Lawyers Alliance for World Security

WHITE PAPER
ON
The COMPREHENSIVE NUCLEAR TEST BAN TREATY

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George Bunn
Sidney D. Drell
Richard L. Garwin
Thomas Graham, Jr
Daryl G. Kimball
Damien J. Lavera
Jack Mendelsohn (Editor)
Paul G. Richards
Amy Sands

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Message from the President of LAWS

The rejection of the Comprehensive Nuclear Test Ban Treaty (CTBT) by the U.S. Senate in October 1999 set back global efforts to protect against the dangers of the spread of nuclear weapons. The long delay in the Treaty's consideration, the manner in which it was addressed by that body, the lack of preparation by its proponents and a politicized and curtailed debate contributed to the perception that the United States had simply disregarded this most important issue. CTBT ratification and entry into force is essential if the United States is to correct this unfortunate impression and if the Nuclear Nonproliferation Treaty regime is to be preserved for the long term.

This *White Paper on the Comprehensive Nuclear Test Ban Treaty* seeks to address the core issues that arose during the debate preceding the Senate vote. It is the second in an ongoing series of White Papers commissioned by the Board of Directors of the Lawyers Alliance for World Security in December 1999 to address contemporary arms control and proliferation issues. The first in that series, the *White Paper on National Missile Defense*, was released in May 2000 and examined the impact a national missile defense program could have on U.S. security. Other White Papers will follow on the role of nuclear weapons and deterrence in the 21st century and the importance of multilateral arms control efforts to U.S. national security.

I would like to thank George Bunn, Sidney D. Drell, Richard L. Garwin, Daryl G. Kimball, Damien J. LaVera, Jack Mendelsohn, Paul G. Richards and Amy Sands, the authors of the CTBT White Paper chapters, for their hard work and insightful analysis. In addition, thanks again to Jack Mendelsohn for his work as editor, to our anonymous consulting editors, and to Alex Slesar and Scott Cantor, LAWS program officers, for their contributions.

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

Acronyms and Abbreviations

ABM(T) – Anti-Ballistic Missile (Treaty)
ACDA – Arms Control and Disarmament Agency
ALCM – Air-launched cruise missile
ASCI – Accelerated Strategic Computation Initiative
CD – United Nations Conference on Disarmament
CIA – Central Intelligence Agency
CTBT(O) – Comprehensive Nuclear Test Ban Treaty (Organization)
DOD – Department of Defense
DOE – Department of Energy
EC – Executive Council (of the CTBTO)
GLCM – Ground-launched cruise missile
GSETT-3 – Group of Scientific Experts Technical Test #3
HEU – Highly enriched uranium (containing 20% or more of U-235)
IAEA – International Atomic Energy Agency
IDC – International Data Centre (of the CTBT)
ICBM – Intercontinental ballistic missile
IMS – International Monitoring System (of the CTBT)
JASON – A committee of independent scientists who consult for DOE and DOD
Kg – Kilogram (2.2 lbs)
Km – Kilometer (5/8^{ths} of a mile)
Kt – Kiloton (1,000 tons of TNT equivalent)
LANL – Los Alamos National Laboratory
LLNL – Lawrence Livermore National Laboratory
LTBT – Limited Test Ban Treaty
NIF – National Ignition Facility
NTM – National technical means (of verification)
NPT – Treaty on the Non-Proliferation of Nuclear Weapons
OSI – On-site inspection
P-5 – Permanent Five Members of the UN Security Council
PNE – Peaceful Nuclear Explosion
Pu – Plutonium
R&D – Research and Development
REB – Reviewed Event Bulletin (of global seismicity)
SLAC – Stanford Linear Accelerator Center
SLCM – Sea-launched cruise missile
SOFAR – Sound fixing and ranging channel (in the ocean)
SSP – Stockpile Stewardship Program
TTBT – Threshold Test Ban Treaty
SALT – Strategic Arms Limitation Talks
SFRC – Senate Foreign Relations Committee
SLBM – Submarine-launched ballistic missile
SNL – Sandia National Laboratory
TS – Technical Secretariat (of the CTBTO)
UNGA – United Nations General Assembly

Executive Introduction

In the fall of 1999, the U.S. Senate rejected ratification of the Comprehensive Test Ban Treaty (CTBT). This White Paper discusses the concerns raised during the Senate debate about the reliability of the stockpile, the verifiability of the Treaty and the importance of the Treaty to the nonproliferation regime. The paper then presents a series of arguments in response to these criticisms and in support of the CTBT and concludes that the Treaty's ratification and entry into force would be in the U.S. national interest.

Chapter I, by Damien J. LaVera, reviews the **History and Summary of the CTBT**. Consideration of a nuclear test ban began in 1954 with Indian Prime Minister Jawaharlal Nehru's call for a "standstill agreement." This would eventually lead President Eisenhower to propose a Conference of Experts in 1958 in Geneva. The Conference concluded that a CTBT could be verified with a network of land-based monitoring stations, but disagreement over the details of verification hampered negotiations. The shock of the 1962 Cuban Missile Crisis reinvigorated interest in limiting nuclear tests and in 1963 the United States, the United Kingdom and the USSR reached agreement on a Limited Test Ban Treaty outlawing tests in the atmosphere, outer space and underwater.

The nuclear testing issue reemerged in 1974 when the United States and the USSR signed the Threshold Test Ban Treaty limiting underground testing to a yield of 150kt. This Treaty, together with one limiting Peaceful Nuclear Explosions (PNEs), came into force in 1990 after extensive verification protocols had been negotiated. In 1992 the Congress imposed a testing moratorium on the United States pending negotiation of a CTBT. In January 1994 formal CTBT negotiations began in the Conference on Disarmament in Geneva and a CTB Treaty was signed in September 1996. The Treaty bans "any nuclear weapon test explosion or any other nuclear explosion" in any environment. It also establishes an extensive verification regime intended to ensure compliance with its basic obligation.

Chapter II, by Daryl G. Kimball, outlines **The Senate Debate over the CTBT**. After languishing in committee for over two years, on October 13, 1999 the Senate brought the CTBT to a vote and rejected a resolution of ratification by 51 to 48. While politics and partisanship were undeniably part of the dynamics of the test ban and vote, the outcome was also shaped by the way in which proponents and opponents of the Treaty framed the issue and by the information available to senators during the brief time allotted for Treaty consideration.

The main objections to the Treaty were that: the United States could not maintain its nuclear weapons stockpile without testing; a CTBT would undermine the U.S. nuclear deterrent; the United States would abide by a "zero-yield" test ban, but other states would not; low-yield clandestine tests could not be effectively verified; and the nuclear nonproliferation value of the Treaty had been overstated and not worth the risks associated with the end of nuclear testing.

In Chapter III, Amy Sands describes **The CTBT Verification Regime**. The International Monitoring System (IMS), which is the centerpiece of the CTBT verification regime, consists of four different remote sensing networks – seismic, radionuclide, hydroacoustic and infrasonic – and an International Data Centre. The IMS will have 321 monitoring facilities and at least 16 radionuclide laboratories located in approximately 90 countries and will provide data to detect events, screen out non-nuclear ones and, in some situations, identify nuclear ones.

The CTBT verification regime will have an overall detection threshold of at least 1kt (or better in certain regions of concern and with certain technologies) and the IMS network will add considerably to the existing capabilities of the United States to determine compliance with the Treaty. Countries attempting to evade CTBT constraints will face a substantial challenge as a result of the combined capabilities of the international and U.S. national verification systems and militarily significant testing could not occur without detection and identification in a timely fashion.

Paul G. Richards, in Chapter IV, discusses **Seismology and CTBT Verification**. The IMS seismographic network, together with unclassified arrays of seismic instruments, can be expected to provide data adequate to monitor vast areas of the globe for underground explosions down to about magnitude 4 on the Richter scale (0.5kt for a fully-coupled explosion) and down to about magnitude 2 to 2.5 (.01kt of well-coupled yield) at Russia's former nuclear test site on Novaya Zemlya. Seismology is continuing to provide new methods of data acquisition and analysis, furnishing useful information that will improve the work of the IMS and assist in the attainment of national and international monitoring goals for a CTBT.

Chapter V, by Sidney D. Drell, explains **The Stockpile Stewardship Program**. The United States relies on an expanded program of stockpile stewardship to ensure that the enduring arsenal remains reliable, effective and safe into the indefinite future without nuclear explosive testing, that it maintains competence in nuclear weapons, and that it retains the technical capability and manufacturing infrastructure to respond to changed strategic circumstances.

Today, Drell actually has more confidence in the long-term credibility of our stockpile than was possible five years ago. This conclusion is based upon what has been learned from the stockpile stewardship program over the last five years and the on-going formal reviews that require the national laboratory directors to certify annually to the President, the Secretary of Energy and the Secretary of Defense that U.S. weapons are meeting stated military requirements. The data being derived from the stockpile stewardship program is far more important for understanding the enduring arsenal, and maintaining confidence in its performance, than continued underground, very low-yield testing.

In Chapter VI, Richard L. Garwin discusses **Clandestine Testing under a CTBT** and concludes that a CTBT can be verified with sufficient confidence to prevent any proliferator from developing thermonuclear weapons whether it already possesses fission weapons or develops such weapons clandestinely. Moreover, while tests with yields vastly smaller than Hiroshima may evade detection, such tests would be useless to Russia and China who have already deployed thermonuclear weapons, and very difficult for a potential proliferator to use for confirming the validity of a clandestinely developed fission weapon.

Chapter VII, by George Bunn, addresses the question of **The CTBT and Nuclear Proliferation.** The U.S. Senate's vote has weakened the NPT, jeopardized implementation of the International Atomic Energy Agency's (IAEA) more intrusive safeguards system, weakened U.S. ability to persuade others to ratify the CTBT and observe strong export controls, and increased the likelihood that more countries will drift away from the NPT and consider going nuclear. Indeed, the Senate's rejection of the CTBT has given countries slow to sign or ratify the CTBT good reason for not doing so because the Treaty cannot come into effect without the United States. If we are to avoid this series of events, and if the United States is to renew its leadership and bargaining leverage in its efforts to stop the spread of nuclear weapons, then U.S. adherence to the CTBT is essential.

Chapter VIII, by Thomas Graham, Jr., on **Russia, China and the CTBT**, argues that ratification and entry into force of the CTBT would clearly benefit U.S. national security in relation to Russia and China. It would strengthen the NPT regime and promote greater transparency at the Russian and Chinese test sites. It would augment the already impressive U.S. global monitoring system and hinder modernization of the Russian and Chinese nuclear arsenals. Finally, it would enhance U.S. security by locking Russia and China into a legally binding, verifiable international ban on nuclear testing and by situating both countries firmly in the nuclear nonproliferation regime.

Jack Mendelsohn, in Chapter IX, asks the question "**Is a CTBT in the U.S. Interest**?" The United States is the most powerful nation in the world, faces a greatly reduced post-Cold War threat, is under no political or public pressure to resume testing and has no military requirement for new nuclear weapons. The enduring stockpile is in excellent shape and the stewardship program is proving capable of maintaining confidence in the safety and reliability of the nuclear arsenal.

As possessor of the world's most sophisticated nuclear stockpile, U.S. technological superiority would be assured by a CTBT. A CTBT would also reduce the likelihood that significant new threats to the United States would arise by limiting the emergence of new nuclear states and constraining the ability of any proliferator to develop advanced thermonuclear weapons. A CTBT would, in addition, enhance already existing and highly capable U.S. monitoring capabilities by putting in place a world-wide network for detecting nuclear explosions.

Finally, ratifying the CTBT would allow the United States to reassert its leadership in the area of arms control and nonproliferation. The Treaty will to the world that the United States is committed to arms control, prepared to fulfill its NPT obligations and willing to rein in its own nuclear programs.

Chapter I

History and Summary of the CTBT

Damien J. LaVera

The Early Years: Eisenhower & Kennedy

Serious consideration of banning nuclear explosive tests began in April 1954 when Indian Prime Minister Jawaharlal Nehru called for a "standstill agreement" on nuclear testing.[1] Little was accomplished at the time in terms of pursuing this idea, but it helped set the stage for significant efforts toward the end of the decade. In August 1957, motivated in part by public reaction to reports of the negative health effects of radioactive fallout from atmospheric nuclear tests, President Eisenhower proposed a two-year suspension of testing under certain conditions. These included a permanent cessation of fissionable material production and agreement to an inspection system to ensure compliance. The Soviet Union rejected the conditions, but announced instead the first unilateral moratorium on testing.

President Eisenhower responded to the Soviet moratorium by proposing a meeting of technical experts to discuss issues related to verifying a test ban. A Conference of Experts met in July and August 1958, and included scientists from the United States, Canada, Czechoslovakia, France, Poland, Romania, the United Kingdom, and the Soviet Union. On August 21, the Conference issued a report indicating that adherence to a CTBT could be verified with a network of some 160-170 land-based monitoring stations. The following day, Eisenhower proposed a one-year testing moratorium and in the fall, trilateral test ban negotiations began among the United States, the Soviet Union and the United Kingdom.

While progress was made on numerous issues in the trilateral negotiations, concerns about the effectiveness of verification emerged as studies were released in the United States indicating that states could hide nuclear test explosions by "decoupling" them (testing in large caverns, see Chapters III and IV) or otherwise masking their signal. The parties also disagreed about the number and nature of on-site inspections, with the United States and the United Kingdom proposing 20 such inspections and the Soviet Union three.

In February 1960, Eisenhower proposed a "phased" approach to a comprehensive test ban. However, events in the international arena began to interfere with the negotiations. In February 1960, the French conducted their first nuclear test. In May of that year, a U.S. U-2 reconnaissance plane was shot down over the Soviet Union contributing to a general deterioration that year in U.S.-Soviet relations. In April 1961, the United States and Britain proposed a threshold test ban that would have prohibited all nuclear tests except underground explosions measuring less than 4.75 on the Richter scale, but the Soviet Union rejected its verification provisions. In September 1961, the Soviet Union resumed atmospheric testing (the United States had actually ended its moratorium in December 1959 but pledged not to resume testing unless others did so). In January 1962, the trilateral negotiations were indefinitely adjourned and in April 1962 the United States resumed atmospheric testing.

