuclear explosive is by far the most reliable. The recent failure of a test of a national missile defense system interceptor indicated that even the most thoroughly tested technology such as the separation between rocket stages can fail if quality control is sufficiently bad. Finally, the human element, at any military undertaking, remains the weakest link.

Let me conclude with remarks about the standards of verification. Much has been said about whether the verification of the CTBT is adequate and whether failure of verification leads to significant military advantage to other countries. I think it is important to remind lawmakers that they are applying a completely different standard to compliance with international treaties as they do to domestic legislation. When you pass domestic legislation, you do not ask whether enforcement will be 100% or adequate. You ask the question whether the national interest is served better with or without the legislation in question, taking into account the limits of enforcement.

Similarly, the right question, which legislatures should ask, is whether the national security is served better with or without the enactment of a CTBT, taking into account the evasion possibilities. And by that standard, the CTBT entering into force would definitely serve our national security. Thank you.

Dr. Chyba: Thank you Dr Panofsky. Are there comments or questions? If there are none we will continue on. The next speaker will be Bob Peurifoy from Sandia National Laboratory (retired).

Mr. Bob Peurifoy: My name is Bob Peurifoy. I believe in maintaining a strong nuclear weapon system capability as a component of national security. I don't know a number of you and a number of you have never heard of me. Therefore, I offer you my qualifications to speak to the nuclear weapon program:

- A 39-year career at Sandia Labs from 1952-1991, all involved with weapons. My last tour (1983-1991) was as the Vice President responsible for such activities as stockpile surveillance, safety assessments, reliability assessments and hostile environment experiments at the Nevada Test Site – all for Sandia-designed products.
- My previous assignment was directing the Sandia Albuquerque weapon development organization from 1973 to 1982 – 9 years. Five of the nine warhead and bomb types now in the stockpile were designed by my organization.
- Since retirement I have been a member of the UC National Security Panel since 1992 and have participated in 16 meetings.
- I am an occasional consultant to the JASONs for studies of the nuclear weapon program – one such study is now underway.

In 1992 President Bush terminated production of nuclear weapons. This has been interpreted to mean "no new devices." That same year he announced a moratorium on yield testing of US nuclear devices. The first decision permitted the second decision.

It is not my intent to argue either for or against continued nuclear yield testing. It is my intent to argue that if, for whatever reason the government chooses to continue the "no new weapon production" decision, the nation can maintain a healthy nuclear weapon stockpile for several decades without yield testing.

My interactions with workers at the three design labs, most recently within the last several months continue to reinforce my assertion. Currently, 50 years seems to be the consensus estimate of probable lifetimes of the hardware. Some brave souls suggest maybe 100 years. At this time, I am

comfortable with 50, however I believe it to be very likely that ongoing, aggressive surveillance will extend my comfort zone. These expectations pertain to generic weapon types.

For the period 1952 to 1992 the United States conducted about 1000 nuclear yield tests. For device types in the enduring stockpile perhaps 100 or so nuclear yield tests were conducted. These nuclear yield tests were conducted for several reasons:

- Physics – one should always want more data but how much is adequate?
- Exploratory – these tests were used to determine feasibility.
- Development – these tests were used to confirm device performance during authorized development.
- Stockpile Confidence – these tests were requested by the Senate Armed Services Committee to confirm performance of weapons in the stockpile. For the period 1972 to 1992 17 such tests were conducted. There were a total of 360 tests.
- Designer final exams

The stockpile surveillance program has examined approximately 15,000 warheads and bombs since 1958. We started at a rate of 50 units of each weapon type every 6 months. We now draw 11 samples per weapon type each year.

Defects have been found. Most result from design or production errors. When found, corrective actions are taken. These corrective actions have not required yield testing of members of the enduring stockpile. Rehabilitation through remanufacturing to repair weapon defects is the outcome. This remanufacturing capability must be maintained (perhaps a 7^{th} safeguard).

Given a 50-year weapon life, routine replacement of complete warheads and bombs could be scheduled to start in the year 2020. Earlier individual part replacement may be required depending on surveillance findings. I expect this will be allowed for. The long-term maintenance of a creditable nuclear weapon based deterrent will depend on:

- National endorsement
- Focused, dedicated management
- Well educated, motivated staff
- An aggressive, broad based surveillance program
- Good facilities
- Adequate funding
- An ability to remanufacture

I assert that if no new devices are called for – nuclear yield testing is not essential to meet the challenge.

In the last paragraph of the first page of the Honorable Melvin R. Laird's statement, he states that "In light of the concerns of the Senate and among some in the scientific community, including the directors of the national nuclear laboratories, that safety and reliability of the U.S. nuclear arsenal cannot be assured with absolute certainty beyond nine years…". I have one observation and would like to raise one question: We are eight years into a nine-year problem without any corrective action underway – how can this be? And my question: when we refer to "safety and reliability", how does one define "safety"?

Please feel free to torment me.

Dr. Chyba: Thank you Mr. Peurifoy. He has invited us to torment him. I think we can do that for just one or two questions if there are any tormentors. Is there any who would care to respond to the two questions in particular that he asked us all?

Ambassador Graham: Secretary Laird wrote that letter from his office in Washington, but my understanding was that he drafted it originally last year in the wake of the Senate debate, and he was looking to the future. There was a lot of talk in the debate about the ten year out provision, and that is what he was thinking about. In order words, to create a Senate ten year out provision, and since a year had passed since then, he made it 9 years. That is were it came from.

Dr. Drell: Let me just answer Bob's second question; let me define safety. It has a specific definition in U.S. policy. First of all, as far as one-point safety requirements, in the event of a detonation initiated at any one point in the high explosive system, the probability of achieving a nuclear yield greater than 4 pounds TNT equivalent shall not exceed one in a million. That shall be inherent in the weapon. Four pounds has to do with an early calculation, about 32 years ago, of the limit on how many neutrons you would want to allow to get into the boiler room of a navy ship if there was a one-point detonation--

Mr. Peurifoy: And all of our devices meet that standard.

Dr. Drell: That was one of the things reviewed in the 1990 safety study that I mentioned. Then, there is the question of premature nuclear detonation of a warhead or a bomb due to malfunction of components in the absence of any input signal. For the normal operation or storage environment as described for the stockpile, the official requirement is that the probability of detonation is less than one part in a billion to release a yield of greater than four pounds, prior to receipt of an arming signal. In an abnormal environment, like lightening storms or something of that sort, the probability is less than one in a million. These criteria are met by our present stockpile. They have not been challenged for ten years until the hearings last October. And now among the types of questions one hears is, are you safe if two lightening bolts hit at the same time? New requirements have been brought into the discussion to raise a scare about whether we have to change our official safety requirements. With regard to our present safety requirement for meeting military needs, our stockpile is safe, period.

Dr. Chyba: Senator Exon will have the last word.

Senator Exon: I don't begin to understood all the technical things about safety, but a general question. Let's take a warhead today on a Trident submarine. Is there any difference in deterioration between a nuclear device, sitting in a Trident submarine and one sitting in a warehouse, or are both of them going to last 50 years?

Mr. Peurifoy: All evidence suggests no difference. They will last regardless of where they are kept.

Senator Exon: As long as they are handled --

Mr. Peurifoy: --with reasonable care. The military services have demonstrated superb attention to handling and caring for the weapons in their hands. I have great respect for that.

Senator Exon: Follow up question. Assume that a Trident submarine is rammed by a freighter, the chances of a nuclear explosion are nil under that scenario, is that right?

Dr. Drell: I think you would worry much more about the reactor or the fuel in the missile, but I would never say an absolute no.

Senator Exon: You would worry about the fuel not the warhead.

Mr. Peurifoy: That's right. I'd worry about the crew.

Dr. Chyba: Thank you. The next speaker will be Dr. Wayne Shotts from Lawrence Livermore laboratories.

Dr. Wayne Shotts: The CTBT sits in a broad national security context. The stated purpose of the Treaty is to ban nuclear testing and thereby slow nuclear proliferation. However, it also heightens issues of concern for U.S. national security related to stockpile stewardship, worldwide monitoring, and the status of other countries' nuclear weapon programs.

These issues were recognized during the negotiation of the CTBT and articulated, in August 1995, as the set of safeguards under which the U.S. would be willing to sign a CTBT. Safeguards A, B, C, and F address maintenance of the U.S. nuclear stockpile, Safeguard D addresses improved monitoring capabilities, and Safeguard E addresses the need to be knowledgeable about foreign nuclear programs.

Stockpile Stewardship

Ensuring the safety and reliability of nuclear weapons without nuclear testing is a technical challenge of unprecedented proportions. We are faced with the need to find a replacement for a testing program that, for fifty years, has proven to be the most technically efficacious and cost-effective means of developing and certifying nuclear weapons and of training the people responsible for ensuring the safety and reliability of the stockpile.

Much progress has been made in implementing science-based stockpile stewardship. The directors of the national security laboratories have been able to certify the U.S. nuclear stockpile as safe and reliable, without the need for nuclear testing, for the fourth consecutive year. However, the program is neither fully implemented nor proven. Annual shortfalls in planned budgets have been compounded by an unexpected increase in the number of stockpile surveillance findings that must be resolved and by a workload considerably greater than the program's original projection.

Of particular concern is the need to recruit and train the next generation of stockpile stewards before our experienced weapon scientists leave the program or retire. The work environment that has developed over the past year and a half has made it difficult not only to attract new scientists and engineers to the labs but also to retain experienced personnel. Long-term commitment to the Stockpile Stewardship Program – and to the people who are the heart of the program – is vital.

Monitoring and Verification

The ability to detect, locate, and identify nuclear explosions in any environment is a fundamental element of U.S. national monitoring capabilities. The technical objectives for monitoring a CTBT are specified in presidential decision directives. Major enhancements to existing U.S. national technical means must be made in order to meet these objectives. Despite the clearly defined need for these enhancements, funding for monitoring R&D has eroded over the past few years.

The International Monitoring System is being established per the CTBT Protocol. However, this extensive system of monitoring stations, together with its International Data Center, will not be fully operational until 2005 at the earliest. In addition, although the international system will augment U.S. national technical means, it is not designed to monitor at the thresholds specified in the U.S. presidential directives.

Even with the planned enhancements to U.S. national technical means and the international capabilities in place, strict zero-yield monitoring is not technically feasible. At some yield level, monitoring assets will not be able to detect, locate, and identify a nuclear explosion with high confidence. The significance of undetected tests will vary depending on the identity of the party conducting the test—weapon state, threshold state, or other country of concern.

Knowledge about Foreign Weapon Programs

National self-interest dictates whether or not countries attempt to acquire nuclear weapons, with different factors driving the national security policies of different countries. Therefore, CTBT or not, we

must be knowledgeable about the nuclear directions and actions of other states. For countries willing to settle for crude devices or to rely on sophisticated computer technology, nuclear tests may not even be necessary.

We cannot assume that the U.S. approach to stockpile stewardship under a CTBT will be the same approach adopted by weapon states. Likewise we cannot assume that other countries will practice similar restraint with regard to continued weapon development and evasive testing. These uncertainties lie at the heart of the safeguard calling for accurate and comprehensive information on worldwide nuclear arsenals, nuclear weapon development programs, and related nuclear programs.

Conclusion

The CTBT is but one element of a larger nonproliferation and national security strategy. The only nuclear-weapons-related activity it directly prohibits is nuclear testing. The Treaty has, at various times, been held up as a way to prevent the proliferation of nuclear weapons, as a means of freezing the development of nuclear weapons technology, and as a necessary step toward the elimination of all nuclear weapons. Even as the debate continues, the U.S. must tackle the nuclear proliferation problem on other fronts as well, including controls on the export of sensitive technology, information, and nuclear materials, while fully implementing and supporting the CTBT safeguards.

Independent of any treaty, the U.S. must continually assess the adequacy of its nuclear deterrent and its monitoring and intelligence capabilities. As the safeguards currently stand, only Safeguard F specifically requires periodic review and assessment. Given the recent pace of technological and geopolitical change, we must assume that there will be significant developments affecting U.S. national security over the next five to ten years. It would perhaps be prudent to consider strengthening Safeguards A through E to ensure that the nonproliferation benefits of the cessation of nuclear testing or the CTBT do not unacceptably jeopardize other critical aspects of national security.

Dr. Chyba: Turning now to Dr. Lynn Sykes from Columbia.

Dr. Lynn Sykes: Evasive nuclear testing was of prime concern during the Senate debate on the Comprehensive Test Ban Treaty (CTBT) last October. Concern about evasion centered on decoupling, i.e. explosions detonated in large cavities so as to reduce the sizes of seismic waves. Views on the possibilities of other countries conducting decoupled testing at yields of military significance without being caught vary as widely today as they have since 1959 when the concept was first proposed. In his memoirs James Killian, Eisenhower's first science advisor, called it a bizarre concept. In contrast, during the Senate debate Dr. Larry Turnbull of the CIA was quoted as saying "that construction of large cavities in both hard rock and salt is feasible…that containment of particulate and gaseous debris is feasible in both salt and hard rock."

Experience with decoupled nuclear testing is remarkably little given the 40-year debate on the subject. Two very small explosions by the U.S., one of 0.38 kiloton in salt in 1996 and another .02 kiloton in soft rock in 1985 – and one partially-decoupled explosion in salt by the Soviet Union of 8 to 10 kiloton in 1976. The latter was recorded at large distances and would be much better detected today.

An evader contemplating decoupled testing faces a verification gauntlet – constructing in secret a huge stable cavity at depth in the earth, disposing of its contents, insuring containment of radioactive products, making sure that either a crater or significant surface displacement is not generated, and avoiding detection by the International Monitoring System, many additional seismic stations and other U.S. verification assets. Given the multiple challenges, the scarcity of data on decoupling and not knowing the characteristics of all monitoring stations, a prudent evader necessarily would have to adopt conservative design procedures.

The American Geophysical Union and Seismological Society of America issued a joint public statement on CTBT verification on October 6, 1999. Their document, in preparation for a year, states that: "One of the biggest challenges to monitoring the CTBT is the possibility that testing could be

successfully hidden by conducting nuclear explosions in an evasive manner. The concern is partly based on U.S. and Russian experiments which have demonstrated that seismic signals can be muffled, or decoupled, for a nuclear explosion detonated in a large underground cavity. The decoupling scenario, however, as well as other evasion scenarios, demand extraordinary technical expertise and the likelihood of detection is high. AGU and SSA believe that such technical scenarios are credible only for nations with extensive practical testing experience and only for yields of at most a few kilotons. Furthermore, no nation could rely upon successfully concealing a program of nuclear testing, even at low yields." It also states the two societies "are confident that the combined worldwide monitoring resources will meet the verification goals of the CTBT."

I agree with their conclusions but examine further the geological materials that either are or are not suitable for decoupled testing at various yields. Our main concern about decoupling should address possible Russian testing in their relatively few, very thick deposits of salt. Many of the USSR's thick salt deposits now are located in new countries such as Kazakhstan. Salt is a geological medium of concern since large deep cavities have been constructed in it, mostly by solution mining. Some cavities created by nuclear explosions in salt have not collapsed for years.

From a monitoring viewpoint, however, earthquakes and chemical explosions rarely occur in salt deposits, making seismic events in them immediately suspect. Has Russia "stored up" cavities in salt created by past nuclear explosions that could be used for decoupled testing of significant yield? The answer is no. A well-coupled nuclear explosion of a given yield produces a cavity that is suitable only for a fully decoupled test of about 5% of its yield. Hence, we know the sites of all cavities that may remain standing in Russia from previous nuclear explosions in salt that could be used for decoupled tests of yield larger than 0.1 kiloton.

While large cavities in salt have been created by solution mining, none are known to have been used for decoupled nuclear tests. That method requires huge volumes of water, thus excluding their construction in dry regions like Iran. Brine or products stored in such cavities must be pumped out to permit their use for decoupled testing. Air-filled cavities in salt are not stable at depths greater than about 1000m. Hence, many deep salt deposits are not suitable for the construction of stable cavities. Well-coupled nuclear explosions of seismic magnitude 2.8 in salt in the Soviet Union have been detected, which corresponds to a fully decoupled explosion of about 2 kilotons. Monitoring decoupled testing of a few kilotons in Russian salt deposits is achievable.

Resolution of the feasibility of decoupled testing at militarily significant yields in hard rock is of prime importance since they, unlike salt, occur widely. No decoupled nuclear tests in hard rock are known. The few data using tons of chemical explosives indicate decoupling factors of 10 to 40, smaller than that of 70 for salt. Leith and Glover (1993) and Turnbull indicate that decoupled tests of 15 kiloton may be possible in large cavities in hard rock. Most of the large cavities listed by the former, however, are far too shallow for containment of the high-pressure radioactive gases produced by a decoupled explosion.

The volumes of the other cavities, which are all situated at depths shallower than 350 m, limit possibilities for full decoupling to yields less than about 1.5 kiloton. Also, the non-spherical shape of those cavities indicated that their shorter dimensions may be struck by shock waves of high enough amplitude to permit escape of radioactive products along cracks and joints that are present in hard rock on scales of 1 to 10 meters.

While Russia has much experience with testing in hard rock, about 75% of underground tests at Novaya Zemlya and 50% at the former test site in eastern Kazakhstan have leaked radioactive gases. Hence, a prudent evader would likely have to limit fully decoupled tests in hard rock to yields below one kiloton. Hence, we should concentrate on monitoring small Russian events in salt.

Dr. Chyba: Thank you Dr. Sykes.

Ambassador Graham: When you said something about the detonation in a salt cavity, was it with a 70 times attenuation? Did I hear that correctly?

Dr. Sykes: Yes, that is the information that we have from the .38-kiloton explosion in salt by the United States in 1966.

Ambassador Graham: Does that mean a reduction in coupled yield of 70 times?

Dr. Sykes: It's actually a reduction in the long-period of seismic amplitude. For most purposes, however, it is the reduction in the yield, but not quite.

Dr. Chyba: General Welch, you have the floor.

General Larry Welch: Thank you. Being last on the roster, I probably have little to add, but that is no deterrent. To put my comments in context, I spent a good part of my adult life working to maintain a nuclear deterrent with lots of help from Senator Exon. My personal net assessment is that the CTBT is good for the country and it is good for the world, which means when I add up the pluses and the minuses, it comes out to be a substantial plus. The reason I make that point is – I certainly agree with General Shali that more impassioned declarations of support are not likely to have very much influence on the opponents or on the skeptics. What is needed instead, if there is to be any hope of advancing the Treaty in the U.S. Senate, is to persuade some of the influential skeptics based on addressing the reasons for their skepticism.

So I believe strongly that we have to acknowledge the compromises that were necessary to get 44 nations to agree to a treaty. Most of all, I think we need to avoid inconsistencies.

So I want to talk about some perceived inconsistencies that are exploitable, and are in fact being exploited that require careful explanation. I will just list four that we have heard repeated today.

One is that testing will benefit established nuclear states to our detriment, but cheating at similar levels would not be militarily significant. There is a strong belief in spite of everything we have heard, that Russia and probably China can indeed get away with cheating at those similar levels.

The second inconsistency is that sub-kiloton tests cannot be useful to those aspiring to join the nuclear club, and yet we have distinguished U.S. weapons designers who argued very strongly that important information was available from sub-kiloton tests.

A third concern is that testing will permit new Russian warhead designs that could change the strategic balance with no suggestion as to what the characteristics of such a design might be, or how it might disadvantage the U.S. I think there are many others who believe strongly that neither Russia nor the U.S. need any new warhead designs to maintain a strategic deterrent. So that can seem to some to be simply an alarmist statement.

Last of all, I'll mention, we hear very confident statements that we will be able to detect sub-kiloton tests all over the globe and yet the official briefings that one gets at the U.S. monitoring centers use two numbers that have been contradicted by experts here today – one kiloton and 70 times. So that seems to be the official story. One kiloton is treated as the detection requirement. So all these declarations that that is not real of course are overwhelmed by the fact that that is the official story at the monitoring centers.

I suggest that the verification issue is the strategic consequence of cheating to the United States rather than the value to cheaters. If we look at the question of why Russia would risk cheating, the most plausible reason I can think of is because they think they need to do so to maintain confidence in their stockpile. While we would not like the method, Russians maintaining confidence in their stockpile is not of negative strategic consequence. It is in fact, probably stabilizing.

If we turn to China, why would China risk cheating? Probably for a similar reason. We would expect China would risk cheating to maintain confidence in what is perhaps a new design, which might

even be a design for a MIRVed warhead. Again, whether or not China has 50 percent confidence in a new warhead, or 95 percent confidence in a new warhead is of little strategic consequence to us. Regardless, we have to assume that the warheads will work.

When we come to the aspiring states, if we are concerned that the aspiring states can gain from the Treaty, we must certainly be even more concerned that they can gain if they do not have to cheat. So clearly they will find it most difficult to cheat at a significant level and they would gain the most if they didn't have to cheat.

If we focus on strategic consequences, we can bypass some of these inconsistencies that are difficult to explain but not nearly so important as they sometimes seem.

The central issue to me is not whether someone else, to repeat what others have said, can benefit technically from testing. They certainly can. Instead, it's whether or not we can maintain our stockpile without testing. That often repeated question has led to a suggestion by many that we should wait and see whether stockpile stewardship will work. Such a suggestion implies that there is a defined end condition to stockpile stewardship. That is stockpile stewardship will take us to a destination where we will be able to say it works, or it doesn't work. I don't think that's the right concept. Stockpile stewardship is not a destination, it's a journey.