Efforts to achieve a CTB were revived in late 1962, but verification concerns continued to hamper negotiations. The October 1962 Cuban Missile Crisis, however, had a sobering effect on both the Soviet Union and the United States and, in July 1963, prompted renewed efforts to reach agreement on a CTB. Once again, differences over the number of annual on-site inspections blocked an agreement and resulted in consideration of the option for a limited rather than a comprehensive test ban. This led to the

[1] This section relies on two principal sources: Catherine R. Mendelsohn, *Arms Control and Disarmament: The U.S. Commitment*, U.S. Information Agency, 1997, pp.45-52 and the Committee on International Security and Arms Control of the National Academy of Sciences, *Nuclear Arms Control Background and Issues*, National Academy Press, 1985, pp. 187-223.

completion in August of the Treaty Banning Nuclear Weapons Tests in the Atmosphere, in Outer Space and Underwater (the Limited Test Ban Treaty or LTBT) which entered into force on October 10, 1963.

The Slow Down: the 1970s and 1980s

While the preamble to the LTBT called for the completion of a treaty banning all forms of nuclear testing at the earliest date possible, putting an end to tests in the atmosphere ironically eased much of the public and political pressure for a comprehensive test ban. For the remainder of the 1960s and into the early 1970s, arms control efforts focused instead on non-proliferation and on limiting and reducing strategic nuclear forces.

The testing issue reemerged in 1974, however, when, with the SALT II strategic nuclear force talks stalled, President Richard Nixon in serious Watergate trouble and a U.S.-Soviet summit scheduled for July, both sides were anxious to demonstrate continuing momentum in the arms control arena. Thus on July 3, 1974 President Nixon and General Secretary Leonid Brezhnev signed the Treaty on the Limitation of Underground Nuclear Weapon Tests (the Threshold Test Ban Treaty or TTBT), which banned all underground tests with yields over 150kt.

A companion Treaty on Underground Nuclear Explosions for Peaceful Purposes (the PNE Treaty or PNET), which limited PNEs to the same 150kt threshold, was signed by President Gerald Ford and General Secretary Brezhnev on May 28, 1976. (The TTBT negotiators had intended to include PNEs in their 1974 agreement, but issues related to distinguishing PNEs from nuclear explosions that could contribute to weapons development prevented agreement at that time.)

Trilateral CTB talks (U.S.-U.K.-USSR) began again in 1977, but by 1979 they were overshadowed by the end of seven years of SALT II negotiations and later by the Soviet invasion of Afghanistan. The CTB negotiations recessed in November 1980, and President Ronald Reagan opted instead in 1982 to pursue negotiation of on-site verification and monitoring protocols to the unratified TTBT and PNE Treaties. These were concluded under President Bush in June 1990 and the Treaties were ratified by the U.S. Senate and entered into force in December of that year.

The End Game: The 1990s

When President George Bush took office in January 1989, he reaffirmed the Reagan administration's policy that while a CTBT was a long-term objective of the United States, it was not in its immediate national interest. In the fall of 1991, however, in response to an October 5 announcement by Soviet President Mikhail Gorbachev of a unilateral, one-year moratorium on nuclear testing,[2] growing pressure within the United States to reciprocate, and the determination by President Bush that, in light of improved U.S.-Soviet relations and the significant reductions in nuclear arsenals negotiated to that point, the United States would not conduct nuclear explosive tests for new weapons designs, a bipartisan Congressional coalition led by Senator Mark Hatfield (R-OR), George Mitchel (D-ME) and Representative Michael Kopetski (D-OR) introduced legislation calling for a similar U.S. testing moratorium.

Senator James Exon (D-NE) worked with fellow senators to offer a modified version of the original proposal (known as the "Hatfield-Mitchell-Exon" amendment) which was approved by the Senate as an amendment to the FY-93 Defense Authorization Act on September 18, 1992 by a vote of 55-40. The House of Representatives followed on September 24, passing the amendment in the Energy and Water Development Appropriations Act by a margin of 224-151. It legislated a 9-month U.S. testing moratorium, placed strict conditions on any further U.S. testing (allowing only five per year primarily for the purposes of reliability and developing safety devices), required test ban negotiations to be completed before September 30, 1996, and prohibited the United States after that date from any testing pending the

[2] The last Soviet/Russian nuclear test was held on October 24, 1990.

completion of a treaty unless another nation had tested. President Bush reluctantly signed the amendment into law on October 2, 1992.[3]

President Bill Clinton took office in January 1993 and in March National Security Advisor Anthony Lake ordered the completion of an interagency review of U.S. policy toward nuclear testing and a CTBT. This review was conducted against the background of preparing for the 1995 Nuclear Nonproliferation Treaty (NPT) Review and Extension Conference and efforts to persuade Belarus, Ukraine and Kazakhstan to surrender the nuclear weapons left on their territory after the dissolution of the Soviet Union. In July 1993, President Clinton announced that, as a result of this review, the United States would extend its testing moratorium and seek to negotiate a CTBT. In August 1993, with U.S. support, the Geneva Conference on Disarmament (CD) established an Ad Hoc Committee on a Nuclear Test Ban with a mandate to negotiate a treaty.

Formal negotiations for a CTBT began in the Ad Hoc Committee on January 25, 1994. Progress in these talks was significantly aided by a U.S. decision in January 1995 to extend its testing moratorium and drop its proposal for an "easy out" clause that would have facilitated a potential U.S. withdrawal from the Treaty ten years after its entry into force and by the August 1995 decisions by the United States and France (and later the other P-5 states) to support a true "zero yield" test ban. In announcing the "zero yield" decision, President Clinton conditioned it with a package of six safeguards (see Box 1).

Box 1
CTBT Safeguards

On August 11, 1995, when announcing U.S. support for a "zero yield" CTBT, President Clinton also established a series of six specific safeguards that define the conditions under which the United States would enter into a CTBT. These six safeguards are:

A: The conduct of a science-based stockpile stewardship program to ensure a high level of confidence in the safety and reliability of nuclear weapons in the active stockpile, including the conduct of a broad range of effective and continuing experimental programs.
B: The maintenance of modern nuclear laboratory facilities and programs in theoretical and exploratory nuclear technology which will attract, retain, and ensure the continued application of our human scientific resources to those programs on which continued progress in nuclear technology depends.
C: The maintenance of the basic capability to resume nuclear test activities prohibited by the CTBT should the United States cease to be bound to adhere to this treaty.
D: Continuation of a comprehensive research and development program to improve our treaty monitoring capabilities and operations.
E: The continuing development of a broad range of intelligence gathering and analytical capabilities and operations to ensure accurate and comprehensive information on worldwide nuclear arsenals, nuclear weapons development programs, and related nuclear programs.
F: The understanding that if the President of the United States is informed by the Secretary of Defense and the Secretary of Energy (DOE) – advised by the Nuclear Weapons Council, the Directors of DOE's nuclear weapons laboratories and the Commander of the U.S. Strategic Command – that a high level of confidence in the safety or reliability of a nuclear weapon type which the two Secretaries consider to be critical to our nuclear deterrent could no longer be certified, the President, in consultation with Congress, would be prepared to withdraw from the CTBT under the standard "supreme national interests" clause in order to conduct whatever testing might be required.

[3] The last U.S. nuclear test was September 23, 1992. The last U.K. test was November 26, 1991.

In the meantime, international pressure for a treaty continued to mount throughout the mid-1990s. In May 1995, the States Parties to the NPT – 178 at that time – convened the NPT Review and Extension Conference to determine the future of that Treaty. In conjunction with agreeing to the indefinite extension of the NPT, the Conference adopted by consensus a Statement of Principles and Objectives for Nuclear Non-Proliferation and Disarmament that included a call for the completion of a CTBT by the end of 1996. The provision on negotiating a CTBT was the only commitment in the Statement of Principles with a specific deadline for completion.

By January 1996, CTBT talks in Geneva had stalled over an Indian proposal to include a provision in the Treaty calling for a time-bound framework for nuclear disarmament and a Chinese proposal to allow peaceful nuclear explosions (PNEs for example civil engineering projects). India's condition would not be included in the Treaty and it would refuse to sign the agreement. In June 1996, China dropped its proposal (although the Treaty allows the PNE issue to be reconsidered at a Review Conference ten years after entry into force and to be permitted if there is unanimous consent).

By this time, however, new disagreements over the requirements for CTBT entry into force had begun to emerge. While some countries, including the United States, wanted a "flexible" entry into force requirement, others, most notably China, the United Kingdom and Russia, insisted on a requirement that would ensure the participation of the new or undeclared nuclear states such as India, Israel and Pakistan. Although the CD was aware of the problems that could be caused by specifying a list of nations that had to ratify before the Treaty could enter into force, that option prevailed.

By August 1996, the parties had settled the remaining disputes but India announced that it would block agreement in the CD. The Australian Foreign Minister then proposed a resolution to the CD impasse by seeking endorsement of the CTBT text from the UN General Assembly (UNGA), a maneuver which India could not veto. The UNGA adopted the text and recommended signature on September 10, 1996 by a vote of 158 in favor, three opposed (India, Bhutan and Libya) and five abstentions (Cuba, Lebanon, Syria, Mauritius and Tanzania). On September 24, President Clinton became the first world leader to sign the Treaty calling it "the longest-sought, hardest-fought prize in the history of arms control."

Summary of the Treaty

Article I of the CTBT sets forth the basic obligations and purpose of the Treaty. It requires each State Party not to "carry out any nuclear weapon test explosion or any other nuclear explosion". This prohibits tests in any environment (i.e. underground, underwater, in the atmosphere, in outer space, etc.) as well as PNEs. Article I also prohibits states from allowing any nuclear explosion on its territory or any territory under its control.[4] Parties are also obligated to "refrain from causing, encouraging, or in any way participating in" nuclear testing.[5] The CTBT prohibits only nuclear explosions and not other activities involving a release of nuclear energy or the maintenance of the nuclear arsenal. Thus, the operation of nuclear power or research reactors, test site preparations and the stewardship of existing nuclear stockpiles are not prohibited by Article I.

Article II establishes the Comprehensive Nuclear Test-Ban Treaty Organization (CTBTO) to ensure implementation of the Treaty and to provide a forum for consultation and cooperation among the States Parties. The CTBTO is located in Vienna, Austria and will consist of a Conference of States Parties, an Executive Council and a Technical Secretariat. The Conference is composed of all the States Parties, will meet annually, and is the overall governing body of the CTBTO. The Executive Council is to be

[4] Neither the UK nor France has conducted nuclear tests on their mainland territory. The UK tested first in Australia and then at the U.S. test site in Nevada. France tested first in Algeria and then at a possession in the South Pacific.
[5] The Israeli nuclear program benefited significantly from data provided from and attendance of Israeli observers at French nuclear tests. The British program benefited from a similar arrangement with the United States.

composed of 51 States Parties, equitably distributed geographically, and as empowered by the Conference, will be responsible for promoting the effective overall implementation of, and compliance with, the Treaty. The Technical Secretariat is responsible for carrying out the Treaty's verification procedures including the supervision and coordination of the International Monitoring System (See Chapters III and IV).

The Treaty, in Article IV and the Verification Protocol, establishes an extensive verification regime intended to ensure compliance with its basic obligation. The regime is designed to monitor seismic and other events and to detect nuclear explosions anywhere in the world in order to deter possible efforts to evade the ban on testing. The verification regime, described in detail in Chapters III and IV, consists of an International Monitoring System (IMS) with global seismological, radionuclide, hydroacoustic and infrasound sensor networks, on-site inspections, consultation and clarification provisions and confidence-building measures involving voluntary data exchanges. The Treaty allows the States Parties to use information gathered through national technical means (NTM) for verification and as the basis for on-site inspection requests.

The Treaty may be amended with the approval of a simple majority of the States Parties, but with no State Party casting a negative vote (Article VII). The Treaty will be subject to review by all the States Parties ten years after entry in force (and may be reviewed every ten years thereafter – Article VIII), at which time the question of conducting underground nuclear explosions for peaceful purposes (PNEs) may be reconsidered. Such explosions, however, would only be permitted if agreed by consensus. The Treaty is of unlimited duration, although each State Party has the right to withdraw from the Treaty if it decides that extraordinary events related to the subject matter of the Treaty have jeopardized its "supreme interests" (Article IX).

In the four years since it opened for signature, 160 nations have signed and 65 have ratified the CTBT but its entry into force is conditioned upon ratification by 44 states listed in an Annex.[6] These states were members of the CD at the time of the negotiations that were listed by the IAEA as possessing either nuclear power or nuclear research reactors. To date, 41 of the 44 have signed (holdouts are India, North Korea and Pakistan) and 30 of the 44 have ratified (including France, Russia and the United Kingdom).

The Treaty includes a provision (Article XIV) for a special conference to explore methods "consistent with international law" to expedite entry into force if this has not occurred three years after its opening for signature (with the option for annual conferences thereafter). This conference convened in October 1999 and is likely to meet again in 2001.

[6] These states were the members of the CD at the time of the negotiations that were listed by the IAEA as possessing either nuclear power or nuclear research reactors.

Chapter II

The 1999 Senate Debate Over The CTBT

Daryl G. Kimball

On September 23, 1997, President Bill Clinton transmitted the Comprehensive Test Ban Treaty (CTBT) to the U.S. Senate for its advice and consent to ratification.[7] A little over two years later, on October 13, 1999, the Senate rejected ratification in a largely party line vote with 51 senators against ratification and 48 in support (with one senator, Robert Byrd, D-WV, voting "present.")

While politics and partisanship were undeniably part of the dynamics of the Senate debate and vote, the outcome was also shaped by the way in which the proponents and opponents of the CTBT framed the issue and by the information presented to senators. This chapter summarizes and briefly analyzes the major arguments against the CTBT presented by Senators at that time. Extensive responses to these senatorial criticisms will be found in the succeeding chapters of this White Paper.

The Context of the CTBT Debate

An important aspect of the October 1999 Senate debate on the CTBT was the relatively short period of time available for many senators to sort out the complexities of the issue and weigh the conflicting evidence and arguments presented by proponents and opponents.

After being bottled up for two years in the Senate Foreign Relations Committee, the debate and vote on the Treaty were scheduled in a sudden burst of activity. In the summer of 1999, Senate Majority Leader Trent Lott (R-MS), Foreign Relations Committee Chairman Jesse Helms (R-NC), and other key Treaty opponents, including Senator Jon Kyl (R-AZ), believed that White House and Senate Treaty supporters were preparing to make a push to begin the process of Senate consideration and a vote. In response to these efforts, Senate Treaty opponents quietly intensified their lobbying efforts with the objective of securing commitments from at least 34 senators to oppose the Treaty.

By mid-September, unaware of the opposition's quiet lobbying effort, Senator Joseph Biden (D-DE), along with other key Senate CTBT proponents and the White House, decided to try to advance the issue by introducing a non-binding Senate resolution that called for beginning the process of considering the CTBT and scheduling a vote on the Treaty by March 31, 2000. On September 29, after having been informed of the Democrats' intention to introduce their resolution, Senators Lott and Helms responded by abandoning their blocking strategy and proposed a vote on final passage of the CTBT on October 7. Lott calculated that the Democrats might not agree to his terms for a truncated debate and that, even if they did, he could assemble the votes needed to block ratification.

Senate Treaty supporters did not believe that the Majority Leader's proposal provided sufficient time for hearings, negotiations on a resolution of ratification, and floor debate. Nevertheless, after gaining a few more days from the Republican leadership, Senate Democratic leaders decided to accept Senator Lott's "take it or leave it" offer for a unanimous consent resolution for a vote on October 12.[8] The decision to accept the offer was motivated, in part, by the belief that the effect of continued inaction on the Treaty could be as severe as outright defeat.[9]

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[7] "Message from the President of the United States Transmitting the Comprehensive Nuclear Test Ban Treaty," September 23, 1997, Treaty Document 105-28.

[8] For further discussion of the political circumstances leading to the October 1999 vote, see Richard Lowry, "The Test-Ban Ban," *National Review*, November 8, 1999 and Daryl G. Kimball, "What Went Wrong: Repairing the Damage to the CTBT," *Arms Control Today*, December 1999.

[9] "Nuclear Test Ban Vote Set for October," Associated Press, October 2, 1999.

The Senate leadership allotted two days of hearings in the Senate Armed Services Committee (October 6 and 7), one day in the Senate Foreign Relations Committee (October 7), and a closed briefing in the Select Committee on Intelligence (October 6).[10] The two and one-half days of floor debate began the morning after the hearings ended and the final floor vote was held just five days after the hearings. There were no committee reports on the Treaty.

Despite the compressed schedule, Senator Lott and other Treaty opponents maintained that this provided ample time to review the issues. (By comparison, the Senate held 11 days of SFRC hearings and devoted nearly three weeks of floor debate to the 1963 LTBT. More recently, the Senate devoted nine days of floor debate to the 1988 Intermediate-Range Nuclear Forces (INF) Treaty after 23 days of SFRC hearings. The Senate conducted three days of floor debate on the 1997 Chemical Weapons Convention (CWC) after 14 days of SFRC hearings.)

For many senators, however, including Richard Lugar (R-IN) and others who would later vote "no," the agreement to Senator Lott's proposal "...reduced to a few days... a process that normally would take many months...."[11] As Lugar noted, "Many senators know little about this Treaty. Even for those of us on national security committees, this has been an issue floating on the periphery of our concerns."

For the White House and Senate CTBT proponents, the short time allotted for the Senate debate compounded the difficulty of responding to the opponents' arguments and objections and to their list of high-profile critics. The uncertainties and doubts of some senators were reinforced by letters from these critics, who included a number of prominent former national security officials, urging that the Treaty be defeated or the vote postponed.

As early as 1998, the Clinton administration had begun to line up support for the CTBT from four former Chairmen of the Joint Chiefs of Staff, the directors of the nuclear weapons laboratories, and the NATO allies, but failed to build upon this base of support with a sustained, high-level Senate lobbying campaign. Although the President and his National Security Advisor, Samuel Berger, called the CTBT "one of the President's top priorities," in reality, the President and the administration were preoccupied with domestic policy priorities, the war in Kosovo and the President's impeachment difficulties and devoted little attention to the ratification effort.

How much of a factor the compressed schedule was on the final vote on October 13 can not be known exactly, but many senators sought more time. In an October 12 letter to Senate Majority Leader Lott and Minority Leader Tom Daschle (D-SD), 24 Republicans and 38 Democrats sought to "put…off final consideration until the next Congress."[12] As Senator Chuck Hagel (R-NE) lamented, "…we are trapped in a political swamp as we attempt to compress a very important debate on a very important issue."[13]

Considering that floor debate began one day after the second (and last) day of hearings, many senators and their staff on both sides of the issue were hard-pressed to fully assess the extensive body of information on the Treaty before the time came for them to render a judgment. For example, President Clinton's six proposed "safeguards" of August 1995, designed to address the concerns of CTBT skeptics **(**see Box 1**)**, received scant attention and there were no public or private exchanges on possible alternative

[10] Shortly after the CTBT was transmitted to the Senate, the Governmental Affairs Subcommittee on International Security, Proliferation and Federal Services held two hearings on nuclear weapons stockpile issues and the CTBT (October 27, 1997 and March 18,1998) and the Appropriations Subcommittee on Energy and Water Development held a hearing on the CTBT and the maintenance of the nuclear stockpile (October 29, 1997).
[11] "Lugar Opposes Comprehensive Test Ban Treaty," Press Release, Office of Senator Lugar, October 7, 1999.
[12] Letter from 62 Senators on Delaying Consideration of the CTBT, *Congressional Record*, October 13, 1999.
[13] Remarks of Senator Chuck Hagel, *Congressional Record*, Oct. 8, 1999.

amendments to the resolution of ratification. Senator Kyl, the floor manager for the CTBT opponents, explained that "We accepted [the safeguards] because it is what is being done anyway... But they are not going to make the Treaty any better or worse."[14]

Summary of Key Arguments Against the CTBT

Over the course of 18 hours of formal debate on October 8, 12, and 13, a total of 64 senators took the floor to speak about the CTBT, including 30 of the 51 senators who would vote against Treaty ratification. The arguments presented against the CTBT closely paralleled letters and briefing materials forwarded to the Senate in the weeks preceding the debate as well as some of the testimony delivered in the hearings by the nuclear weapon laboratory directors.

Among the most often cited documents were an October 6, 1999 letter from six former Republican Secretaries of Defense,[15] a September 9, 1999 open letter to Senator Lott from 52 former government officials and experts,[16] and a collection of statements and individual letters criticizing the Treaty assembled by the office of Senator Helms.[17] The main lines of argument against the CTBT in these testimonials and in the floor debate were based primarily on a relatively small number of think tank critiques, [18] and earlier statements from key officials.[19]

The 51 "no" votes came from two principal groups of senators: the so-called "hard-liners," such as Senators Kyl and Helms, who oppose most, if not all, forms of arms control, consider the CTBT as "fatally flawed," and believe the United States should have the option to test and modernize its nuclear arsenal; and the so-called "moderate" Republicans, such as Senators Pete Domenici (R-NM), Hagel and Lugar, who support arms control and the goals of the CTBT but who said that they considered the CTBT to be, on balance, "…not of the same caliber as other agreements." [20]

The main objections to the Treaty were that:

– the United States cannot maintain its nuclear weapons expertise or the safety and reliability of its nuclear stockpile without nuclear testing, that there is no proven, guaranteed "substitute" for testing, and that the United States therefore should not ratify a test ban of indefinite duration. Most hard-liners argued that the Stockpile Stewardship Program (SSP) will never work; most moderates were concerned about current stewardship capabilities and suggested more time was needed to improve them (see Chapters V and VI for further discussion of these issues);

[14] Remarks of Senator Jon Kyl, *Congressional Record*, October 12, 1999.
[15] Letter to Trent Lott and Tom Daschle from James Schlesinger, Richard Cheney, Frank Carlucci, Casper Weinberger, Donald Rumsfeld, and Melvin Laird, October 6, 1999.
[16] "An Open Letter to Trent Lott," Richard V. Allen, Kathleen Bailey, et. al, September 9, 1999.
[17] "Memo to all Senators from Senator Helms [on the CTBT]," Office of Senator Jesse Helms, October 7, 1999.
[18] "The CTBT: The Costs Outweigh the Benefits," by Kathleen C. Bailey, *CATO Policy Analysis* No. 30, January 15, 1999 <http://www.cato.org/pubs/pas/pa-330es.html> and "The Clinton Administration and Nuclear Stockpile Stewardship: Erosion by Design," Floyd D. Spence, Chairman, House National Security Committee, Oct. 30, 1996. For rebuttals to these reports, see: "Facing Reality: Resuming Nuclear Test Explosions Would Harm U.S. and International Security," by Christopher Paine, Natural Resources Defense Council, February 1999, <http://www.clw.org/coalition/nrdc299b.htm> and "The Test Ban and Stockpile Stewardship: A Response to Chairman Spence," A Coalition to Reduce Nuclear Dangers Report by Tom Zamora Collina, June 1997, <http://www.clw.org/coalition/collina.htm>
[19] Senate Governmental Affairs Subcommittee on International Security, Proliferation and Federal Services on the Condition of the U.S. Nuclear Stockpile, October 27, 1997.
[20] "Lugar Opposes CTBT," Press Release, Office of Senator Lugar, October 7, 1999.

- the United States will abide by a "zero-yield" test ban, but other states will not. Opponents also claimed that the United States will be unable to effectively monitor all low-yield nuclear test explosions that could provide hostile states with military advantages, and the Treaty can not be effectively enforced in the event of a violation (see Chapters III, IV and Box 5 for further discussion of these issues); and that

- the nuclear nonproliferation value of the Treaty is negligible. Hard-line opponents said the CTBT has little or no value to nonproliferation, while moderates suggested its non-proliferation value was overstated and not worth the perceived risks associated with a test ban treaty (see Chapters VII, VIII and IX for further discussion of these issues).

First Argument: The CTBT Will Undermine the U.S. Nuclear Deterrent

A fundamental difference between those senators who spoke for and those who spoke against the Treaty was their view of the effect of the CTBT on the U.S. nuclear weapons stockpile and its "deterrent" capability. Nearly all senators who spoke against the CTBT asserted that nuclear test explosions are necessary to maintain the existing nuclear arsenal. Despite the more stringent certification process adopted following the 1993 extension of the nuclear test moratorium, some Treaty opponents claimed that confidence in the safety and reliability of U.S. nuclear weapons has already declined since the last nuclear test in 1992 and that "this degradation in confidence cannot be quantified."[21]

Citing weapons scientists in and outside of government, CTBT proponents argued that nuclear test explosions were not needed to maintain the U.S. stockpile or to detect age-related defects and that the arsenal is and can continue to be sustained through stockpile surveillance, tests of non-nuclear components, sub-critical tests, disassembly, component inspection and remanufacture (see Chapters V, VI and Appendix B).

Senator Kyl was among a small number of senators who also focused on the effect of a test ban on warhead "safety." Kyl suggested that the CTBT eliminates the possibility of improving the safety of current weapons through the incorporation of existing, well-understood safety features.[22] This argument overlooks the fact that U.S. nuclear weapons have for some time been considered to be satisfactorily configured to preclude accidental nuclear detonations and minimize the dispersal of radioactive material in the event of an accident. It also neglects the fact that the U.S. military has determined that it is not cost-effective to spend the billions that would be required to install additional safety features and has instead implemented operational procedures to achieve the required margins of warhead safety (see Chapter V).

A small number of the most ardent CTBT opponents, including Senators Larry Craig (R-ID) and Jeff Sessions (R-AL), opposed the CTBT on the basis of the fact that it would impede the ability to the U.S. to create new types of U.S. nuclear weapons for potential future military missions and on the fear that it would "allow ...our adversaries to catch up and, God forbid, pass us." [23]

Citing the "uncertainties" of the post-Cold war era, these senators stated that "... our nuclear weapons continue to serve as an essential hedge against a very uncertain future with both Russia and China ... and an even broader range of threats than in the past, including rogue states armed with weapons of mass destruction."[24] Although President Bush had adopted a policy of not conducting nuclear tests for the development of new types of nuclear weapons in 1992, these senators urged defeat of the CTBT because

[21]Prepared Testimony of Dr. Robert B. Barker, Senate Armed Services Committee, October 7, 1999.
[22] Remarks of Senator Jon Kyl, *Congressional Record*, 106th Congress, October 8, 1999
[23] Remarks of Senator Jeff Sessions, *Congressional Record*, 106th Congress, October 8, 1999.
[24] Remarks of Senator Jon Kyl, *Congressional Record*, 106th Congress, October 13, 1999.

it would prevent the United States from making its "... arsenal relevant to a world of rogue actors with dug-in, hardened shelters and WMD capabilities that will likely require new weapons designs."[25]

The question of nuclear weapons modernization as a means of coping with future security threats is an important one. The debate, however, did not address whether some of the operational characteristics of existing nuclear weapon systems can be adapted to give warheads new capabilities without testing the nuclear explosive package, as was the case of the B-61 Mod 11 earth-penetrating gravity bomb. The debate also avoided discussion of whether it was necessary or wise to create new "war-fighting" capabilities for the U.S. deterrent force of several thousand warheads.