Stockpile stewardship has to provide tools and knowledge faster than we will encounter problems in the stockpile. And that demand will go on as long as we have nuclear weapons. So far it has met the need. We have encountered difficulties in the stockpile that we have been able to deal with due to the stockpile stewardship that we could not have dealt with without testing before the effort that has gone into stockpile stewardship.

Regarding confidence and whether or not we will be able to stay ahead of emerging challenges in the stockpile, with new tools and new knowledge, we come down to how much is enough. We often hear the laboratories and supporters of the laboratories talk about the shortfall in funding. That is, instead of getting $4.5 billion, they got $150 million less than that. Again, it's a wrong baseline. $4.5 billion cannot be the right baseline because it was derived from a baseline of a ten-year job costing $45 billion dollars. How could we know the cost in time or dollars of something we've never done before that's extremely complex and extremely difficult?

In fact we could not know that. I would estimate that it took us at least five years to learn enough about what's required to be able to define a Stockpile Stewardship Program so that we can determine what this program looks like and what resources are required. I think we know how to do that now but we have not.

And the fact that we have not done that adds to the impression by significant opponents of CTBT that the real agenda of supporters of CTBT is to contribute to the withering away of nuclear weapons. So they question whether or not we are serious about stockpile stewardship and whether stockpile stewardship will indeed enjoy the kind of support required. We cannot answer that question until we have a definition of what kind of program is required to proceed at the proper pace for stockpile stewardship.

So I would suggest that the reason that you continue to hear what sounds like hedging from the laboratory directors – which can be devastating to the CTBT – is not because they don't believe in it and not because they are not good Americans. It's because we have given them no reason to have confidence that they will get the resources required to do what we have charged them with doing.

So I would argue that a critical need is to define and support the Stockpile Stewardship Program, which includes all of those things that Dr. Drell said that we have to do. We have to know what it takes to maintain the stockpile, and we have to have the means to do what it takes to maintain the stockpile. At the moment, we're well along on the first, we're in dismal condition on the second, and have not really defined what it takes to do both.

And the last thing I would say is that we really have to return to treating the national laboratories as national treasures instead of the way that we've treated them for the last year-and-a-half. It's been just devastating.

Dr. Chyba: Thank you General. Are there one or two comments? Yes please.

Dr. Hagengruber: I would just like to add a personal memoir of credibility regarding what the General said. It's not very well known, but we struggled very hard as laboratories and plants trying to decide what the right thing to do was. Vic Reis, who was then the Assistant Secretary [of Energy], sent us all to the drawing board for a budget exercise a number of years ago – about 1996, I think. And all the labs and plants came in and we went through everyone's budget. It was unprecedented for everybody to see everyone's budget in detail for two days. The estimated need, absent plutonium and tritium, was $5.4 billion. Reis said go back and do it again, only this time the number one priority is to make sure that we take care of the CTBT and the stockpile. Everything else is nice to have, but they're third or fourth priority. So we came back again and it was $5.1 billion. So Vic went to Secretary Curtis and to some other folks that he knew and said "it looks like it's going to be $5.1 billion" and he [Curtis] said "there's no way that you're ever going to get $5.1 billion. It's just too much money." And instead, we ended up with an agreement to try for $4.5 billion.

We had a meeting with the Congress, and three of us with the labs went in to explain what stewardship was to a whole set of people from the House. And to a person, Democrats and Republicans alike, they were overwhelmed by the difficult, complex job of stewardship. But the first question after all those good statements was "how much is this going to cost?" Someone said as an aside to a Republican member, "$45 billion over ten years" and then he said, "God that's a lot of money."
So what we did is we ended with the $4.5 and we had a meeting with the National Security Council. They had the DOD there and everyone else because it was going to take $300 million from the DOD budget to get to $4.5, which is a very acrimonious decision. But the decision was made around the table and basically directed by the NSC that it would be $4.5.

My comment to support General Welch…. (I know this is a lot of micro-detail) ...Within a week, the deal was not $4.5 and inflation, which had been the agreement. It was $4.5 and no inflation. Within a month the $4.5 had become $4.5 except we're going take $50 million out for this; we're taking $100 million out for that… The constant pressure of planning among laboratories was because the budget was always at the margin because, "that's a lot of money". But it is at the margin that a lot of decisions about what you're going to do in stewardship have to be made.

And I couldn't agree more with the impression that he left at a more strategic level – that it's not a matter of the details of that price – it has to be earned. But the process that actually formalized stewardship and embedded it in the system vanished almost instantly within the bureaucracy of the government.

Dr. Chyba: Thank you Dr. Hagengruber. The next speaker today was to have been Dr. Herbert York. I'm sorry to say that Dr. York has injured himself while traveling and is unable to join us today, but we're grateful for his willingness to take part in today's roundtable. I would like to make a presentation of my own, but since one should never verify oneself, I'll turn the gavel over to my co-chair and ask Jack to take care of my time.

Jack Mendelsohn: Thank you Chris. Whenever you are ready.

Dr. Chyba: Two main arguments were made in October 1999 by Senators opposed to the ratification of the Comprehensive Test Ban Treaty (CTBT): that it is insufficiently verifiable; and that it would undermine the reliability of the U.S. nuclear weapons stockpile, and hence undermine deterrence. The sense in which the word "deterrence" was used—whether it referred to "countervalue" deterrence, "counterforce" deterrence, or something else – was unclear during the debate. Here I hope to clarify thinking about the fate of U.S. deterrence under the CTBT.

A number of Senators emphasized the Treaty's threat to credible deterrence. Senator Trent Lott remarked that "Our adversaries must believe that U.S. leaders possess the will to use the nuclear force if

need be, and must also believe that our nuclear weapons can be used—that they are safe and reliable enough for U.S. leaders to consider seriously the possibility of their use. Without these conditions, American threats of retaliation become less than credible, and the contribution of nuclear deterrence to the national security strategy of the United States would be unacceptably eroded." Senator Richard Lugar, in his press release of October 7, 1999, and again in a subsequent article in the *Bulletin of the Atomic Scientists*, said that "The United States must maintain a reliable nuclear deterrent for the foreseeable future. . . . At present, I am not convinced the Stockpile Stewardship Program will permit our experts to maintain a credible deterrent in the absence of testing." Similarly, Senator Helms quoted from a letter from six former Secretaries of Defense, who wrote that the CTBT "will reduce the credibility of America's nuclear deterrent." Analogous concerns were expressed by Senator John McCain and others.

How much will the CTBT threaten deterrence? Let me first use a specific example to examine this question for the case of counterforce deterrence, with the caution that this discussion is a preliminary one. I will then try to shed light on the less demanding requirements of countervalue deterrence.

Consider the probability of destruction against a target hardened to 2000 psi, which is a hardness appropriate for, say, a missile silo. This "kill probability" is proportional to the overall system reliability and depends exponentially on warhead yield and accuracy—but is far less sensitive to the yield than to the accuracy. Warhead accuracy does not depend on nuclear testing. In preliminary work that I am currently extending, I have examined the case of a two-warhead attack on a 2000-psi hardened target, given yields and accuracies (which may be found, e.g., in *Jane's Strategic Weapons Systems*) appropriate to the Minuteman III and Peacekeeper missiles. The Trident D-5 will give results similar to those for the Peacekeeper.

If the U.S. directs two warheads against each hardened target, assuming an overall system reliability of 85%, and assuming that U.S. warhead accuracies in the future are comparable to those of the Minuteman III, counterforce deterrence would be significantly affected only if warhead yields dropped to below 50% of their design yields, or overall system reliability dropped substantially below 85%. If counterforce attacks were carried out with Peacekeeper or Trident D-5 missiles, warhead yields would have to drop by 75%, to below 25% of their design yield. With overall missile reliabilities in the 80 to 90 percent range, warhead reliability (meaning here the reliability that the warhead would explode at all) could fall by 5% with barely a discernable effect on kill probability.

There are some data in the open literature (for example in the *Nuclear Weapons Databook*) regarding warhead reliability. Tests in the early 1960s of an extremely corroded W47 warhead and an aged W45 warhead resulted in a slightly reduced yield and a 50% drop in yield, respectively. The corrosion problem was discovered by the stockpile surveillance program; the "aging" problem involved both corrosion and inadequate performance with aged tritium. The latter problem was suspected during the testing moratorium from 1958-1961, then confirmed by testing in 1962. In the 1970s, a problem arose with an SLBM warhead, the W68, due to deterioration of high explosive; a switch was made to another high explosive and the modified explosive tested successfully. There are other examples in the open literature of reliability problems (most from the 1960s), many involving aging and corrosion effects, but I have not yet found quantitative estimates of the impact of these effects on the warheads' yields or overall reliability.

With respect to counterforce deterrence, the question becomes whether stockpile stewardship will be able to prevent, or at least detect in a timely way, warhead degradation that is likely to lead to drops in yield of more than 50%, or probabilities of complete failure of greater than ~ 5%. Provided that the modern Stockpile Stewardship Program detects the effects of aging and corrosion as well as those defects were detected in the W45 and W47 warheads in the early 1960s, then we could expect no significant impact on counterforce deterrence.

The President's letter of transmittal of the CTBT to the Senate stated that, "If the President is advised, by the above procedure [involving the weapons lab directors, the Secretaries of Defense and Energy, the Commander of the U.S. Strategic Command, and others], that a high level of confidence in the safety or reliability of a nuclear weapon type critical to the Nation's nuclear deterrent could no longer

be certified without nuclear testing, or that nuclear testing is necessary to assure the adequacy of corrective measures, the President will be prepared to exercise our "supreme national interests" rights under the Treaty, in order to conduct such testing." The lab directors, in their joint statement on the safety and reliability of the U.S. nuclear weapons stockpile released on October 8, 1999, emphasized the importance of this safeguard.

Degradation in warhead reliability or yield of sufficient magnitude to compromise counterforce deterrence could be viewed as the threshold for invoking this safeguard. But even if it were the case that one warhead in the inventory were to become unreliable, the history of reliability problems with the W45, W47 and W68 suggest that the degradation in reliability of one warhead type alone is insufficient to undermine deterrence. Together, these arguments suggest that counterforce deterrence is likely to remain robust under the CTBT.

If counterforce deterrence remains effective, then countervalue deterrence should, a fortiori, remain strong as well. But there is also an intriguing historical example that bears consideration, that of the Israeli nuclear deterrent. The Israeli example demonstrates that it is possible for a countervalue deterrent to remain credible to a nation's adversaries in the absence of testing for decades. I want to spend just a few minutes here discussing this example.

Israel's nuclear deterrent is intentionally "opaque," so difficult to assess. However, the Israeli technician Mordechai Vanunu, who had worked at the Israeli Dimona plutonium separation facility for nine years, provided a detailed exposé to the London *Sunday Times* in 1986 prior to being abducted, tried and convicted by Israel. His detailed account, which included 57 photographs of the Dimona complex, of models of interior weapons components, and of one actual component, were described as credible by U.S. nuclear weapon designer Theodore Taylor and British nuclear weapon scientist Frank Barnaby.