The majority of the senators voting "no" on the CTBT said their opposition was based on their view that the SSP was an inferior "alternative" to periodic nuclear test explosions, that the SSP had not yet been proven, that it would not be "fully operational until 2010 or beyond," and that long-term funding for stockpile stewardship activities is not certain and may erode, jeopardizing stockpile safety and reliability.[26] These views were influenced by incorrect assumptions about the role and purpose of nuclear weapons tests and the belief that every future SSP element is essential to maintaining the arsenal in the absence of nuclear test explosions. Some Treaty opponents criticized Clinton administration negotiators for not insisting that the CTBT last only 10 years. They argued that this would provide a future President with greater flexibility to resume testing to "fix" potential problems with the nuclear stockpile if they arose.

Largely as a result of the manner in which the Clinton administration – and particularly the Department of Energy[27] and the nuclear weapons laboratories – presented the SSP program, many CTBT opponents incorrectly perceived that it was intended to "... accomplish the goals previously achieved through nuclear testing,"[28] Consequently, Senate opponents argued, "If we are to put our faith in a program other than testing to ensure the safety and reliability of our nuclear deterrent ... we must have complete faith in its efficacy." [29]

The critics of the SSP were concerned that remanufacturing existing nuclear warheads, rather than creating and building new warhead types, could be a potential problem because many of the components and procedures used in the original weapons designs no longer exist. [30] Some expressed concern that parts of the SSP program have experienced setbacks. Calling it "the linchpin" of the program, Senator Kyl also noted that the National Ignition Facility (NIF) has fallen behind schedule, is over budget, and may not achieve its goal of thermonuclear ignition (see Chapter V and Appendix B).[31]

In the absence of greater clarity about SSP, many senators were troubled by the October 7 testimony delivered by the National Laboratory directors, which implied that because of long-term funding uncertainties for the $4.5 billion a year SSP program and because some additional program elements will not be fully in place "until the middle of the next decade," confidence in the future success of the program cannot be guaranteed. Without such a guarantee, many Senate Treaty opponents concluded, the United States could not afford to ratify a ban on nuclear testing of unlimited duration.

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[25] Remarks of Senator Jon Kyl, *Congressional Record*, 106th Congress, October 8, 1999.
[26] Lugar Opposes Comprehensive Test Ban Treaty," Press Release, Office of U.S. Senator Richard G. Lugar, October 7, 1999 and Remarks of Senator Wayne Allard, *Congressional Record*, 106th Congress, October 8, 1999.
[27] See Fiscal Year 2000 Stockpile Stewardship Plan, Executive Overview, U.S. Department of Energy, March 1999.
[28] Letter from John Knuckolls to Senator Jon Kyl, September 2, 1999, in *Congressional Record*, 106th Congress, October 12, 1999.
[29] "Lugar Opposes Comprehensive Test Ban Treaty," Press Release, Office of U.S. Senator Richard G. Lugar, October 7, 1999.
[30] Ibid.
[31] Remarks of Senator Jon Kyl, *Congressional Record*, 106th Congress, October 8, 1999.

However, as the three nuclear weapons laboratory directors elaborated in an October 8, 1999 statement, "While there can never be a *guarantee* that the stockpile will remain safe and reliable indefinitely without nuclear testing, we...are confident that a fully supported and sustained stockpile stewardship program will enable us to continue to maintain America's nuclear deterrent without nuclear testing." The laboratory directors and Senate CTBT proponents further noted that if there ever is a stockpile problem, "Safeguard F—which is a condition for entry into the Test Ban Treaty by the U.S. – provides for the President, in consultation with the Congress, to withdraw from the Treaty under the standard 'supreme national interest' clause in order to conduct whatever testing might be required."

Senate Treaty proponents, including Senator Biden, argued in the floor debate that the arsenal is safe and reliable and can be maintained without nuclear testing. Biden and other proponents cited the 1995 report by the JASON group, which concludes that "nuclear warhead device problems which occurred in the past...have been corrected and that weapon types in the enduring stockpile are safe and reliable" (see Appendix B). The report also found that U.S. abilities to maintain its nuclear arsenal without underground testing "are consistent with U.S. agreement to enter into a CTBT of unending duration." Subsequent reviews, including the Department of Energy's December 1999 "Stockpile Stewardship Program 30-Day Review," have found that " the program is working today, as evidenced by three [annual nuclear weapons] certification cycles, and is structured to sustain this success long into the future."

Second Argument: The CTBT Cannot Be Effectively Verified

CTBT opponents and proponents also differed on whether the "zero-yield" CTBT can be effectively verified and on what constitutes "effective" verification. Many opponents took effective verification to mean the ability "... to detect any and all nuclear explosions under the Treaty." [32] They judged that low-yield explosions are of military significance, that such explosions have, can and will escape detection, and that a "zero-yield" test ban is unverifiable (see Chapters III and IV).

Even if it were determined that a CTBT violation had occurred, CTBT opponents charged that the on-site inspection and enforcement mechanisms were insufficient, "have no teeth," and would provide little reason for countries to forego nuclear testing (see Box 5).[33] At the core of the Senate uncertainty about "zero-yield" CTBT verification was the belief that other nations can and will conduct low-yield, militarily significant nuclear test explosions with little or no risk of detection despite the vast array of extensive sensors and detection technology that is already deployed and that would be augmented by the CTBT monitoring system.

Chief among the verification concerns of senators who voted against the CTBT was the possibility of low-yield test evasion scenarios, particularly "de-coupling." Citing Dr. Larry Turnbull, Chief Scientist of the CIA's Arms Control Intelligence Staff, Senator Lott said, "We know, however, that it is possible to conduct a nuclear test with the intention of evading systems designed to detect the explosion's telltale seismic signature. This can be done through 'decoupling,' whereby a nuclear test is conducted in a large underground cavity to muffle the test's seismic evidence. ...Not only is this 'decoupling' judged to be 'credible' by the intelligence community, but...a 70kt test can be made to look like a 1kt test, which the CTBT monitoring system will not be able to detect."[34] (See Chapters IV and V and Box 7).

Senators Helms, Kyl, and Richard Shelby (R-AL) made similar claims about "de-coupling," as well as other theoretical evasion scenarios. In doing so they emphasized the limitations of U.S. national

[32] Testimony of Senator Richard Shelby, Chairman of the Senate Select Committee on Intelligence before the Foreign Relations Committee, October 7, 1999.
[33] See Footnote 29.
[34] Remarks of Senator Trent Lott on the CTBT, *Congressional Record,* 106th Congress, Oct. 8, 1999.

intelligence capabilities and gaps and weaknesses in the “unfinished” CTBT International Monitoring System. Although the “de-coupling” claims were misrepresented, none was challenged during the Senate debate, nor did senators evaluate the plausibility of evasion scenarios or the capabilities of combined international monitoring assets. Moreover, the Senate CTBT debate produced very little discussion of what weapons might be developed without testing and what would constitute a test of military significance. Senior Clinton administration officials and Senate Treaty advocates made the case that the combined monitoring resources of the IMS, national intelligence networks and civilian seismic networks can effectively detect and deter militarily significant nuclear test explosions. Proponents acknowledged that it is not possible to detect every potential low-yield nuclear explosion, but asserted that no would-be violator could be confident that nuclear explosions of sufficient nuclear yield to threaten U.S. security would escape detection and that the CTBT allows for confidence-building measures and short-notice on-site inspections to clarify ambiguous events (see Chapters III and IV).

The debate also ignored the October 6, 1999 joint statement of the Seismological Society of American and the American Geophysical Union on CTBT verification and the decoupling issue. These groups found that “no nation could rely upon successfully concealing a program of nuclear testing, even at low yields" and that “… the decoupling scenario, as well as other evasion scenarios, demand extraordinary technical expertise and the likelihood of detection is high. ... [S]uch technical scenarios are credible only for nations with extensive practical testing experience and only for yields of at most a few kilotons." [35]

Nonetheless, some opponents charged that the “CTBT’s verification regime seems to be the embodiment of everything the United States has been fighting against in the UNSCOM inspections in Iraq.” Several senators expressed concern that on-site inspections required a three-fifths affirmative vote of the CTBT Executive Council, which they suggested was too challenging a barrier to overcome.[36] Senators Rod Grams (R-MN), Helms, Kyl, Lugar, and Shelby asserted that on-site inspections could be thwarted because the Treaty allows "the inspected party to declare areas up to 50 km off limits to inspection."[37]

The CTBT does allow an inspected State Party to declare "restricted access" sites to "prevent disclosure of confidential information not related to the purpose of the inspection."[38] Senator Shelby failed to mention, however, that no site may be larger than 4 km^2, they cannot be contiguous (there must be at least 20 meters between them) and, if more than one site is declared off limits, the sum total can be no more than 50 km^2. Moreover, if a State Party denies access to any area, it is obligated to use alternative means to show that it is in compliance with the Treaty.

Adding to these uncertainties, Senators Kyl and Helms alleged that the CTBT does not specify what activities are prohibited, suggesting that some states, like Russia, might not agree that the CTBT commits them to an actual “zero-yield” ban on any nuclear explosion. In his Senate testimony, Ambassador Stephen Ledogar, the U.S. CTBT negotiator, countered that Russia and the other P-5 states (China, France and the United Kingdom) clearly concurred with the view that “…zero should mean zero,”[39] and that this understanding could be demonstrated by the negotiating record at any level of confidentiality.

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[35] "Capability to Monitor the Comprehensive Test Ban Treaty," Joint Statement by the American Geophysical Union and Seismological Society of America, October 6, 1999, <http://www.agu.org/sci_soc/policy/test_ban.html>

[36] Lugar Opposes CTBT,” Press Release, Office of Senator Lugar, October 7, 1999.

[37] Testimony of Senator Richard Shelby, Chairman of the Senate Select Committee on Intelligence before the Foreign Relations Committee, October 7, 1999.

[38] Protocol to the Comprehensive Nuclear Test Ban Treaty, Part II, Para. 89.

[39] Testimony before the SFRC, Oct. 7, 1999.

Third Argument: The CTBT Will Not Stop Nuclear Proliferation

Test ban proponents said that the zero-yield test ban would constrain the nuclear weapons program of Russia and China, and would help prevent nations with less sophisticated arsenals, like India and Pakistan, and certain other nations seeking nuclear arms, from making advanced, two-stage thermonuclear warheads. Ratification of the CTBT, proponents argued, would also meet a commitment made by the United States in 1995 to gain the support of many non-nuclear weapons states for the indefinite extension of the Nuclear Non-proliferation Treaty and it would keep the United States in the forefront of global efforts to curb proliferation (see Chapters VII, VIII and IX).

For various reasons, most senators who spoke in opposition to the CTBT were not convinced that the benefits of the CTBT – principally its contributions to nuclear non-proliferation – were worth the risks they perceived were present in the SSP and the verification regime. The most ardent CTBT opponents criticized the Treaty as a mere "piece of paper" that would not stop proliferation because it could not be verified and would not stop test explosions. Most senators voting "no" expressed the view that the CTBT would allow China and Russia to improve their nuclear arsenals. These views were strongly influenced by news articles published just before the debate about unconfirmed, clandestine Russian test explosions and by reports of a new CIA assessment claiming that it could not monitor low-yield tests by Russia precisely enough to ensure compliance.[40]

The concerns raised by the reports were reinforced by the October 7 testimony of Sandia National Laboratory Director Paul Robinson in which he said "... nuclear testing in the sub-kiloton range could have utility for certain types of nuclear designs." Aside from the fact that the release of these reports did not allow adequate time for Treaty proponents to rebut the claims, senators did not seriously explore the question of why Russia would assume the risks and cost of developing new, low-yield warheads when it holds in reserve thousands of proven tactical warheads. Another matter that was not explored in any depth was the positive effect a test ban would have on impeding the modernization of the Chinese nuclear arsenal.[41]

Several other opponents articulated the view that the CTBT would not contribute to nonproliferation because testing is not necessary to develop relatively simple, first-generation devices.[42] States such as Iraq and Iran, said Senator John McCain (R-AZ), can achieve without testing ".. very good confidence that a first generation nuclear weapon will work, as the detonation over Hiroshima ... demonstrated...."[43] CTBT proponents did not claim that such devices require extensive nuclear test explosions. Rather, they pointed to the effect of the CTBT on impeding development of relatively smaller, lighter two-stage thermonuclear weapons, which are more easily deliverable on missiles (see Chapter VI).

Despite the fact that the leading U.S. allies in Europe and Asia were strongly urging the United States to ratify the CTBT, a small number of senators suggested that because the CTBT would erode U.S. nuclear deterrent, "... it is likely that our allies confidence in the nuclear umbrella will similarly decline. This could lead to allies reevaluating their own security needs. ...[M]ight not they consider developing their own nuclear deterrents?"[44] This argument overlooked the fact that both France the United Kingdom – the other major nuclear powers in the NATO alliance – had already ratified the Treaty and it assumed that a CTBT would somehow weaken U.S willingness to retaliate with nuclear weapons.

[40] Bill Gertz, "Russians May Have Tested Nuclear Device Underground," *The Washington Times*, September 15, 2000; Roberto Suro, "CIA Unable to Precisely Track Testing: Analysis of Russian Compliance With Nuclear Treaty Hampered," *The Washington Post*, p. 1, October 3, 1999.
[41] See: House of Representatives Select Committee on U.S. National Security and Military/Commercial Concerns with the People's Republic of China, May 1999.
[42] Remarks of Senator John Kyl, *Congressional Record*, 106th Congress, October 12, 1999.
[43] Remarks of Senator John McCain, *Congressional Record*, 106th Congress, October 12, 1999.
[44] Remarks of Senator John Kyl, *Congressional Record*, 106th Congress, October 12, 1999.

A few senators suggested that the CTBT was redundant because it did not provide any non-proliferation benefits beyond those established by the NPT, although this argument overlooks the fact that three nuclear weapons states, India, Israel and Pakistan, do not belong to the NPT. Senator Lugar, for example, argued that the NPT already prohibits the acquisition and possession of nuclear weapons, except by the recognized nuclear powers. Therefore, "I fail to see how an additional norm will deter a motivated nation from developing nuclear weapons after violating ... the NPT."[45]

Several senators also argued that U.S. ratification of the CTBT would be meaningless because its entry into force depends on ratification by India and Pakistan among other holdout states. There was, however, little information or discussion about the potential effect of the CTBT on the South Asian arms race or the prospects for Indian and Pakistani accession (see Chapter VII).

The arguments lodged against the nonproliferation value of the CTBT underscore the importance of a more detailed evaluation of the capabilities of various states (including the United States) to maintain or develop nuclear weapons without nuclear test explosions, the ability to detect low-yield nuclear explosions and the military value of such explosions, the political and military utility of nuclear weapons, and the role of U.S. leadership in reinforcing international non-proliferation efforts (see the succeeding Chapters of the White Paper for further discussion of these issues.).

Finding Common Ground?

In the aftermath of the vote on the CTBT, many senators on both sides of the issue expressed disappointment about the process surrounding the vote and concern about its national and international security ramifications. Several indicated they considered the CTBT unfinished business. Two senators, Joseph Lieberman (D-CT) and Charles Hagel (R-NE) noted that "constituents and our country's allies have expressed grave concerns about our hasty rejection of the Treaty and the impact of that rejection on the Treaty's survival. They need to know that we, along with a clear majority of the Senate, have not given up hope of finding common ground in our quest for a sound and secure ban on nuclear testing." [46]

[45] "Lugar Opposes Comprehensive Test Ban Treaty," Press Release, Office of U.S. Senator Richard G. Lugar, October 7, 1999. While the Senate paid substantial attention to the Indian and Pakistani tests in 1998, it did not do so in the course of the 1999 CTBT ratification debate. At the time of the tests, some key Treaty opponents, including Senator Helms and Lott argued that "the nuclear spiral in Asia demonstrates the irrelevance of U.S. action on the CTBT." In addition, Lott claimed that the treaty banning nuclear testing "... actually accelerated the greatest proliferation disaster in decades: two new nuclear powers emerging in the last few weeks."

[46] Joseph I. Lieberman and Chuck Hagel, "Don't Give Up on the Test Ban," *The New York Times*, October 16, 1999.

Chapter III

The CTBT Verification Regime

Amy Sands

Introduction

Bringing the CTBT into force is critical both substantively and symbolically to efforts to prevent the proliferation of nuclear weapons and the technological enhancement of existing nuclear arsenals.[47] Substantively, while it is true that states can develop first-generation nuclear weapons without testing, the inability to test severely diminishes the level of confidence a state has in the performance of these weapons and limits technological improvements as well as delivery options. For states that have tested, not having access to additional test information constricts their ability to develop new designs that could result in more powerful, complex, flexible, and smaller weapons. Symbolically, the CTBT has become a litmus test by which non-nuclear weapon states judge the true intent of nuclear weapon states: agreeing to non-testing obligations is seen as a crucial step towards reducing and ultimately eliminating reliance on nuclear weapons.

Despite the careful attention given to developing a robust verification regime for the CTBT during its negotiation, several questions emerged about its verifiability during the brief debate by the U.S. Senate prior to the defeat of its ratification in October 1999 (see Chapter II). This verification regime, which is a central element of the CTBT and key to the Treaty's success, was purposefully designed in order to make it difficult and costly to test without being detected. This chapter will focus on the elements of the Treaty's monitoring regime,[48] the technologies involved, and the international organization at its core. As the evaluation of these verification capabilities will demonstrate, the negotiators of the CTBT developed a verification regime that is politically bold, technically sound, and able to provide high confidence in monitoring compliance once it is fully in place.

The CTBT's Verification System

The challenge for the CTBT verification system is to be credible given the comprehensive scope of the Treaty. It should be able to detect and locate suspicious events in all environments, screen out non-nuclear events, and then identify and attribute those that are nuclear explosions. To address this challenge, the Treaty established a mix of technologies and activities that range from an extensive, international remote monitoring system to specific on-site inspections. While each component of the Treaty's verification system is significant, there is a synergy to the totality of the verification efforts that allows for high confidence that cheaters will be detected in a timely fashion.

The most substantial element of the CTBT verification regime, and the one considered by most as its principal tool for detecting and identifying possible treaty violations, is the International Monitoring System (IMS) that consists of four different remote sensing networks and an International Data Centre (IDC). At the core of the IMS is the fact that the distinctive physical processes associated with nuclear explosions can be detected, collected and analyzed by a combination of various sensors.

The four technical sensors of the IMS include seismic, radionuclide, hydroacoustic, and infrasonic sensor technologies and provide data that can be used to detect events, screen out non-nuclear ones, and in some situations identify nuclear ones. The IMS will have 321 monitoring facilities and at least 16 radionuclide

[47] The author would like to thank her student researcher, Nicola Prall, for assistance in researching and writing this paper.

[48] Most of the discussion will focus on non-seismic monitoring capabilities. Chapter IV of this White Paper will cover the seismic monitoring network in greater detail.

laboratories, located in approximately 90 countries. The data from each network flows to the IDC, which then will make it available to the National Authority of States Parties. It is important to recognize that the IDC collects and analyzes the IMS data only to indicate when there are events of concern. Neither the IDC nor the Technical Secretariat (TS), which is responsible for supervising and coordinating the operation of the IMS, will be making assessments as to whether these events are nuclear explosions or not – their role is to provide the information to States Parties who are responsible for their own national evaluations of the significance of this information to compliance with the CTBT.

Box 2
Spotting An Event

A nuclear explosion may produce these effects:	when detonated in these environments:
Seismic waves	Underground, oceanic, or near-surface atmospheric
Infrasound waves	Atmospheric, near-surface underground, or near-surface oceanic
Hydroacoustic waves	Oceanic or near-surface atmospheric
Radioactive particulates	Atmospheric, near-surface underground, or near-surface oceanic
Radioactive xenon gas	Atmospheric, near-surface underground, or oceanic
Optical flash (x)	Atmospheric
Electromagnetic pulse	Atmospheric, near-surface underground, or near-surface oceanic

(x) These nuclear-explosion effects, best observed by sensors on satellites, will not be monitored by the IMS. The Treaty allows a State Party to use satellite-based systems at its own expense (as part of NTM), and provides for the use of such data in a request for OSI.

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This monitoring system attempts to use existing resources where possible and to limit its intrusiveness and expense. Where feasible, existing facilities and capabilities will be upgraded and certified for use by the IMS. All of these monitoring facilities will be run by the states on whose territory they are located, although the cost of operations will be shared internationally (with the United States assuming 25%). Finally, to ensure the proper integration and certification into the IMS system, host countries must sign facility agreements or arrangements with the CTBT Organization (CTBTO). A brief description of each of the technologies used in the IMS and the IDC is provided below.

Remote Monitoring Systems

Seismic: The seismic network will primarily be used to detect underground explosions and possibly atmospheric explosions (see Chapter IV). There will be 50 primary and 120 auxiliary stations worldwide. The primary network will have a detection threshold of about 1kt (or better in certain regions of concern such as the former Russian and Chinese test sites) for a fully coupled underground nuclear explosion. By using both the primary and auxiliary networks, location estimates for underground explosions will be accurate to a few hundred to 1000 km^2. The challenge for the seismic network is not only detecting an event but also identifying it as a nuclear explosion, since earthquakes and non-nuclear explosions will be detected by the network as well. Regional seismic calibration, information about mining activity, and scientific analysis will help distinguish these chemical and naturally occurring events from nuclear explosions. Moreover, data collected from the other monitoring systems will provide additional corroborating information.

Radionuclide: The 80 radionuclide stations will measure radioactive particles from atmospheric nuclear explosions or particles vented from underground explosions. At least half of these radionuclide sensors will also include noble gas detectors that can capture the noble gases that are vented in subsurface tests and provide possibly the best evidence of a nuclear test. In the CTBT Protocol, 16 radionuclide laboratories are identified as having the specific analytical capabilities needed to confirm the presence of nuclear debris when there is an indication of radionuclide anomalies on samples from these sensors.

The radionuclide sensors collect, analyze and send their data once a day to the IDC. Data that appears suspect, i.e., a level of radioactivity has been reached that can not be explained as being natural or expected due to known man-made activities in the region, will be sent to one or two of the radionuclide laboratories where more sensitive and independent assessments will be performed in order to corroborate the original analysis of the suspect data. The laboratory results will then be provided to the IDC, which will pass it on to States Parties for their own review.

The detection threshold for the radionuclide detectors will be less than 1kt for above ground explosions, but for underground explosions, detection will depend on how much venting occurs. Information containing the data from these sensors will be provided in the Fission Product Event Bulletin and suspect data will initiate the use of atmospheric transport models to backtrack the source location of the anomalous fission product.

The nature of the radionuclide network means it depends on atmospheric winds to move the debris from a site to a monitoring station and may take several days. To determine location of an event based on radionuclide data requires extensive meteorological information, atmospheric transport models, and a solid understanding of background noise. Because of this, there can be problems with location accuracy if attempting to use only the radionuclide sensor data. The radionuclide system, however, is the only network that can distinguish—with certainty—between nuclear and non-nuclear events, making it most effective when combined with the other networks in the IMS.

Hydroacoustic: The hydroacoustic sensors will be able to detect underwater and low altitude atmospheric explosions. There will be 11 stations in this network; 6 underwater hydrophones and 5 island-based "T-phase" stations. The hydrophones will each have 3 microphones at each end of 100 km fiber-optic cables. The sensors used by these stations are underwater gauges that detect pressure waves in the ocean.[49] They will be detecting signals in an oceanic acoustic waveguide called the Sound Fixing and Ranging channel (SOFAR). Hydrophone stations detect the signals directly, while the T-phase stations detect seismic signals made when hydroacoustic waves hit the island.[50]

Since the northern hemisphere is well covered by seismic monitors, the decision was made to focus on covering the vast ocean areas of the southern hemisphere where distances between stations are larger and where there is less shipping traffic. T-phase stations will be located in northern oceans. The detection threshold for underwater events is expected to be significantly smaller than 1kt. In addition, research

[49] To gain acceptance, States Parties had to be comfortable that these arrays would not sense submarine movements. The sensors are therefore detecting in a frequency range appropriate to nuclear explosions, not screw propellers.
[50] T-phase stations can detect an ocean acoustic wave when it converts to a seismic wave upon striking the ocean bottom near the island.

shows that events detectable by three or more stations will have a location accuracy of less than 1000 km^2. Hydroacoustic stations will not be able to distinguish between underwater chemical explosions and underwater nuclear explosions so other sources of data, including data from the other sensors in the IMS as well as national technical means (NTM) or information about explosions caused by mining and oil exploration, will have to be exploited.

Infrasound: The 60 infrasound stations will detect and measure air pressure changes that are caused by low-frequency sound waves from atmospheric nuclear explosions. The system may also monitor underground and underwater environments. Each station will have an array of at least four infrasound sensors about 1 km apart. This formation improves the signal-to-noise ratios relative to single sensor configurations and also helps measure the direction from which the signal came. It is the least developed but potentially the most sensitive network because of the frequency ranges now available through technology. These infrasound signals travel long distances through the atmosphere producing a reflection and refraction waveguide effect much like the SOFAR channel. Infrasound networks should be able to detect explosions in the 1kt range globally, but thresholds are dependent on atmospheric conditions. Location accuracy estimates range from 1000 km^2 to over 10,000 km^2 but, when used in conjunction with the seismic and hydroacoustic networks, location accuracy should improve.

International Data Centre

The IDC is clearly an innovative aspect of the CTBT's monitoring system. The advent of advanced communications systems and information technologies has made it possible to integrate and authenticate this data in a credible way.

The IDC will have extensive technical demands placed upon it, many of which have been identified and addressed during the operations of the prototype. For example, although the technologies of the IMS have similar requirements for data transmission and processing, standardized formats, and communication protocols, each technical system has distinctive conditions that affect data processing[51] and must be integrated into the IDC's methodologies. In addition, the IDC, which will process over 10 gigabytes of data on a daily basis when the IMS is fully operational, will receive data continuously transmitted from all but the radionuclide sensor system, which will provide results every 24 hours.

At the IDC, the data from all the sensor systems will be authenticated, analyzed, distributed, and archived. The interactive combination of the data will be compiled in the IDC Reviewed Event Bulletin and will include a list of event locations (without specific identification). This bulletin, along with the original raw data and processed data, will be made available to all States Parties. The United States will receive the complete set of data acquired by the IDC and then will incorporate additional data from its own national technical intelligence system (including other seismic, hydroacoustic, infrasonic, radionuclide sensors, as well as satellite sensors) into its own national treaty monitoring activities.

Other Elements of CTBT Monitoring Regime

Executive Council of the CTBT Organization: The Executive Council (EC) consists of representatives from 51 States Parties from six geographic regions. The United States will most likely have ongoing membership on the EC. The Executive Council supervises the Technical Secretariat (TS) and ultimately determines whether an on-site inspection will occur once a request for one has been made. Delegating to the TS the actual operation of an on-site inspection (OSI), the EC reviews the progress of an OSI and may

[51] An example of different processing details is that detection of infrasonic signals require correlation detectors (because of low signal-to noise ratios characteristic of infrasound signals) rather than ratios of short-term signal power to long-term power as used for seismic waves. Discussed in *Research Required to Support Comprehensive Nuclear Test Ban Treaty Monitoring*, National Research Council, National Academy Press, Washington, D.C., 1997.

approve additional time for more on-site investigation. Compliance assessments, however, remain the prerogative of individual States Parties.

Technical Secretariat: The Technical Secretariat is responsible for supervising and coordinating the operation of the IMS and the IDC. Specifically, this involves: receiving, processing, analyzing and reporting on IMS data; providing technical assistance in, and support for, the installation and operation of monitoring stations; and negotiating agreements or arrangements with States Parties for sensor facilities or technical support. The TS also assists the EC in any process of consultation and clarification among States Parties and receives the initial requests for an OSI. As the EC considers these requests, the TS will provide technical support for and during an OSI, reporting its findings to the EC.