Taylor interprets Vanunu's photos as depicting a bomb that is a boosted fission weapon, with lithium-deuteride used as the fusion material; this is consistent with details provided by Vanunu on lithium-6, deuterium, and tritium production at Dimona. In 1989, a U.S. Defense Intelligence Agency report obtained and released by the Natural Resources Defense Council claimed that Israel had nuclear warheads on its Jericho I ballistic missile, a single-warhead missile with a 500 km range, 750 kilogram payload, and an accuracy of 1 km CEP (circle of equal probability). The International Institute for Strategic Studies' *The Military Balance 1998/99* states that Israel is "widely believed" to have a nuclear arsenal of up to 100 warheads, deliverable by aircraft as well as Jericho I and Jericho II missiles. The Jericho II is an intermediate range, solid propellant, single warhead ballistic missile with a range of 1500 km, able to carry either conventional or nuclear payloads of 1000 kilogram with an unknown accuracy. (For comparison with the these payloads, the plutonium bomb dropped on Nagasaki weighed about 4700 kilogram.)

In the CTBT context, it is important to note that Israeli nuclear deterrence has remained effective despite the fact that Israel has apparently not tested its nuclear weapons for over two decades. Unconfirmed reports in the open literature claim that Israel and South Africa conducted at least three joint nuclear tests, concluding with a test in the South Atlantic Ocean in September 1979 that was detected by a U.S. Vela satellite as a 2- to 4-kiloton nuclear explosion. (It remains controversial whether this "detection" was or was not really due to a nuclear test.) Israel may also have been given access to results from early French nuclear tests (it was France that made it possible for the Israelis to construct the reactor and reprocessing plant at Dimona), but Israeli access to French data is reported to have ended in the 1960s. Note that my argument concerning the continuing credibility of the Israeli deterrent in the absence of testing is not affected by French (or any other) assistance to Israel in the creation of that deterrent.

It appears that Israel possesses a somewhat sophisticated nuclear arsenal that goes well beyond Hiroshima- or Nagasaki-type weapons. The warheads in this arsenal have apparently not been tested for over twenty years, yet the Israeli deterrent is evidently viewed as utterly credible by its adversaries.

Beginning in the late 1970s, numerous Arab journalists, commentators, government officials, and heads of state expressed the belief that the Israeli nuclear force could cause incalculable damage. For example, in a 1976 interview, President Anwar Sadat stated that Israel's use of nuclear weapons against

Egypt could result in a million dead; that same year he predicted that "in five or six years it is possible that Arab military power will be neutralized by the Israeli nuclear threat." The political scientist Avner Cohen suggests that Israel's image as an invincible nuclear power was instrumental in convincing Sadat to come to Jerusalem in 1977 and, more recently, was the most important reason that the Palestinians decided to "accept the facts and seek peaceful co-existence with Israel."

Israel's nuclear weapons appear to have deterred the use of chemical weapons against Israel by Iraq during the Gulf War: Iraq had some 30 chemical warheads for al-Hussein missiles, strong political motives to draw Israel into the conflict, and to this end launched some 40 conventionally armed al-Husseins against Israel – but it did not attack Israel with chemical weapons. Israel's nuclear stockpile provides it with the ability to threaten—even if implicitly—unacceptable punishment to any mideast state challenging its survival.

One might object that the Israeli arsenal is less sophisticated than that of the United States, so that its credibility after two decades without testing provides an insufficient guide. But stockpile stewardship in the U.S. is buttressed by the knowledge base established by over one thousand tests (compared to at most a few for Israel), and an investment in maintaining reliability of which Israel is entirely incapable. Moreover, even after a possible START III agreement, the U.S. strategic inventory would contain an order of magnitude more warheads, and presumably a wider range of warhead types, than that of Israel.

To summarize, then, the Israeli example suggests that a nation's strategic nuclear stockpile can remain an entirely credible countervalue deterrent for decades in the absence of testing. With respect to counterforce deterrence, initial calculations regarding hardened-target kill probabilities as a function of warhead reliability and accuracy suggest that counterforce deterrence is also unlikely to be threatened by the CTBT, provided that stockpile stewardship can either prevent or give timely warning of drops of warhead yield of greater than fifty percent.

Mr. Mendelsohn: Thank you. We will now go off the record for an informal discussion…

CLOSING REMARKS

Mr. Mendelsohn: We now will go back on the record so that any discussants that would like to do so can make a few brief remarks in closing. We will work around the table, starting, to be fair, with General Welch. General…

General Welch: I would add one further thought about the need for a defined program for the overall Stockpile Stewardship Program. I want to reiterate that we now know enough to define a fairly explicit front end funding stream for this program. There is a certain amount of funding for a certain period of time, then to be followed by the long term sustaining funding, which is no different than any other program. If we set out to buy a new airplane, there is no end there. We have a period of front end funding, followed by a sustainment. I think we can have exactly that kind of program resource discipline, and we now know how to do that. I would also note that General John Gordon is currently actively engaged in establishing that needed kind of planning program.

Dr. Sykes: I have commented about decoupling, and in particular I have claimed that the feasibility of decoupled testing in hard rock is a problem that needs to be addressed seriously. It is something that only countries that have had extensive testing experience are likely to undertake, and only at the sub-kiloton level. For those countries, it is testing in large cavities in salt of a few kilotons that we need to worry about. That is a solvable problem. It is not a solvable problem at the ten-ton level. For hard rock, we do not have a consensus since decoupled testing in hard rock has not been examined in much detail. It has been put on the table as an issue, and we need a serious examination of it.

Finally, a very small group in the United Kingdom has worked on test ban verification for at least forty years. They have had an outstanding record throughout many different British administrations of doing a thorough examination of about one problem seismic event every three years. Their results are published; it is the type of analysis that they have done on a much smaller budget than we have in the U.S. We need to do their work for a very tiny fraction of the 30,000 events per year that Paul Richards referred to. We are always going to have a very small number of problem events. Thus, we need to have a group of people to address them who are reliable in terms of their scientific capabilities and who are non-ideological. The British group has established a very good track record there.

Mr. Peurifoy: We should try to keep emphasizing that many of the items which we are discussing here are equally important in the CTBT and the non-CTBT context, namely the need to maintain our ability to collect nuclear weapons intelligence. Also, the vast majority of the activities under the stewardship program have nothing do with a CTBT. They are a continuation of things that we have been doing, and, in view of the long time involved here, we that should be doing with intensified refocusing.

Finally, maintaining a viable non-proliferation regime is an overriding security need of the United States. We should avoid giving more ammunition to the kind of attitude, which was reflected in the statement by the Indian [Foreign Minister], never to negotiate with the United States unless you have a nuclear weapon. Namely, we should not state that the United States is continuously fine-tuning its own ability to maximize the efficiency of its nuclear weapons establishment. By such statements we signal to the world that we, with the world's most powerful conventional weapon establishment and other overriding aspects of superiority, still want to fine-tune the efficiency of nuclear weapons. We are being extremely shortsighted in feeding this kind of perception, which is reflected by the remarks of the Indian Foreign Minister.

Ambassador Ledogar: Some opponents of the CTBT say they do not like it because we need now to return to testing, or they already see in the near future that we will need to return to testing to develop new nukes. Others say that they are uncertain about it, and that they cannot say now that we can go without

testing for a very long time, possibly forever. I would like to pick up in that context the thought of the gentleman observer who said that in trying to convince your opponents, do not lose your supporters. That is a very important point, and as he said it applied both internationally and domestically. Domestically, in 1994, when we began the negotiation, the concept was that if the nuclear deterrent can be maintained without explosive testing, and if the U.S. nuclear advantage over Russia, China and others could be locked in, why continue to suffer the downsides of continued nuclear testing? The political downsides, and we saw a big display of that when the French in Muraroa had their last-minute campaign to correct their codes. They took a lot of heat. Also the environmental downsides, and then the moral downsides. I'll not push the moral issue in this company.

But, in 1994, we had consensus to try CTBT negotiations precisely because the international community disagreed on reasons to try to get a CTBT. The minority, the United States, the P-5, and a few others, said that we can go into a CTBT because we can maintain the deterrent without explosive testing. But the majority of countries went into the CTBT because they believed that it was an important first step on the slippery slope to the elimination of nuclear weapons in the world.

We want to try to maintain the support of American citizens and their representatives from across that spectrum, whether we agree or not.

Dr. Jeanloz: I am summarizing what I heard as key conclusions. The stockpile is currently healthy and any analysis demonstrates that. The Stockpile Stewardship Program is coming into focus such that General Welch pointed out, we would now know how to document in detail the priorities and the plans. In fact, there is every opportunity to do that now with the establishment of the new NNSA, and General Gordon in charge of that.

My second comment on verification is an amplification of what has been said. I don't believe I heard it strongly enough, but it was implied in passing. I want to emphasize that it is not just the current capability, but also the fact that in this domain as well, the situation is quite dynamic, and I believe there is every reason to expect significant enhancement in verification capabilities, both technical and methodological. I will not document that conclusion, but I believe that it is in the process of being documented. The point is that no matter where we stand now, there is every reason to believe that there will be significant enhancements in the near term.

Ambassador Goodby: I am grateful that we had a very broad discussion of the test ban treaty. I was impressed by comments that suggested the trends are in the right direction in terms of stockpile stewardship and verification. Bill Perry, for example, mentioned the four issues that were of concern to him as Secretary of Defense, and that he felt that things are better now than they were in 1995. That was very reassuring. There were worries about the situation in the laboratories, and here we can all agree that a national commitment is needed to the Stockpile Stewardship Program. Beyond that, I was concerned by what I heard about the turmoil in the past year-and-half and its effect on the laboratories' morale, recruitment abilities, and so forth. That affects what we have been talking about today in a major way. We must get past that.

Senator Exon: The CTBT is clearly one of the most important treaties of the last century affecting the future of mankind. I am here to ensure its eventual success. We are not doing only our national security work, but the Lord's work as well.

I would also like to thank the Lawyers Alliance for World Security for their sponsorship of this very important and productive meeting. I also want to thank the Stanford University Center for International Security and Cooperation for this great facility. I would like to say to Stanford University that if they want full cooperation in the future, they could let Nebraska go to the college world series once.

Dr. Cobb: I learned a lot, and I appreciated the day and everybody's input. Coming from the labs and maybe speaking for my colleagues at the labs, the people I know, and I have been there for more than half of the existence of Los Alamos, are very committed and proud of our contribution to national security during the Cold War. Since the end of the Cold War, we still have many people enthusiastic about supporting the directions that we want to take in terms of maintaining our deterrent, curbing proliferation, arms control, and so forth. The labs will continue to support this work. What we need is three things. We need some predictability in the programs and the missions that we have, we need some stability, and we need some modest insulation from the political process.