On-Site Inspections: States Parties can request an OSI based on data collected by the IMS or other sources including data from NTM that has been collected in ways generally found acceptable by the international community. At least 30 of the 51 members of the EC must approve the request within 96 hours after the initial request is made, although preparations for the OSI can begin immediately. States are encouraged to utilize the consultation and clarification procedures provided in the Treaty before requesting an OSI. Once the request has been made, additional efforts at clarification aimed at alleviating the need for an OSI may occur, but these must fit within the 96-hour turn-around time for a final decision by the EC as to whether to proceed with the requested OSI.

Once the decision has been made to go ahead with an OSI, the TS has overall responsibility for the preparations. Since the TS will not have a standing inspectorate, personnel will be drawn from a group of trained inspectors nominated by member states. The inspection team, which will consist of no more than 40 inspectors, has to be geographically representative and capable of being organized within six days of the initial OSI request. The OSI request can cover an area up to 1000 km^2, but an inspection team will try to target its ground-based activities more specifically by using IMS data along with photographic information derived from the over-flight of the area that is permitted during the initial phase.

An OSI may consist of two phases totaling 60 days. The first phase, or the initial period of inspection, is 25 days long and inspectors are allowed to use techniques such as visual and photographic inspection, measurements of radioactivity, environmental sampling, and passive seismology. The second 35-day phase, or the continuation period of inspection, immediately follows Phase 1 unless it is terminated by a majority vote in the EC. During the second phase, inspectors may use other techniques including active seismology, magnetic and gravitational field mapping, ground penetrating radar, electrical conductivity, and drilling. A 70-day extension, requiring a majority vote approval by the EC, may be requested.

Although states are permitted to “manage access” and to declare areas “off limits” to inspectors, the area of such limitations is constrained by the Treaty and by the political reality that preventing access to an area considered critical to the inspection will only add to the appearance of a violation. Moreover, having the opportunity to request and pursue OSI will deter potential violators who cannot know for certain that their testing can be hidden from such direct monitoring and evaluation. Also, by providing access to locations from which data might not otherwise available, OSI will greatly enhance the ability of the United States and other States Parties to address quickly and effectively any compliance concerns they might have.

Confidence-Building Measures: States Parties are encouraged voluntarily to provide notification and information about any singly detonated chemical explosion in excess of 300 tons (.3kt). States Parties are also encouraged to provide, voluntarily, information on the location, nature, and frequency of all other chemical explosions in excess of 300 tons – including multiple-detonated explosions. Additionally, States Parties are encouraged to work with the TS to perform regional calibrations to enhance the performance of the various technical sensors in the IMS as well as add to the understanding of their capabilities. These efforts may include voluntary visits and cooperative activities with staff from the TS.

How Good Will the CTBT Verification System Be?

The CTBT verification system being established relies heavily on cooperative monitoring efforts founded on realistic political and technical agreements. Synergy in the CTBT verification regime occurs in many ways and on different levels, starting with the fact that it focuses on different potential test environments: underground, underwater, and in the atmosphere. But, in many cases, it also will provide overlapping coverage that strengthens detection, location, and identification capabilities.

Joint association of hydroacoustic and seismic waves could help define an event that may not have been recognized by either one alone. Also, the data from one system (infrasound, for example) can be most effectively utilized in conjunction with data from other systems (hydroacoustic or seismic) that may provide information about the approximate origin, time, and location of the event. The synergy between seismic and infrasonic systems can also be used to increase the certainty and size of events, especially near mining sites. If an event is deemed suspicious because of infrasonic, hydroacoustic, or seismic data, radionuclide detection may be able to distinguish between a nuclear and non-nuclear event.

While it will take several years before the IMS will be able to complete the current network, it should be recognized that the IMS is already reporting useful data – for example, 62 IMS stations reported on the Indian tests in 1998 – and the IMS will evolve, exploiting new developments in sensor technologies and adding these as they are certified and made available. The challenge may be to keep the costs reasonable and the commitment of States Parties to such a dynamic technical environment energized.

Since 1947 the United States has monitored other countries' nuclear programs and nuclear explosions by relying on an extensive and technically sophisticated nuclear detection program. The U.S. Atomic Energy Detection System (USAEDS) is a global monitoring system, operated and maintained by the Air Force Technical Applications Center (AFTAC), that provides data about ambiguous or disturbing events underground, underwater, in space, or in the atmosphere. Its capabilities include an array of seismic stations located throughout the world, radionuclide detectors in place around the world and also ready to be used in airborne or naval sampling efforts, hydroacoustic stations, and satellite-based sensors that can detect optical signals, radar, gamma rays, neutrons, and the electro-magnetic pulse possibly associated with nuclear testing.

This integrated and global set of sensors enables the United States to monitor foreign nuclear weapons and testing programs. Experts at AFTAC and in the U.S. intelligence community have for several decades analyzed the data collected by USAEDS as well as that collected by other intelligence sources for nuclear test identification and information about foreign nuclear activities. These efforts provide the foundation for effective American verification of compliance with the 1963 Limited Test Ban Treaty, the Treaty on the Non-Proliferation of Nuclear Weapons, the Threshold Test Ban Treaty of 1974, and the Peaceful Nuclear Explosions Treaty of 1976.

Under the CTBT, the United States will not relinquish any of the existing capabilities used to detect and monitor nuclear proliferation. In fact, the CTBT verification system provides extensive additional information that will supplement U.S. national intelligence resources. First, the United States will gain access to data collected by additional sensors that are placed in locations currently not available to the United States. For example, it is expected that the IMS will have 31 monitoring stations in Russia, 11 in China, and 17 in the Middle East, all sensitive areas where the United States would not otherwise have such extensive access. In addition, the United States will only have to pay one-quarter of the costs for installing, upgrading, and operating many monitoring stations that are required for its own national purposes since they will be integrated into the International Monitoring System and other states parties to the CTBT will be responsible for the remaining three-quarters of the costs.

Another benefit to the United States is the possibility of getting direct access, via an OSI, to areas not otherwise available for inspections. Thus, the United States will not only have the opportunity to request additional clarifications, but also even an OSI of a potential test site. Finally, the data collected by the IDC will be internationally accepted and authenticated, providing the United States with a solid basis for multilateral discussions of possible violations without necessarily having to resort to potentially sensitive NTM data. So, while the United States will continue to rely on its own data and assessments for compliance questions, it will have much more information at its disposal.

Countries attempting to evade the CTBT verification regime and national monitoring capabilities face a substantial challenge because of the combined capabilities of the international and national verification systems (see Chapters IV and VI). The synergy between the various components of the system, when combined with national monitoring capabilities, raises the likelihood of being detected. It also will make evasion harder because there will be more technical and cost hurdles to overcome. In addition, there is the possibility that exogenous events, such as intelligence leaks or unpredictably high yield explosions, may compromise any clandestine program.

The capabilities provided by the CTBT verification system adds considerably to the ability of the United States to determine compliance and will definitely enhance the ability of other States Parties to monitor compliance with the Treaty. In conjunction with existing U.S. national monitoring capabilities, the CTBT is effectively verifiable and no militarily significant testing (see Box 7) could occur without detection and identification in a timely fashion.

Chapter IV

Seismology and CTBT Verification

Paul G. Richards

The purpose of this chapter is to explain the role of seismology in treaty verification, to describe what seismology (and associated infrastructures) can and cannot do using monitoring systems now in place, and to give a sense of what can be expected with likely future improvements.

Seismology is the study of how the ground moves, not just for strong earthquakes such as the one that severely damaged the San Francisco Bay area in 1989, but for ground motions that can be even a billion times smaller and still detectable, caused by earthquakes and explosions which may originate on the other side of the world. Each earthquake or explosion sends out a mixture of different types of seismic waves, and for decades seismologists have been interpreting these signals in order to characterize the seismic source. Seismology has overlapping infrastructures to study the internal structure of our planet, to study earthquake hazard, and to monitor explosions.

Seismology became particularly important as a monitoring technology following the LTBT of l963 which forced nuclear testing by the United States, the Soviet Union and the United Kingdom underground. Underground explosions generate easily detectable seismic signals, observed all over the world for most nuclear tests. On average, about one nuclear explosion a week was carried out underground from the early 1960's to the early 1990's and seismology was built up as a practical science because it became a principal means to learn of the developing nuclear weapons capability of a potential adversary. It was also recognized to be an arms control technology for monitoring compliance with an eventual ban on nuclear testing.

States Parties to the CTBT will be subject to three types of seismic monitoring:

- that carried out directly by the International Data Centre (IDC) using data contributed by the International Monitoring System (IMS), associated with the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) in Vienna;
- that carried out by National Technical Means (NTM), i.e. the procedures established unilaterally by various countries using any information available to them, with all countries having right[52] to use objective information from NTM as a basis for requesting an on-site inspection; and
- that carried out by numerous private or national organizations, each acquiring and/or analyzing data of some relevance to CTBT monitoring.

This chapter will concentrate on the first type of monitoring – the work of the IMS and IDC – since this provides a base upon which other contributions can be made. From the IDC, IMS data is sent on request to National Data Centers. The U.S. National Data Center is operated by the U.S. Air Force which was given the job of leading U.S. efforts to monitor foreign nuclear testing by President Truman. This work is done by the Air Force Technical Applications Data Center (AFTAC) with headquarters at Patrick Air Force Base in Florida (see Chapter III).

[52] CTBT Article IV, paras 34 and 37.

While the details of the capabilities of the second type of monitoring – NTM – are generally classified, U.S. NTM can be presumed to build upon IMS data, uses technologies other than those four pursued by the IMS, and focuses on areas of particular concern rather than treating all regions equally. Thus the United States is more concerned with monitoring China, Russia and North Korea than Canada and New Zealand.

The third of these types of monitoring, associated with what the CTBT calls supplementary data,[53] can be important, for example in confidence building measures and as a source of much basic information and many skills needed by the IMS and IDC. Hundreds of different institutions operate seismometers of various types. Vast regions of North America, Europe, the Western Pacific, and parts of Central Asia, Northern and Southern Africa and the Middle East are now being monitored 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 type of earthquake monitoring, and from field programs to study earth structure, that geophysicists have acquired their knowledge of seismic signals in different regions, as well as familiarity with the differences between signals from earthquakes and from blasting associated with the mining, quarrying, and construction industries. Seismology is still a growing science, likely to be driven indefinitely by the need to understand and mitigate earthquake hazards. Explosion monitoring for the CTBT will therefore be greatly improved in the long term by cross-fertilization between the earthquake monitoring and explosion monitoring communities. For example, the ability of treaty-monitoring systems to locate seismic sources accurately will depend upon procedures used to calibrate IMS stations – procedures that in turn will depend upon information derived from regional seismic networks established for the study of earthquake hazard.

The work of monitoring for underground nuclear explosions using seismological methods can be broken down into the separate steps of:

- detecting seismic signals and grouping all the signals associated with a particular seismic source;

- estimating the location of that source, and the uncertainty in the location; and

- identifying the seismic source (whether earthquake or explosion), together with estimating the source size. The role of the IMS, vis-à-vis identification, is that of "Assisting individual States Parties with expert technical advice in order to help the State Party concerned to identify the source of specific events."[54] The responsibility of identification is left to each State Party, but the IDC assists by carrying out a process called event screening, described below.

Seismology also plays a role in on-site inspections and in confidence-building measures.

Detection of Seismic Signals

The CTBT Protocol lists 50 IMS sites around the world at which either a three-component seismographic station[55] or an array of seismometers[56] is to be operated, sending uninterrupted data by satellite to the

[53]CTBT Article IV, paras 27 and 28.

[54]CTBT Protocol, Part I, para 20(c).

[55]In order to characterize ground motions completely at a single site, they are usually recorded in the vertical direction and two horizontal directions (north, and east). Hence the term "three-component."

[56]An array of seismometers consists typically of ten to thirty separate instruments, installed over a region several square km in area. Somewhat similar in operation to a directional microphone, an array of seismometers can pickup weaker signals than a conventional seismographic station. An array can also be used to measure the direction from which a seismic signal arrives.

IDC. These 50 stations constitute the primary network. Much experience has been gained and data made available from a network of similar size and including many of the IMS stations. It has operated full-time since January 1, 1995 initially as part of a technical test known as GSETT-3, carried out under the auspices of the Geneva-based Conference on Disarmament (CD) which negotiated the text of the CTBT.[57] The GSETT-3 IDC, based near Washington, DC, became the Prototype IDC (PIDC) shortly after the CTBT was opened for signature in 1996,and served for five years as the test bed for many procedures that were taken up by the Vienna-based IDC in February 2000.

For seismic sources whose signals are detected by the primary network, and for which the location estimate and other attributes of the source are likely to be better quantified if additional signals are acquired, the CTBT Protocol lists an additional 120 IMS sites around the world at which either a three-component seismographic station or an array is to be operated. These stations, constituting the auxiliary network, are to operate continuously; but their data is sent to the IDC only for time segments that are requested by a message from the IDC. Much experience with such an auxiliary network, of somewhat smaller size, has now been acquired by the PIDC.

From January 1995 to February 2000, when operations transferred to Vienna, the IMS stations grew from about one-half up to two-thirds of the intended 50-station primary network, and reached approximately one-half of the intended 120-station auxiliary network. During this five-year time period, the PIDC made available a number of reports of global seismicity derived from the primary and auxiliary networks.[58] The most important report is the daily Reviewed Event Bulletin (REB), typically published three to five days in arrears, listing the events that have occurred that day, including location estimates, magnitudes, a map of the reporting stations for each event, and arrival times of detected phases at these stations. About fifty events per day have been reported on average, with some wide variations, for a total of about 100,000 events included in the REB over its first five years. Nuclear explosions carried out by France and China (prior to their signing the Treaty in 1996) were well recorded, as were the nuclear explosions of India and Pakistan in 1998.

What then is the current detection capability of the IMS seismographic network, and what is its expected capability when the network is eventually completed? The design capability of the primary network has not been formally specified. The short answer is that the IMS can be expected to provide data adequate to monitor for underground explosions down to at least magnitude 4. For an explosion executed in the usual way without making special efforts at concealment, magnitude 4 corresponds to a yield of approximately 0.5kt. In practice, however, the detection threshold appears to be better than magnitude 4 for regions where the IMS is complete – and even where it is incomplete.

This tentative conclusion emerges from several lines of argument. First, from looking at an earlier network to which the modern IMS network is roughly comparable, we find that GSETT-3 was planned[59] to have a threshold detection capability in the magnitude range below 3 for large parts of Eurasia and North America. (It was above magnitude 3.4 in some continental areas of the Southern Hemisphere, and above magnitude 3.8 in parts of the southern oceans.) Second, in technical reports[60] that have mapped the value of magnitude at which three or more IMS stations have a high probability of detecting signals, we find that virtually all of Eurasia and North America lies in zones with magnitude less than 4. Third, in certain areas of particular interest, which include the former test sites in Nevada for the United States and in Novaya Zemlya for the Russian Federation, the IMS seismographic network is now essentially complete and has a detection capability that is typically below magnitude 2.5 which corresponds to a

[57] GSETT-3 is an acronym for the Group of Scientific Experts Technical Test #3.
[58] At http://www.pidc.org.
[59] See CD/1254, a paper of the Conference on Disarmament.
[60] For example, the NORSAR semi-annual report of May 1998, pp. 72 - 88.

yield of approximately 10 tons of TNT equivalent (or lower under certain conditions – see Chapter VI) well-coupled into the ground. The IMS station nearest to the Chinese former test site at Lop Nor is an array in Kazakhstan, at a distance of less than 800 km. It was opened in June 2000, and can be expected to provide detections down to comparably low magnitudes for Western China. Finally on this point, there are specific examples to show that the IMS is providing data adequate to characterize small seismic sources that are located in regions where the IMS is far from complete.[61]

Location of Seismic Sources

The CTBT Monitoring Protocol states that "The area of an on-site inspection shall be continuous and its size shall not exceed 1000 km^2 (see Chapter III). Also: "There shall be no linear dimension greater than 50 km in any direction."[62] This condition presents a challenge for those who may have to estimate the location of an event that could become the basis of an on-site inspection request. It is a challenge, because for earthquakes and explosions below magnitude 4, there may not be enough detections at IMS stations for an accurate estimation of the location by the IDC, using current procedures.

The challenge is being met by a series of international activities that have successfully demonstrated in northwestern Europe how improvements in location accuracy can be obtained. These methods are now being systematically applied to other regions of Eurasia, to North America, and to Northern Africa.

Identification of Seismic Sources

After an accurate location estimate has been obtained, the next step in monitoring is that of event identification. A review of the best technical methods for carrying out this step is given, for example, by a 1988 report of the Office of Technology Assessment.[63] But the actual identification of an event as possibly being a nuclear explosion and hence a treaty violation, perhaps warranting a request for an on-site inspection, entails judgments that bring in political as well as technical assessments. Therefore, as noted above, the IDC's role in event identification is limited to providing assistance to States Parties to the treaty, rather than actually making an identification. The CTBT Protocol states that the IDC may apply "standard event screening criteria" based on "standard event characterization parameters." To screen out an event means that the event appears *not* to have features associated with a nuclear explosion. The underlying idea is that if the IDC can screen out most events, then States Parties to the treaty can focus their attention on the remaining events. A few examples will suffice to demonstrate how methods of identification can become the basis of standard screening by the IDC.

The most successful discriminants are an interpretation of the location (including the depth), and a comparison of the magnitude of two different types of seismic waves.

About 70% of all earthquakes occur under the ocean. But if a seismic event is located with confidence in an ocean area, it can only be an explosion if the device was set off in a hole drilled into the ocean floor, or if it was set off in the water column. The logistics of sub-oceanic drilling to sufficient depths for containing a nuclear explosion are so formidable as to rule out this possibility in most areas. The simplest way to screen an oceanic seismic source is then to examine hydroacoustic data, because an explosion in

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[61] A chemical explosion of 0.1 kiloton took place on August 22, 1998 at the former Soviet nuclear test site in Eastern Kazakhstan. In this region of Central Asia there are several IMS stations which are not yet operational, but the explosion was well located on the basis of detections at stations far away in Sweden, Norway, Scotland, Central Africa and Alaska, as well as at three nearer stations in Russia. The explosion took place under a joint US-Kazakhstan program to destroy facilities at the former test site. It was a very unusual seismic event, since chemical explosions at depth that fire 100 tons all at once, essentially in the way that small underground nuclear explosions have been fired in the past, are very rare.

[62] A circle of radius 18 kilometers (about 11 miles) has an area around 1000 km^2.

[63] U.S. Congress (1988). "Seismic Verification of Nuclear Testing Treaties," OTA-ISC-361, Office of Technology Assessment, Washington, DC, US Government Printing Office.

the water column would generate very large sound waves within the water that would travel to very large distances (thousands of km) and still be easily detectable. An absence of hydroacoustic signals can therefore screen out, as earthquakes, all seismic sources confidently located in ocean areas.

An event may have its depth estimated with high confidence as, say, 50 km. Such an event would be screened out, by a practical criterion that "events confidently estimated as deeper than 10 km are not of concern."

A screen based on comparison of magnitudes exploits the fact that shallow earthquakes are far more efficient than nuclear explosions in exciting long-period surface waves, for events with comparable short-period compressional-waves. In a preliminary study of PIDC data, more than 98% of shallow events (but no nuclear explosions) were successfully screened out by the quantitative comparison of surface-wave and compressional-wave magnitudes.[64]

Depth estimates, and measurements of seismic magnitudes, can be based upon so-called teleseismic waves which travel deeply in the Earth and reach distances more than 1500 km. In practice it is important also to develop discriminants, and their specific application as screens, for events too small to be well-characterized teleseismically. One example is the use of high-frequency spectral ratios between different types of seismic waves that travel only at shallow depths. In practice, such ratios are abnormally high for small underground explosions as compared to shallow small earthquakes, and this discriminant can be applied successfully down to magnitude 3 and possibly even smaller.[65] The preliminary result of this method applied to PIDC data is that more than 60% of events with magnitude 3.5 are screened out on the basis of spectral ratios[66]. In practice, objective screening based upon such a discriminant will likely be developed and routinely applied at the IDC in ways that may have to be fine-tuned slightly differently for different regions.

Below magnitude 4, mine-blasting can result in seismic events detected and located by the IDC which appear similar to small nuclear explosions using criteria such as depth estimates, weak surface waves, and high spectral ratios. Some researchers have found characteristic spectral interference patterns for such events, caused by the fact that commercial blasts routinely consist of numerous small explosions which are fired in a sequence of delays.[67] The resulting seismic source is spread out in space and time, and is therefore very different from a single-fired nuclear explosion. Another potential discriminant of mine blasting is the infrasound signal which can be generated by such sources,[68] and which would not be expected from a small underground nuclear explosion unless it vented significantly – which, in turn, would likely result in a characteristic radionuclide signal. New discriminants for particular types of small seismic events continue to be developed, both in field projects with specially deployed monitoring

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[64] Results reported at a Workshop on Event Discrimination sponsored by the Defense Threat Reduction Agency, Kansas City, June 2000.
[65] Hartse, H.E., Taylor, S.R., Phillips, W.S., and Randall, G.E. (1997). "Preliminary study of seismic discrimination in central Asia with emphasis on western China", *Bulletin of the Seismological Society of America,* pp. 87,551-568 and Kim, W.-Y., Aharonian, V., Lerner-Lam, A.L., and Richards, P.G. (1997). "Discrimination of Earthquakes and Explosions in Southern Russia Using Regional High-Frequency Three-Component Data", from the IRIS/JSP Caucasus network, *Bulletin of the Seismological Society of America,* pp. 87, 569-588.
[66] D. Jepsen, paper presented at a Workshop on Event Discrimination, sponsored by the Defense Threat Reduction Agency, Kansas City, June 2000.
[67] Hedlin, M.A., Minster, J.B., and Orcutt, J.A. (1989). "The Time-Frequency Characteristics of Quarry Blasts and Calibration Explosions Recorded in Kazakhstan, USSR", Geophys. J. Int., 99, 109-120 and Kim, W.-Y, Simpson, D.W., and Richards, P.G. (1994). "High-Frequency Spectra of Regional Phases from Earthquakes and Chemical Explosions", *Bulletin of the Seismological Society of America*, pp. 84, 1365-1386.
[68] Hagerty, T., Kim, W. Y., and Martysevich, P. (2000). "Infrasound Detection of Large Mining Blasts in Kazakhstan," in press*, Pure and Applied Geophysics*.

equipment, and in subsequent adaptation for candidate screening methods to be applied at the IDC to IMS data.

From the above examples, it may be appreciated that an underlying difficulty in treaty monitoring is making the trade-off between simple methods of analysis that are robust, objective, unchanging, and easily explained to people who lack technical training; and those more sophisticated methods which are demonstrably more effective but that require a greater degree of expert judgment and which will surely change from year to year as methodologies improve. The very existence of so much practical and specialized experience (coming from the decades of monitoring nuclear weapons tests), and of so many seismological resources generating potentially useful data, fundamentally enhances CTBT monitoring capability.

Evasion Scenarios

Almost all underground nuclear explosions in the past have been carried out with the explosive device tightly packed into surrounding rock (or, at least, with only a small amount of space between the device and the rock) and deep enough that little or none of the fractured rock mass blows out of the ground. In such cases, the explosion is said to be well-coupled. In contrast, if a nuclear explosion is conducted deep underground (depth around 1 km) at the center of a large spherical cavity in hard rock, with a radius greater than or equal to about 25 meters times the cube root of the yield in kilotons, then the seismic signals can be reduced by a so-called “decoupling factor” that may reach up to about 70 (see Chapter II). It is easier to build cavities of the same volume that are elongated rather than spherical, and such aspherical cavities can also achieve comparable decoupling factors, but they also increase the concentration of stress near the cavity and can make it much more likely that radionuclides will be released into the atmosphere through fissures in the rock and be detected by the radionuclide monitoring network of the IMS. An overall evaluation of the cavity decoupling scenario therefore raises a number of different technical issues:

- Does a country considering an evasive test have access to a suitably remote and controllable region with appropriate geology for cavity construction?

- Can the site be chosen to avoid seismic detection and identification (recognizing that seismic events are routinely reported down to about magnitude 3 by earthquake monitoring agencies for many areas in industrialized countries, and many countries routinely monitor neighboring territory)?

- Can cavities of suitable size and shape and depth and strength be constructed clandestinely in the chosen region, with disposal of the material that has to be removed from below ground?

- Can nuclear explosions of suitable yield be carried out secretly in sufficient number to support the development of a deployable weapon? (This question covers numerous technical issues, including the ability to ensure the yield will not be larger than planned; and to keep all yields of a test series large enough to learn from, yet small enough to escape identification.)

- Can radionuclides be fully contained from a decoupled explosion?

Each of these questions has been the subject of extensive technical analyses.

It is clear that decoupling – at least for small yields – is technically feasible. The key question is up to what yield could such a nuclear explosion be carried out yet remain hidden from CTBT monitoring systems? The American Geophysical Union (more than 35,000 members) and the Seismological Society of America (about 3000 members) in 1999 issued a joint position statement on this matter as follows:

> "The decoupling scenario… 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."

In addition, a nation with extensive testing experience would have little to learn technically and much to lose politically by clandestine testing (see Box 5).

Another evasion scenario is the use of mining operations and large chemical explosions to mask or disguise an underground nuclear explosion. There is a limit on the yield of any nuclear explosion that could be hidden in this way. Chemical explosions are almost always delay-fired at shallow depths, so they are inefficient in generating seismic signals, relative to nuclear explosions that are tamped.[69] It therefore appears that only a limited number of mines with the largest blasting operations are conceivably candidates for hiding militarily significant efforts at CTBT evasion.

There are two types of technical effort that can be carried out to help monitor mining regions for compliance with a CTBT. The first of these is installation of nearby seismographic stations that record digitally at high sample rates. Such data can distinguish between single-fired explosions and the multiple-fired explosions typical of mining operations. The second is provision of technical advice to mine operators so that they execute their blasting activities using modern methods of delay-firing – which have economic advantages as well as enabling the blasting of rock in ways that do not make the large ground vibrations (and strong seismic signals) typical of old-fashioned methods of blasting.

Addressing the reality of how the IMS and the States Parties will handle large blasting operations – or the occasional single-fired chemical explosion (whose seismic signals may indeed look the same as those of a small nuclear explosion), the treaty calls for each State Party "to cooperate with the Organization and with other States Parties in implementing relevant measures" that would "contribute to the timely resolution of any compliance concerns arising from possible misinterpretation of verification data relating to chemical explosions." These measures provide, on a voluntary basis, information on single-fired chemical explosions using 300 tons or more of TNT-equivalent blasting material; and information on mine blasting (such as mine locations) for all other chemical explosions greater than 300 tons TNT-equivalent.

To the extent that mine blasting remains a serious concern, problems can be addressed with nearby installation of infrasound and radionuclide monitoring equipment, and with site visits. These activities would be voluntary under the CTBT. Potentially they could also be made the subject of mandatory bilateral agreements, and/or of agreements between neighboring countries in a particular region.