General Shalikashvili: I too would like to thank LAWS and CISAC for this very useful, very informative gathering, which will help a long way towards sharpening the arguments I want to include in my report to the President. Not so much to prove that the opponents of the Treaty are wrong, as to help answer their concerns. All the discussions here and the work that is being done will go a long way in that direction. Finally, I do have to associate myself with Ambassador Goodby's comments and those others of you who spoke to the need to a national commitment to the laboratories. All my years in the military have convinced me that it is not the tanks, planes, and ships that make us the best military, it is the people that operate them. And it is not the best computers in the laboratories that will make all of this work, but it is the people that will operate those computers and the other facilities that we are building. Thank you again for this conference.

Dr. Drell: My strongest comments were made by Raymond Jeanloz and Jim Goodby. Keep in mind that the Stockpile Stewardship Program is important whether we have a CTBT or not. We still need to have a process to help set better priorities and identify the program needs on a sustained basis than we have today. Let me finish by reminding you why it is timely what we are doing. For five decades, the world proliferated nuclear weapons at the rate of one new nation every five years. That lasted until the decade in the 1990s. Since then, the number has gone down. The three former Soviet Republics of Belarus, Kazakhstan and Ukraine have given up [nuclear weapons]. Pakistan has confirmed [its nuclear status] but we knew it. South Africa has given up its weapons. Brazil and Argentina walked away. We are at a crossroads now. For a whole decade, we have been holding order. We really have to get on because although the CTBT will not guarantee nonproliferation, it is a very important component of the effort to try and prevent it from spreading. Thank you.

Dr. Sands: First, a brief comment about the national laboratories as somebody who has worked for 11 years at one of them but is not very technical. I can only reiterate the fact that morale and human resources are going to be critical to the success of the stockpile stewardship, as well as to any other activity that the labs would have to be involved with. It will be important to try to insulate them in a way that they have not been in the last year from political upheavals.

In terms of today's workshop, it has been a very worthwhile and enriching discussion, and I thank you for letting me participate. There have been numerous mentions of the dynamic nature of the environment in general, and it is important to realize that that can cut either way. Clearly, the security interests and needs of the United States are changing. The role of nuclear weapons is changing, the meaning of deterrence or the way one might think about using nuclear weapons might be changing, but also the technology is changing in ways that will facilitate both some of the stockpile stewardship as well as the monitoring interests. In a dynamic environment, it might be interesting to think about how to use it to our advantage instead of bemoaning the fact that it is uncertain, because the uncertainty is moving in the right direction. It should not be an excuse not to do CTBT or not to do stockpile stewardship, but actually should be a reason why you can see how to do it. You just must be sure to build in the flexibility to respond to the change.

Dr. Richards: I learned some important new points here. One, about a need for a better understanding for our monitoring capability that is country specific, particularly in the context of evasion scenarios. Those of us who work on the monitoring side need to prepare better summaries of those capabilities. And I wish that those who propose evasion scenarios would themselves be far more specific about what they are saying might be possible. Many times I hear evasion scenarios that are not fleshed out, or just that it might be possible to build a cavity. That is irrelevant if it is not something that can be built deeply enough. I wish that more pressure could be brought to bear on those who propose these scenarios. Otherwise one is fighting a ghost that is moving around all the time.

Second, I do plan to follow up on General Welch's point that certain inconsistencies have been a handicap. Particularly, I believe some of the numbers that I offered in my background paper, are entirely consistent with what people at the working level are saying in a number of different organizations. However, I accept the point, and we have to work on making sure that inconsistencies are removed to the extent that is possible.

Let me make a personal point here that some of this work of presenting the monitoring story is rather difficult because there are many facets, and to present it, as we had to today with the demand to do it in 10-20 minutes to a friendly audience is tough enough. Agencies have to do it for 100 Senators, and that is extraordinarily difficult. There are so many points of view out there, so many technologies to cover and many capabilities are changing. Some of the people who do the work of presenting capabilities in the political forum for understandable reasons have almost made a career of such presentations. In a rapidly changing world, the people at the forefront of understanding some aspect of monitoring capability are a very long way removed from making the presentation. The presentations that eventually get made particularly by government agencies, in practice, represent a worst-case scenario analysis, but that is a personal opinion. It is very difficult to stay at the forefront of some improving monitoring capability, and also have the time to work hard in the presentation of these ideas in a faithful way in a political forum.

There have been many congratulatory things said about the weapons labs, the quality of the people and the need to maintain this. In contrast, I want to interject a note that may come across as a little sour. Mike May is no longer here, but he specifically said to us that "the system we set up for nuclear weapons was not designed to handle this situation," speaking of a CTBT. And I have to ask, why were nuclear warheads not designed with a CTBT in mind? This was declared U.S. policy since the 1950s. One president after another has declared that this has been a long-term objective of the United States. So, I just have to ask why were the weapons labs not prepared?

Dr. Chyba: I would like to begin by thanking LAWS and all of you on behalf of CISAC for coming today. I think it was been a very valuable day. Earlier today, almost at the outset, General Shalikashvili listed four particular points of concern and I would like to return to those briefly and make some comments about what I think we may have learned and things that might yet have to be done.

The first was that the case has not yet been sufficiently made why the CTBT is important to national security. Scott Sagan has pointed out that when making that case, one has to be very carefully exactly how one makes it to tread the right line, and that was emphasized by Ambassador Ledogar as well. We have heard a number of responses to that question having to do with limiting the Russian and Chinese nuclear forces and in effect having to do with locking in the United States' nuclear superiority, and also with maintaining the nuclear non-proliferation regime. General, I am sure that on each of the points you mentioned, an extensive classified study could be performed, and probably there is no one in the room better to prompt that than yourself. I also cannot help but wonder whether it might not be useful for you for a few individuals to each, separately produce a very short document, for example. A three or four pager that Tom and Pief might write on the case for why the CTBT is important for national security.

Your second point was uncertainty. Why should a senator sign up to a treaty of infinite duration given how quickly science and technologies are moving? You had two possible suggestions. One was an absolute trigger that would require the President to act, and from what we heard around the table today,

there are probably profound constitutional issues with that kind of trigger. The second was a suggestion of former Secretary Laird, that there be a regular review conference every 5-10 years. I thought I heard something of a consensus around the table that that would make a great deal of sense.

Your third concern had to do with communicating science-based stewardship and two of the key points were clearly maintaining personnel at the labs and giving an assurance of a long-term funding stream and what was called stability. That strikes me as an issue that needs to be worked politically in Washington, and I do not know that this group can be especially helpful in that regard.

It makes me think of an issue that arises out of safeguard F. When the President sent the Treaty to the Senate, he said: if the President is advised that a high level of confidence in the safety and reliability of a nuclear weapon type critical to the nation's nuclear deterrent could no longer be certified without nuclear testing, etc. One point that I would like to emphasize is that that question of the reliability of a nuclear weapon type would need, as a political matter, to be put into a broader context of yield, reliability, and the number of warheads we have in our arsenal to determine whether that is really critical to the nation's nuclear deterrent. With respect to this idea of an absolute trigger, one of the impediments to that idea in addition to a constitutional one is that I cannot imagine how there could be a purely technical decision made on those grounds, because it has to fit into the larger concept of deterrence at various levels.

The fourth point had to do with monitoring. There it strikes me that people here might be able to be of considerable use. Lynn Sykes emphasizes that what we really need is a country-by-country statement on what the thresholds are and I cannot help but wonder whether Lynn and Paul might be able to produce a short cogent document on a quick turnaround.

Finally, similarly, General Shalikashvili mentioned the need of a study for work to be done below the monitoring threshold nation by nation. Sid, I cannot help but wonder whether you might be able to produce a short document on a quick turnaround that could be especially helpful there. Having volunteered other people's time, I think I should pass the gavel.

Ambassador Graham: First I want to thank CISAC for all their support. It has been great working with you on this conference, and I also want to thank all of you for coming. I think it has been a very useful and interesting dialogue that we have had today. I am always, Chris, willing to write papers. I will say that in my opinion, fundamentally the number one national security argument for why CTBT is in the nation's interest is that broadly speaking, without the CTBT, at least in the next few years, over the longer term, we are not going to have the NPT. I cannot imagine anything more damaging to our long-term security than that. This CTBT is the price as a country we have to pay if we want the NPT. It is as simple as that in my opinion, but of course there is a lot more to it than that. I also very strongly support the idea of a national commitment to the labs. Not only in the Stockpile Stewardship Program, but insulation from the political process and all the rest. We depend a great deal on all the work that is being done there. To sum up, I think that it has been an interesting and constructive dialogue. I thank everyone again for coming. I think this will be a useful public document once we publish the transcript, and I hope we will be helpful in Shali's work in the future in the general effort to gain U.S. ratification of the CTBT and eventually entry into force of the Treaty.

Ambassador Bunn: I want to talk about some recollections of history and what it may mean for the chances for ratification of the Treaty, depending on which candidate is elected president. I do not think we should give up because George Bush has opposed the Treaty. You may have noticed that he did not oppose the moratorium. I remember a long time ago, the Non-Proliferation Treaty was opposed by Richard Nixon in the 1968 campaign. Even though we had Senate hearings, the President did not press for a vote and so the Treaty went over to the next administration. Nixon won and a couple of months after he was in office, he supported the NPT and he got it through the Senate in a breeze. So I would not give up.

WRITTEN SUBMISSIONS

President Jimmy Carter: Efforts to reduce the number of nuclear weapons and constrain their spread remain critical to the enhancement of America's security. That is why U.S. leadership in the struggle against nuclear proliferation remains indispensable to ensuring our nation's future. But the Senate's rejection last year of the Comprehensive Test Ban Treaty (CTBT) was a serious blow to the nuclear non-proliferation commitment and to the efforts to reduce the quantity of nuclear weapons. The U.S. leadership mantle must be regained, the confidence of our friends and allies must be restored, and the nuclear non-proliferation effort must be reinvigorated if we are ever to be freed from the scourge of nuclear weapons.

It is now almost four years since negotiations on the CTBT were successfully completed, but the Treaty has yet to enter into force. This cannot take place, however, unless the United States ratifies the agreement. Additionally, the United States should take the lead in convincing other key states to approve the Treaty. But the United States can hardly prevail upon other nations to abandon nuclear testing if this nation has not itself undertaken a legal commitment to do so.

The CTBT does not undermine U.S. national security or its nuclear deterrent. The United States has the most advanced nuclear arsenal in the world. I believed this as a submarine officer, I knew this as Commander-in-Chief, and I remain convinced of this since I have left office. Moreover, this country's leading scientists believe that in a CTBT regime our national deterrent can be reliably maintained without testing, that the Treaty will be effectively verifiable, and that it will forestall additional nations from developing advanced nuclear weapons.

What can undermine America's vital security objectives would be to damage the global nuclear non-proliferation movement by failing to bring the CTBT into force. Compliance with the Non-Proliferation Treaty (NPT) and the CTBT are inextricably linked. Without the CTBT, NPT compliance will lag. And if the NPT is not enforced, then the more than 60 nations which can do so would be free – and feel increasingly compelled – to develop nuclear weapons. There could be no scenario more threatening to American interests.

President Clinton was the first national leader to sign the CTBT, but its policy roots stretch back to the Eisenhower Administration, and it has until recently enjoyed bipartisan support. We must work now to reestablish this national comity and then reassert American leadership in the international community to maintain a healthy and effective nuclear non-proliferation commitment and to work for still further reductions in weapons holdings.

I urge you to develop the broadest possible consensus on political measures to lay the groundwork for a thoughtful reconsideration of the Treaty by the Senate and its subsequent ratification.

Major General William F. Burns: United States nuclear arms control initiatives for most of the last half-century have centered around three goals:

- Attempts to constrain, limit, or reduce nuclear forces;
- Attempts to limit the participation in development of modern, high technology weapons, particularly weapons of mass destruction;
- And attempts to restrict the production and maintenance of such weapons.
- Examples in the first category might be the INF and START Treaties. In the second category, we find the NPT, and in the third, the Limited Test Ban Treaty.

We have achieved greatest success, perhaps, in treaties of the first category. The INF Treaty did, indeed, eliminate an entire class of nuclear weapons delivery systems and the START agreements have brought about a significant reduction in strategic delivery systems. In the second, the NPT has worked in

that far fewer countries than predicted have embarked on nuclear weapons development. In the third category, we have had the most difficulty.

U.S. policy for over half a century has directed overt and covert actions to prevent, slow, and thwart the efforts of states to acquire nuclear weapons, beginning in the days when the U.S. was the only nuclear power and jealously guarded that position. One of the principal and more convincing signs that a state is attempting to acquire a nuclear weapons capability is nuclear testing or preparation therefore. Thus, the U.S. attempted early on to identify the signs of imminent testing, to discourage states from undertaking such testing, and to develop monitoring capabilities to learn as much as possible about the nuclear weapons potential being tested. Many of these capabilities were developed and directed against the Soviet Union, but now provide the capability for the U.S. to monitor such activities on a broader scale.

Testing limitations, however, cut differently depending upon the nature of the nuclear state's arsenal. A reciprocal ban on testing in order to develop new weapons strikes all parties to a treaty much the same way. However, nations with large stocks of sophisticated nuclear weapons face a much more complex and expensive task to maintain the stockpile than do nations possessing relative small stocks of simple weapons. The Comprehensive Test Ban Treaty provides international assurances that nuclear weapons are not being tested without regard for the reason and thus impacts on the larger nuclear powers more than the smaller.

Therefore, I grant without further argument that future nuclear testing could be advantageous to the U.S. It provides both opportunities to gain high assurance that the present stockpile is safe and secure, and it would permit the most cost-effective development of future nuclear weapons if this became necessary and advisable. However, the CTBT acts to prevent nuclear weapons proliferation by non-nuclear states and restricts further development of nuclear arsenals by present nuclear weapons states. Which is more advantageous to the United States?

I have become convinced that nuclear testing is not necessary to assure that the present stockpile is safe and secure and that nuclear weapons in it will function properly if detonated. That is not to say that risk would not be reduced to some degree and that the process to come to such assurances would not be easier if testing were undertaken.

Nevertheless, the risk seems to be acceptable and the cost – in terms of dollars, people and national security – is manageable.

- The task to provide a stand-by capability to test in order to develop new types of nuclear weapons if the world situation changes drastically in the next critical decade or so is formidable, indeed, under a test-ban regime.
- The nuclear laboratories are currently charged with this mission and, with proper funding, can be expected to accomplish it.

The advantage of a test-ban regime thus falls to the nuclear superpower, not to the emerging nuclear wannabe.

The present Administration's handling of the ratification process for the CTBT was rather inept. The 1999 debate on the Treaty in the Senate hinged more on politics – the second impeachment trial, if you will – than on the technical worth of the CTBT for arms control or for the health of the U.S. arsenal.

Nonetheless, the solution is not to abandon the CTBT. This Treaty has wide adherence and the world seems now ready to forgo further nuclear tests. In this climate, it is unlikely that the U.S. or any other Nuclear Weapons State would test without some extreme emergency or provocation. Undeclared nuclear states would be unlikely to test in the environment; if they did, concerted opinion would limit or offset whatever advantage they might see in testing.

It is not too late for the U.S. to take steps to preserve its advantages in the CTBT and to limit any disadvantage:

1. Allow the dust to settle until after the present election campaign.
2. Develop a favorable political rationale for the Treaty for those who voted against it principally to show solidarity against the present administration.
3. Concentrate on the technical arguments, briefly argued above, for the net advantage to the U.S. of some sort of nuclear test ban.
4. Prepare a comprehensive plan, to convince other signatories of the Treaty that the U.S. remains seriously interested in a comprehensive test ban.
5. Revive the Treat in the next session of the Congress with whatever caveats need to be appended to meet technical concerns. At the same time, provide reasonable political "cover" for those senators who would reconsider their earlier vote against the Treaty.
6. Prepare a plan to assure the U.S. remains prepared to test if this becomes necessary for supreme interests involving security. The criterion for this plan should be that testing could resume after the maximum time expires following denunciation of the Treaty.

Finally, we must remember that arms control agreements that have successfully weathered the ratification process in the Senate have been the product of careful preparation and intense interaction between the executive and legislative branches. The INF Treaty was in process for eight months. More than one thousand questions were raised formally by Senate committees and these were answered carefully and completely by the administration. Key Administration figures and members of the negotiating team testified both in an unclassified and classified environment. The CTBT, if we are serious about it, deserves nothing less.

Dr. Richard Garwin: (transcript of testimony before the Senate Foreign Relations Committee, October 7, 1999, submitted by author) Good afternoon. Thank you for the opportunity to testify in support of the Comprehensive Test Ban Treaty.

I am Richard L. Garwin, Phillip D. Reed Senior Fellow for Science and Technology at the Council on Foreign Relations. I am also IBM Fellow Emeritus at the Thomas J. Watson Research Center of the IBM Corporation. I chair the Arms Control and Nonproliferation Advisory Board to the Secretary of State. In addition, I am a member of the JASON group of consultants to the US government, and have participated in several of the JASON studies for the Department of Energy on stockpile stewardship. Since 1950 I have been involved with the nation's nuclear weapons establishment, having contributed to the development and testing of fission weapons and to the creation of the first thermonuclear weapons. Most of this involvement has been at the Los Alamos national Laboratory. I am currently a consultant to Sandia National Laboratories. Nevertheless, in my testimony I speak only for myself. In 1998 I was a member of the Rumsfeld Commission to Assess the Ballistic Missile Threat to the United States. In 1996 I received from the US foreign intelligence community the R.V. Jones Award for Scientific Intelligence; and also in 1996 I received from the President and the Department of Energy the Enrico Fermi Award for my work with nuclear weapons.

The Bottom Line

Complex technical issues should not be allowed to obscure the important conclusions that I state here, up front, and that I believe follow from a balanced assessment:

1. In assessing the merits of the CTBT it is essential to bear the difference in mind between fission weapons of the Hiroshima-Nagasaki variety and thermonuclear weapons which are used on all deployed US, Russian and Chinese strategic nuclear weapons.
2. The CTBT can be verified with sufficient confidence to prevent any proliferator from developing thermonuclear weapons whether he already possesses fission weapons or develops such weapons clandestinely.

3. While tests with yields vastly smaller than Hiroshima may evade detection, such tests would be useless to Russia and China, and very difficult to use for confirming the validity of a clandestinely developed fission weapon.
4. If secret information regarding thermonuclear weapons has been acquired by others, or may be so acquired in the future, as has been alleged in regard to China, this information cannot be turned into a deployable weapon without tests forbidden by the CTBT.
5. The US does not need tests banned by the CTBT to maintain full confidence in its weapons stockpile. The vast majority of components in a nuclear weapon can be examined and tested and upgraded without nuclear explosions. The nuclear (or physics) package itself can be remanufactured to original specifications should surveillance reveal deterioration. The Stockpile Stewardship Program will further enhance our high confidence in our stockpile, which is now certified each year by the weapons builders, together with the military who will have to use the weapons.
6. Given that nuclear proliferation is probably the most serious threat to the national security, and given the confidence that our own deterrent will be fully maintained under the CTBT, it is clear – totally clear – that the United States will run fewer dangers with the CTBT in force than without it.

Why A Treaty?

We are better off with a test ban than without it. Of that there can be no doubt. Naturally, any treaty or contract will have both benefits and costs to any of the parties. Here we are concerned with the benefits and costs to the United States. If one looked only at the costs, and imagined them as the total effect of the Treaty, one would never consider such a deal.

The costs to the United States include constraining the United States from testing nuclear weapons. The benefits come from constraining other countries from testing nuclear weapons. So let's look first at the benefits. The greatest benefit of the CTBT arises from its contribution to preventing the proliferation of nuclear weapons. It does this directly by preventing nuclear tests and indirectly by keeping nations on board the Nonproliferation Treaty (NPT). The United States does not want additional states to have nuclear weapons, and the members of the NPT don't either.

It is possible to build simple nuclear weapons without nuclear explosion tests, but there will always be a nagging doubt whether or how well they will perform. The Hiroshima and Nagasaki bombs each weighed about 9000 pounds, with a yield of 15 to 20 kilotons. The Hiroshima bomb used artillery-gun assembly of 60 kilograms of enriched uranium, which was not tested before its use. The Nagasaki bomb, tested three weeks beforehand in the New Mexico desert, contained some 6 kilograms of plutonium. Compare these weapons with a two-stage thermonuclear bomb tested in 1957 that weighed some 400 lbs with a yield of 74 kilotons; its diameter was a mere 12 inches, with a length of some 42 inches.

Without nuclear tests of substantial yield, it is difficult to build compact and light fission weapons and essentially impossible to have any confidence in a large-yield two-stage thermonuclear weapon or hydrogen bomb, which can readily be made in the megaton class. Furthermore, even in the yield range accessible to fission weapons, thermonuclear weapons are attractive because of their economy of fissile material, their compact size, and their improved safety. Just for example, a pure fission weapon, which is the best a sophisticated proliferator could do without verifiable testing, of 200 kilotons yield would require some 60 kilogram of plutonium or U-235. And the chemical explosive might weigh 4000 to 8000 lbs. That amount of fissile material would suffice for 10 thermonuclear weapons, each of which could be in the megaton class and weigh less than 1000 lbs. However, such H-bomb type weapons would require testing that would be readily detected and would therefore be prevented by the CTBT. This limits greatly the destructive power that can be wielded by newly nuclear states such as India and Pakistan.

So a CTBT that was respected would make a big difference in the threat that could face the United States or our allies, even if nations overtly or clandestinely pursue nuclear weaponry without explosive tests.

The CTBT bans any nuclear explosion of any size – it is a "zero threshold" agreement. Can one be certain that a nation has not tested in the vast range between zero and the magnitude of test that would be required to gain significant confidence in an approach to thermonuclear weaponry – say, 10 kiloton? No, but the utility of such tests to a weapons program has been thoroughly explored and found to be minimal.

First, I recall the August 3, 1995 report of JASON chaired by Dr. Sidney Drell, of which I was a co-author. Conclusion 6 of that study refers to a nuclear weapon test that would involve full yield of the fission primary and some ignition of the thermonuclear secondary, and that such tests, to be useful, would "generate nuclear yields in excess of approximately 10 kilotons." That is clearly verifiable by the CTBT's International Monitoring System (IMS), with its seismic, hydroacoustic, and infrared sensors, and its detectors of radioactive gases and particles.

These Conclusions resulted from a detailed classified analysis of the more than 1000 nuclear tests, and they were supported unanimously by the authors of the study, including four experienced nuclear weapon designers from US nuclear weapon laboratories.

A proliferant country might well want to acquire fission weapons of 5-kiloton yield, but the chance of detonating such a weapon undetected is small. The International Monitoring System (IMS) will have a good probability of detecting a nuclear explosion anywhere in the world – underground, underwater, or in the atmosphere at a level of one kiloton. And in many portions of the world the detectability is much better. For example, on September 23, 1999, the background noise in seismic arrays in the Scandinavian region was such that a test on the order of one ton (not one kiloton) could have been detected at Novaya Zemlya.

The CTBT bans explosive tests that release any amount of nuclear energy. The United States conducted some scores of so-called hydronuclear tests with an intended energy release less than 4 lbs. of high explosive equivalent. These are banned under the CTBT; they would very likely not be detected by the International Monitoring System. It is clearly impossible seismically to distinguish a test that may have had 200 lbs of high explosive from a test with 200 lbs of high explosive and 1 lb nuclear yield. The 1995 JASON Nuclear Testing study judged that there was little to be learned from such a test of yield 10 million times lower than that of the bombs that destroyed Hiroshima and Nagasaki. Such major changes would need to be made in a full-scale nuclear explosive to produce such a small yield that information available from the hydronuclear test would be of minor value in the development of a substantial fission weapon.

Russian nuclear weapons experts have expressed interest in fission weapons with yield no bigger than a few tons. These might be built without testing, or might be tested unobserved by US sensors, with or without a CTBT. In no case would the US react by testing its own nuclear weapons, and the inhibition posed by a CTBT on a Russia that wishes to remain engaged with the rest of the world would be substantial. The possibility of Russian programs of this type is not a valid argument against the CTBT.

In other words, one can cheat on the CTBT without being discovered by the International Monitoring System, but to what end? Useful national security information would not be acquired, and the bragging rights are not worth much if one can't tell anyone. For instance, a clandestine test cannot be used to intimidate other states.

Additional Means To Detect Violations

In addition to the International Monitoring System, the United States will maintain national means ranging from human agents to communications intelligence to sensors other than those included in the IMS. Furthermore, there are completely open and unclassified sensors such as research seismometers that can augment and in many cases greatly improve the sensitivity of the IMS.

I am confident that the CTBT can be adequately verified; this means that experimental validation by nuclear explosion testing cannot be accomplished by a states that is party to the CTBT.

Can The US Maintain Its Nuclear Weapons Sage And Reliable Under A CTBT?

Our review of the US nuclear tests and of defects discovered in stockpile weapons revealed many defects that were detected in the routine surveillance process – i.e., not by nuclear explosion tests. Defects observed by nuclear explosion tests were associated with weapons that had been put into the stockpile without the normal development testing and a production verification test. Today we have no such weapons; and we will have none in the future. All weapons in the enduring stockpile have been fully tested.

Some deficiencies identified by surveillance were eliminated by substituting a different warhead or design that required nuclear testing, but that was an option – not a necessity.

This analysis of our own stockpile and test record underscores the importance of explosive testing at an assuredly detectable level to a proliferator.

At present and for the foreseeable future, a reliable and safe US nuclear weapons stockpile is essential to the security of the United States, its allies, and to peaceful nations of the world. It is important to understand whether the US nuclear weapons can be maintained reliable and safe for 10 years or 20 years or 50 years, without nuclear testing. To this end, the Department of Energy is spending $4.5 billion annually on the Stockpile Stewardship Program, to provide assessment an understanding of the state of the stockpile and to remedy deficiencies as they are detected. Of the 4000 or so individual parts of a modern US nuclear weapon, most can be thoroughly tested without nuclear explosions and many are not even involved in a test explosion. Thus, batteries, timing and fuzing systems, and most of the weapon itself can be assessed and improved to the state-of-the-art, using modern technology when it is warranted by the reduction in cost in the long run to compensate the investment in the short run. This is no different from any other modernization program. But under a CTBT, the explosive-driven plutonium primary cannot be tested to nuclear yield, and neither can the secondary explosive that is ignited by the flood of X rays from the primary explosion.

Instead, the United States has an assessment program, in which each year 11 examples of each type of warhead in the inventory are dismantled and exhaustively monitored. Of the 11, one is totally disassembled and the interior of the primary and secondary inspected for aging, corrosion, and the like.

Eventually, signs of aging may force the remanufacture of these parts; if they are remanufactured to the same specifications as they were initially produced, they will be as good as the day they were first made. This can be done any number of times, and is the basis for my confidence in the future stockpile. As a result of the Stockpile Stewardship Program over the last four years of so, we have a much better understanding of the aging plutonium than we did previously. It seems to be benign, and this knowledge has led to a belief that the plutonium pit will survive for 50 years or more. But if it doesn't, remanufacture will make it "good as new."

We need to have not only the assessment but also the remanufacturing facility; the need for that facility has nothing to do with the CTBT. It is neither more nor less necessary under a CTBT than in a regime in which the United States might still test occasionally.

The US laboratories under the CTBT will maintain weapons safe and reliable by the Stockpile Stewardship Program, but they will also maintain and improve the capability to design and build nuclear weapons. It is clear that this capability could not be exercised under a CTBT in the form of newly produced weapons, but should the CTBT regime ever collapse, it would avoid delay of many years before new-design nuclear weapons could be produced.

A Balanced Assessment

The nonproliferation and arms control benefits to the US of a CTBT are substantial; the adherence of other nations to the Nonproliferation Treaty and to the CTBT is fundamentally influenced by US ratification of the CTBT. A Party could conduct tiny nuclear tests without being detected by the

Treaty's monitoring system, but tests in the hydronuclear range releasing a millionth of the energy of a Hiroshima bomb will provide little useful knowledge; tests releasing 100 tons – that is, 1% of Hiroshima yield – might sometimes be missed by the monitoring system, but would often be detected and located by other means. They, too, would have little value in the development of nuclear weapons. US nuclear weapons will be maintained reliable and safe under a CTBT, thanks to the Stockpile Stewardship Program for assessment and remanufacture. Last but not least among the six safeguards that the Administration has announced is the explicit readiness to invoke the supreme national interest clause should the need arise as a result of unanticipated technical problems in the enduring stockpile of nuclear weapons, that affect a key portion of that stockpile. On the basis of my experience in the nuclear weapons program, I agree with those US military leaders who have reviewed the benefits and costs to US security from a CTBT and strongly support the Treaty. Our national security will be improved by ratification and impaired by further delay.

It is thus greatly in our interest to ratify the CTBT now.

General Andrew J. Goodpaster: The Comprehensive Test Ban Treaty (CTBT) represents a constructive contribution and extremely important net addition to U.S. security. It is a key element in the coordinated effort to combat the proliferation of nuclear weapons, and despite the failure of the U.S. Senate to ratify it in late 1999, renewed effort leading to its reconsideration at the earliest appropriate time for ratification is clearly and unmistakably in our country's highest national security interests.

Together with the other key measures to which the United States is a party, it is a historic opportunity to help rein in and reduce nuclear danger to the United States (and to other nations as well). These measures include the Non-Proliferation Treaty (the NPT); the continued step-by-step reduction of Russian, U.S. and other nuclear arsenals to the lowest verifiable level consistent with stable security; and the cooperative U.S.-Russian measures currently being taken to give maximum reassurance regarding the security of Russian nuclear weapons and weapons-grade material.

The Non-Proliferation Treaty, a primary tool for preventing the spread of nuclear weapons, was made permanent in 1995 on the basis of a firm commitment by the United States and the other declared nuclear-weapons states to negotiate a CTBT by 1996. It is important to U.S. security that no excuse be given to nations to withdraw from the NPT nor that the Treaty be allowed to erode. To retain a leadership role in the effort against nuclear proliferation, the United States should act affirmatively and as soon as possible on the Comprehensive Test Ban Treaty through ratification.

The CTBT enjoys broad support within the United States in the interest of strengthening our national security. It has been endorsed by a long list of experienced and dedicated U.S. security officials, among them former Defense Secretary William Perry and current and former Chairmen of the Joint Chiefs of Staff including Admiral William Crowe and Generals David Jones, Colin Powell, John Shalikashvili and Hugh Shelton. The Administrations of past presidents going as far back as Presidents Eisenhower and Kennedy have each assigned high priority to the completion of a comprehensive test ban. In May 1961, former President Eisenhower said, "[not achieving a nuclear test ban] would have to be classed as the greatest disappointment of any administration, of any decade, of any time and of any party."

The test ban holds to a minimum the number of nations possessing or developing nuclear arsenals and provides a valuable basis for verification of adherence to its provisions. The United States has discontinued such testing and, barring future nuclear threats now unexpected and unforeseen, seems certain to continue on this path. The CTBT gives a high degree of assurance that other signatories will do the same. Ratification by the United States is a condition essential to the CTBT entering into force, thus precluding a resumption of testing by other countries. Verification of the test ban is a matter of particular importance. Through the CTBT there will be added technical capability to what now exists to detect nuclear explosions through a cooperative worldwide monitoring system.

The program of stockpile stewardship now underway in the United States, utilizing the superb technological capability possessed by our national laboratories, is expected to provide the necessary

degree of confidence as to the safety and reliability of United States nuclear weapons without nuclear explosive testing. It is making impressive progress in the regard, and in each of the years to date since U.S testing was discontinued, the laboratory directors have certified as to the safety and reliability of their weapons. If the need to revert to testing should nevertheless arise, there is a Treaty provision for timely reconsideration of the Treaty's restrictions.

This is a matter that warrants high priority in terms of American security. It should receive serious and responsible handling by our government at the earliest possible time.

Senator Mark O. Hatfield: The October 1999 Senate debate on the Comprehensive Test Ban Treaty demonstrates the importance, wisdom, and continuing relevance of the Cold War axiom that politics should stop at the water's edge. But the spirit of nonpartisanship that has so often, and so appropriately characterized our national security discourse was absent in the run up to the Senate's rejection of the CTBT, a treaty unquestionably in our best interest, ending an era in which the test ban itself enjoyed broad bipartisan support. As a result, if the situation is not soon corrected, U.S. national security and its position of global leadership may be jeopardized.

In 1992, I, along with Senators James Exon and George Mitchell, authored the landmark amendment which mandated an end to U.S. nuclear testing not later than 1996 and urged the president to negotiate within this same period a multilateral CTB treaty that would close the era of nuclear testing globally. Following a spirited debate, the Senate on a strong, bipartisan vote of 68-26 agreed that nuclear testing should end and that a CTBT was in our best interest. I believed then – as I do today – that it was vital that the United States, the world's pre-eminent nuclear power, seize the opportunity to set the correct example so that we can persuade other nations to refrain from acquiring nuclear weapons, and avoid giving any nuclear power reason to resume nuclear testing.

The questions debated in 1992 are similar to the questions about the Treaty today: Can we verify the reliability of our nuclear arsenal without testing? Can we enforce a global ban on nuclear tests? What happens if America fails to act or approve the test ban? The answers to these questions are the same as they were in 1992 – a nuclear test ban is clearly in America's national security interests.

The U.S. nuclear weapons arsenal is the most well-tested in the world. We have conducted more than 1,000 nuclear tests – far more than all other nations combined. The United States possesses the most advanced and effective nuclear arsenal of any nation. Since the nuclear test moratorium began in 1992, the nation's nuclear weapons laboratories have maintained the safety and reliability of U.S. nuclear weapons without nuclear testing and have even successfully undertaken warhead modernization programs. Our nation's leading nuclear weapon scientists and lab directors have determined that, with appropriate support, the remaining arsenal can be maintained through non-nuclear tests and evaluations.

Given the overwhelming nuclear capability of the United States, the CTBT is clearly in our national interest. By verifiably ending nuclear testing, it would make it much more difficult for countries with advanced nuclear weapons to produce new and even more threatening ones. It would also help stop nuclear proliferation and contribute to U.S. national security by deterring, if not preventing, nations from developing sophisticated nuclear weapons that can be delivered by ballistic missiles. The Treaty establishes an International Monitoring System of more than 320 monitoring stations around the world, including 31 in Russia, 11 in China and 17 in the Middle East, and a regime for onsite inspection. While it may be the case that detecting tests of very low yield could be very difficult, such tests are of limited military utility, especially to so-called "rogue states" and would be extremely difficult for a state with little experience with nuclear tests to successfully undertake.

While ratifying the CTBT and promoting its entry into force would support U.S. non-proliferation objectives and limit the qualitative improvement to existing nuclear arsenals without undermining the safety and reliability of our arsenal, failure to reverse the October vote could have severe consequences. The strong international reaction to the Senate's rejection of the Treaty demonstrates that two crucial tasks remain: securing approval of the Treaty by the Senate and working with our friends and allies to persuade such current non-signatories as India and Pakistan that the Treaty is in their national interest.

These two tasks are inextricably linked as, until the United States has ratified the Treaty, our standing in urging the few remaining required holdouts to join will be undercut, and the Treaty will not enter into force. History shows the cause of peace and security around the world is best served when the United States leads, and now is unquestionably a time for U.S. leadership. With the situation in South Asia as tumultuous now as ever before, and made all the more so by their possession of nuclear weapons, it is clear that little could be more important than limiting the advancement of these nations' nuclear arsenals and edging them closer to the global non-proliferation regime. These objectives can best be achieved by securing CTBT entry into force, which itself cannot happen without U.S. leadership.

But that leadership was undermined by partisanship in October. In a July 19, 1999 statement I said it was clear to me that ratifying this Treaty would be in the national interest, and that it was equally clear to me that Senators have a responsibility to the world, the nation and their constituents to put partisan politics aside and allow the Senate to consider this Treaty. Now, almost one year to the date, I renew my call to put partisanship aside and give this treaty the serious and balanced consideration it deserves. I hope your discussions will contribute to making this a reality. I wish you the best of luck. Thank you.

The Honorable Melvin R. Laird: In October 1999, I, along with five other former Secretaries of Defense, prepared a letter to several members of the U.S. Senate expressing concern about the impact that a Comprehensive Test Ban Treaty CTBT could have on the U.S. nuclear deterrent and, therefore, on U.S. national security. Our concern focused primarily on the fact that the CTBT is of indefinite duration, prohibiting the United States from conducting tests which might someday be necessary to ensure confidence in the reliability of the U.S. nuclear weapon stockpile. While my reservations about an indefinite ban on testing remain, I understand that the CTBT is nevertheless an important treaty. Arms control can and should continue to play a role in our national security posture. If proper reservations or conditions are clearly understood, then the CTBT is one that the United States as a leader in the effort to constrain the spread of nuclear weapons should embrace.

The uncertainties regarding the long-term impact that the CTBT could have on the U.S. nuclear deterrent, coupled with the Treaty's importance to global non-proliferation structures, demonstrate the immense complexity of the debate on its ratification. It is regrettable that the Administration failed to exert timely and effective leadership on CTBT issues. In its debate last October, the Senate was presented with equally compelling, yet conflicting interests, and the nature of its truncated deliberations ensured that no side received adequate attention. But this Treaty is too important for the October debate to be the last word. The question of whether a permanent CTBT can be made to be consistent with U.S. national security objectives is one that will certainly need to be addressed before a final decision is made.

Notwithstanding the difficulties in amending the CTBT text, I believe that certain conditions can be established. It may be possible to ratify the CTBT – without damage to the U.S. nuclear deterrent even if the Stockpile Stewardship Program should prove unsuccessful – by carefully crafting conditions in the resolution of ratification that protect our national security. The President himself established six conditions for U.S. participation in a zero-yield CTBT of indefinite duration. These include the conduct of an effective science-based Stockpile Stewardship Program, the maintenance of modern nuclear laboratory facilities that will attract and retain scientists, preservation of the ability to conduct tests if necessary, continuation of research and development to improve treaty monitoring capabilities, the development of broad intelligence gathering capabilities, and annual certification by the Secretary of Defense and the Chairman of the Joint Chiefs that they are both confident in the safety and reliability of the nuclear arsenal. Should they not be able to make such a certification, the President has the option to exercise our right under the supreme national interest's clause and withdraw from the Treaty. The Congress, through the U.S. Senate as a co-equal branch of our government, as well as the President, should have this same withdrawal option and condition available in the future.

In light of the concerns of the Senate and among some in the scientific community, including the directors of the national nuclear laboratories, that the safety and reliability of the U.S. nuclear arsenal

cannot be assured with absolute certainty beyond nine years, I believe that another additional condition is required. This would stipulate that the Congress conducts a formal and full review of the implementation and operation of the Treaty nine years after the United States ratification of the CTBT and at regular intervals thereafter, at times to be determined by the Congress after each review.

The nine-year review would address the impact of the CTBT on the U.S. and Allied security, on the proliferation of weapons of mass destruction, on the safety and reliability of the U.S. nuclear arsenal, and other essential concerns. The condition could direct that the Congress advise the President as to the outcome of their review and actions. The President should be required to inform the Congress annually on progress in implementing the recommendations and these conditions. In addition, the President shall submit to the Senate and House both classified and unclassified annual reports on compliance with the CTBT on a country-by-country basis and on steps the United States is taking to deal with any noncompliance issues.

With these conditions, my concern over the indefinite ban on testing could be largely met. I would then agree that being a party to a CTBT, by preserving the qualitative advantage of our nuclear arsenal and constraining the further development of advanced nuclear weaponry, would be in the best interest of the United States.

Ambassador Paul H. Nitze: For more than five decades, I was privileged to serve in a variety of foreign policy and national security positions for both Republican and Democratic administrations. In my experience there is one constant, incontrovertible fact that remains regardless of which party is in power in Washington: U.S. national interest is best served when America leads. When America hesitates, opportunities to improve our strategic situation are lost, and our security suffers.

Last year, with the rejection of the Comprehensive Test Ban Treaty (CTBT), the United States missed an opportunity for such leadership. Faced with a chance to strengthen the international nuclear non-proliferation regime, which the United States itself has long championed, the Senate decided instead that the United States should blaze its own trail. If this misguided unilateralism in a global age is not corrected, it will gravely undermine U.S. non-proliferation policy and our national security.

President Eisenhower was the first in a long line of American leaders who have sought to protect the nation by pursuing a global ban on nuclear testing. He viewed a test ban as a means to curb the U.S.-Soviet nuclear arms race: a test ban is essential today to verifiably constrain advanced and not-so-advanced nuclear weapons states from developing and deploying more sophisticated and more dangerous nuclear weapons capabilities. Nothing could be more important for ensuring U.S. security today than preventing the spread of nuclear weapons and moving to reduce their numbers worldwide. The CTBT is central to both objectives and therefore to U.S. security.

Continued failure to bring the CTBT into force fundamentally challenges U.S. national security by weakening the non-proliferation regime. The United States, as the nation with the strongest, most advanced conventional military forces in the world, benefits most from a strong nuclear non-proliferation and non-testing regime. No nation or conceivable collection of nations can challenge our ability to promote our interests around the world – unless they have nuclear weapons. Proliferation levels the playing field for weaker nations by negating our conventional superiority. With a nuclear test ban potential adversaries will not be able to develop and deploy sophisticated nuclear weapons with confidence and would therefore be unlikely to expend the resources necessary to develop them. Without a nuclear test ban, however, the NPT regime could eventually crumble, allowing nuclear weapons to span the globe. Nothing could be worse for American security.

We must always remember, however, that no matter how important a treaty's objectives may be, the United States cannot maintain its security by relying on unverifiable promises. In this respect, we should act with great caution, along the lines of President Reagan's maxim of "trust but verify" – one which guided my approach to arms negotiations with the Soviets. I am confident that the CTBT will pass this test. This Treaty's verification regime gives the United States new tools to assess compliance with a ban on nuclear testing – including the right to request a short-notice, onsite inspection if we had evidence

that a test might have occurred. Combined with the Treaty 's extensive international monitoring system and our own intelligence resources, the CTBT is effectively verifiable.

The United States is the most powerful nation in the world with the most advanced nuclear arsenal, a condition which would be preserved for the foreseeable future by the CTBT. By charging the national laboratories, home to the world's finest scientists, with safeguarding our nuclear deterrent, the President has assured that the CTBT will not degrade our ability to maintain a strong nuclear deterrent. I am confident that the United States will be able to maintain the safety and reliability of its nuclear arsenal through the Stockpile Stewardship Program. In light of our enhanced verification capabilities, our sophisticated Stockpile Stewardship Program, and the obvious benefits from stemming proliferation, I can find no technical, political or military reason why the CTBT is not the right thing to do.

In May 1961, President Dwight D. Eisenhower said, "[not achieving a nuclear test ban] would have to be classified as the greatest disappointment of any administration, of any decade, of any time and of any party." Almost forty years later, after such a treaty has finally been negotiated, I believe that failure to ratify the CTBT would have to be regarded as the greatest disappointment of any Senate, of any time, of any party. I remain convinced that the United States must lead international nuclear non-proliferation efforts and that for this reason we must ratify the Comprehensive Test Ban Treaty as soon as possible.