Some remarkable assessments of evasion scenarios were presented in the U.S. Senate debate of October 1999 leading up to the negative vote on CTBT ratification. Thus, the Senate majority leader stated in executive session that "a 70 kiloton test can be made to look like a 1 kiloton test, which the CTBT monitoring system will not be able to detect."[70] He was referring to the decoupling scenario (see Chapter II). Treaty opponents gave speeches which included exactly the same sentence: "While the exact thresholds are classified, it is commonly understood that the United States cannot detect nuclear explosions below a few kilotons of yield." It was also stated that "Advances in mining technologies have

[69] Khalturin, V.I., Rautian, T.G. and Richards, P.G., "The Seismic Signal Strength of Chemical Explosions", *Bulletin of the Seismological Society of America*, pp. 88, 1511-1524, 1998.
[70] See Footnote 34, Chapter II.

enabled nations to smother nuclear tests, allowing them to conduct tests with little chance of being detected."

It is important to examine each of these three statements in turn.

A 70kt explosion would be enormous, about twice the energy of the combined Hiroshima and Nagasaki bombs, and would indeed be of military significance. The cavity that theoretically might reduce signals from a test of this size to something comparable to 1kt would have to be deep underground (on the order of 1 km deep), with volume equal to that of a sphere 200 meters in diameter. Such a spherical cavity could not be built in practice, not even in the open, let alone in secret. If it could be built, almost all the 70kt energy released by the test would go into pumping up gas in the cavity to about 150 times normal atmospheric pressure. These gases would be radioactive, and the high pressure means they would leak through cracks that inevitably would exist in the 125,000 square meters or more of cavity wall (i.e., about 35 acres), even if the cavity did not collapse. Distant radionuclide sensors of the IMS would detect the test if only 0.1% of the radioactivity escaped. The small fraction of energy released as seismic signals, if comparable to those from a typical (well-coupled) 1kt test, would travel far beyond the rock surrounding this hypothetical (impossible-to-construct) cavity, and would be large enough for detection at numerous seismometers all over the world, including those of the IMS.[71]

As for the United States not being able to "detect nuclear explosions below a few kilotons of yield", this might have been an accurate representation of the state of affairs in 1958 when CTB negotiations began. But it is not accurate more than 40 years later. Unclassified arrays of seismic instruments continuously and routinely monitor vast areas of the globe for earthquakes and explosions down to low seismic magnitudes reaching down to about magnitude 2 to 2.5 at Russia's former nuclear test site on Novaya Zemlya. This capability translates into the ability to detect down to about 10 tons (.01kt) of well-coupled yield.

As for mining technologies, the overall trend of modern methods of mine blasting has resulted in general in smaller seismic magnitudes than prevalent a few decades ago. There are only a limited number of mining regions where signals from a small (~ 0.1kt) nuclear test could be masked by a simultaneous mine blast without taking the additional steps of putting the nuclear test in a cavity – which would be associated with the complications listed above[72].

To summarize, if concern over evasion scenarios is sufficient that problems are targeted for resolution, then the goal of "... monitoring ... nuclear explosions down to a few kilotons yield or less, even when evasively conducted" is achievable.[73]

Conclusion

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. Evaluations of CTBT monitoring capability may be carried out as part of the domestic ratification process in each of the different signatory States. Such evaluation during the U.S. Senate debate of October 1999 relied upon a series of unsupported assertions.

[71] A specialized issue here is the question of how big a suitably deep cavity can be built, clandestinely, in salt domes or thick layers of salt – since this is by far the easiest material to use for such construction. To the extent that there is sufficient concern over this issue, it can potentially be addressed by bilateral or multilateral agreements to monitor such regions down to low magnitude. This type of geology has few earthquakes, and a potential treaty evader would know that any seismic activity would arouse attention.

[72] Regions of mine blasting with unusually large seismic signals, to the extent they are of concern, could also be made the subject of special monitoring.

[73] The U.S. position quoted in CD/NTB/WP.53 of 18 May 1994.

Evaluations have been carried out from time to time, together with budgetary review, by government agencies, not all of them eager to put resources into a major initiative in nuclear arms control. A review of nuclear explosion monitoring has not been carried out in the U.S. political arena since the 1980's.[74]

The work of treaty monitoring is enhanced by the existence of major seismological resources other than the IMS primary and auxiliary networks and the IDC. This point is acknowledged in the CTBT and its Protocol, which make several references to the need to take national monitoring networks into account. National networks are increasing in number and quality and are the basis for producing detailed bulletins of regional seismicity that typically are intended to meet objectives in the study of earthquake hazard.[75] Such bulletins, and easy access to the underlying digital seismogram data, can be very helpful in CTBT monitoring, for the study of problem events and for improving the IDC's routine seismicity bulletins. It is to be expected that the background of earthquakes will provide a means of calibration to achieve more accurate location of all seismic events. Seismology is continuing to provide new methods of data acquisition and data analysis, furnishing useful information that will improve the work of the IMS and assist in the attainment of national and international monitoring goals for a CTBT.

[74] See Footnote 57.

[75] For example, a major upgrade of the South Korea network has just been announced. The network is to have 74 high-quality stations, linked in real time to an analysis center. It appears the whole Korean peninsula can be monitored to very low magnitudes.

Chapter V

The Stockpile Stewardship Program

Sidney D. Drell

The end of the Cold War has signaled a dramatic change in the U.S. nuclear weapons program. The continuous cycle of developing, testing, and deploying new nuclear weapons has ended. As announced by President George Bush in 1992, the United States does not need to develop new nuclear warhead designs for deployment. It was this decision that opened the possibility of the CTBT.

The United States now relies on an expanded program of stockpile stewardship[76] to ensure that:

- the enduring arsenal remains reliable, effective and safe into the indefinite future without nuclear explosive testing;
- it maintains competence in nuclear weapons; and
- it retains the technical capability and manufacturing infrastructure in order to respond, as required for U.S. security, to changed strategic circumstances.

In order to make a net assessment of the impact of the CTBT on U.S. national security it is necessary to have a clear understanding of the benefits and risks to the U.S. ability to meet the requirements of the Treaty and still maintain an effective deterrent under a test ban.

This chapter will address the technical issues involved in making such an assessment. Three important facts define the starting point:

1. Today the nuclear weapons that are designated to remain in the enduring stockpile are, and will remain for the foreseeable future, effective, safe, and reliable. Confidence in today's stockpile is based on understanding gained from almost 50 years of stockpile surveillance, and the experience and analyses of more than 1,000 nuclear tests, including more than 150 nuclear tests of modern weapons types over the past 25-30 years.

2. The overwhelming majority of U.S. nuclear tests during the Cold War were devoted to developing for deployment new and more advanced warheads and weapons systems. Only a very small percentage, well under 10% of the 150-200 underground nuclear explosive tests of modern weapons from 1972 to the end of testing in 1992 by the U.S., were stockpile confidence tests; i.e., tests conducted on currently deployed weapons to confirm confidence in them. That is well less than 1 test per year for the whole arsenal of many thousands of weapons.

3. The CTBT in no way limits most of the testing and analysis work that goes on in connection with maintaining the U.S. deterrent. This includes testing the performance of the warhead, including the high explosives that initiate the implosion in the primary leading up to the

[76] The Stockpile Stewardship Program (SSP) is the responsibility of DOE. It includes operations associated with manufacturing, maintaining, refurbishing, surveilling and dismantling the nuclear weapons stockpile; the activities associated with the research, design, development, simulation, modeling sub-critical nuclear experiments and non-nuclear testing of nuclear weapons; and the planning, assessment and certification of the safety and reliability of nuclear weapons in the stockpile. The administration's FY-01 budget request for this program totaled $4.6B, a figure which the Congress seems prepared to increase.

> ignition of the fission stage itself. Flight tests of the missiles and their guidance systems will continue. All of the approximately 6,000 parts of the nuclear warhead, other than the nuclear package, will continue to be tested under the SSP as they have been for more than 40 years. Statistically significant numbers of such experiments have been carried out and provide meaningful measures of high confidence in the U.S. systems. Functional testing of the non-nuclear components of a nuclear warhead and flight-testing of the weapons system are not – and will not be – restricted by a CTBT.

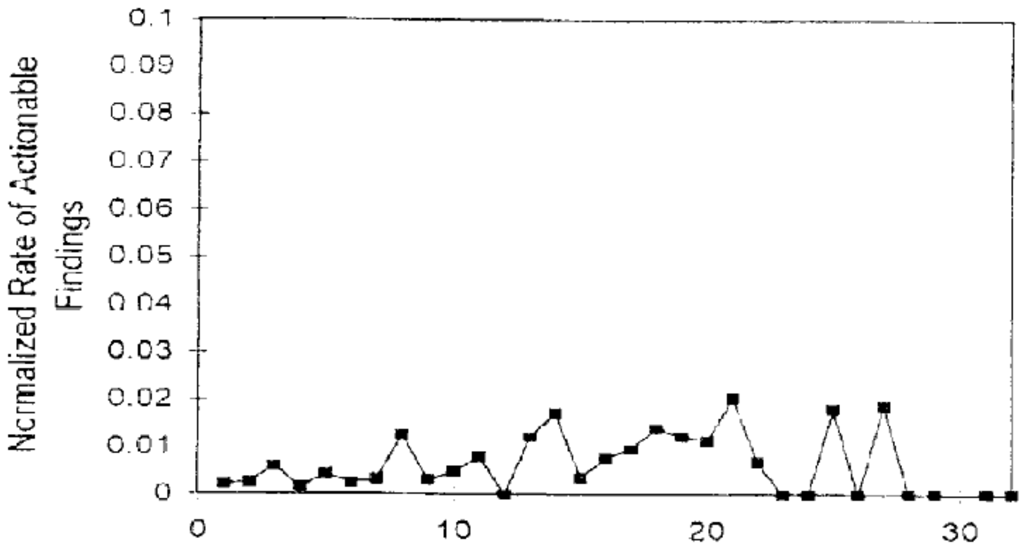
As to the requirement to preserve core intellectual and technical competencies in the national laboratories, the SSP offers exciting new science and technology work. No new nuclear designs are being developed for testing and deployment, although design work can proceed. However, the SSP supports and indeed depends on doing exciting new science to fill in gaps in understanding of the physical processes occurring under the extreme temperatures, pressures, and shock conditions of a weapon explosion. Weapons phenomenology is advancing to a fundamental constitutive understanding of these processes, including for example the physical properties of plutonium (Pu) with its many phase changes and complicated equation of state (i.e. the relationship between pressure, density and temperature). To accomplish this the United States requires data – the coin of the realm – that can now be obtained with the new tools that are available for diagnostics. The SSP presents a difficult management challenge.[77] This challenge can certainly be met with assurance of steady national and budgetary support for the SSP in all its aspects, and with strong, enlightened leadership from whoever occupies the newly created post of Administrator of the National Nuclear Security Administration and Under Secretary of DOE (to which General John Gordon, USAF (ret.), has recently been appointed and confirmed).

As to the challenge to maintain confidence in the performance and reliability of an aging stockpile, a variety of dynamic and static experiments are being pursued with very sophisticated equipment under the SSP. They are revealing detailed features of the crystal structure of Pu, and whether its aging affects its strength and integrity under the extreme conditions during the implosion. In the enhanced surveillance program, the national laboratories are doing detailed forensics on each warhead type in the stockpile. In particular, each year 11 copies of each warhead type are removed from the stockpile and evaluated for evidence of changes. (Over two years, such analysis gives 90% confidence of detecting a flaw present in 10% of the weapons in the stockpile.) Typically, one warhead of each type is destructively disassembled and inspected in every detail for signs of cracks or defects developing as the warhead ages, due to the radiation environment created by the Pu, for example, or due to defects in its production. These are areas in which the data are being obtained on the metals, the explosives and other chemicals in the warheads; and the findings so far have shown that the weapons are not noticeably showing the effects of deterioration or aging (see Figure 1).

In above-ground experiments weapons scientists are able, literally, to X-ray the behavior of a warhead up to the point when the nuclear chain reaction would have been ignited, had the plutonium not been replaced by a non-fissioning substitute. The important sub-critical explosive underground experiments at the Nevada Test Site are studying spall and ejecta (i.e., small fragments shocked from the surface of the metal) from Pu samples (without initiating a nuclear chain reaction) to search for possible changes in behavior that depend on the metal's age or manufacturing processing.

[77] This is discussed in the Chiles Commission report on Maintaining Nuclear Weapons Expertise (1999).

Figure 1



Year Post First Production Unit

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 cohost age. (SAND 95-2/51; CC-700)

The United States also has the ability now, with the world's most powerful computers acquired by the Accelerated Strategic Computation Initiative (ASCI), to make detailed analyses and simulations using quantitative three-dimensional explosion codes. With these advanced codes and computers, scientists can model imperfections due to cracks or voids that may develop in the structure and calculate to what extent they would degrade the performance of a warhead. It is of particular concern to retain confidence that the yield of the primary remains adequate to ignite the secondary, or main stage of a modern thermonuclear weapon, and produce the anticipated nuclear yield as designed. The codes are being benchmarked for added confidence against old data, and in particular by study of anomalous results from previous underground tests, as well as against new experimental data. In particular, the National Ignition Facility (NIF) will add new data on the behavior of hot plasmas. This data will be useful to benchmark new ASCI codes, as well as add to our understanding of material properties and interactions under conditions similar to those occurring during nuclear explosions.

Overall this is a very sophisticated and technically challenging program. The United States is getting data not heretofore available. And with the two device labs, Livermore and Los Alamos, peer-reviewing each other's work in the newly established dual revalidation program, there is no room for slack. (This is the best argument to keep both labs active in weapons work). This will tell the lab scientists if, when, and what has to be done to refurbish or manufacture warheads as needed. They will be able to identify and evaluate means of extending the lifetimes of the warheads in the enduring stockpile beyond previous experience, and thereby determine the required capacity of the remanufacturing infrastructure relative to the total numbers of warheads the United States plans to retain in its force structure (see Figure 2). Most importantly, the SSP will enable scientists to hear whatever warning bells may ring signaling evidence of deterioration due to aging, no matter how unanticipated, and enable them to make the necessary fixes in a timely fashion.

Figure 2

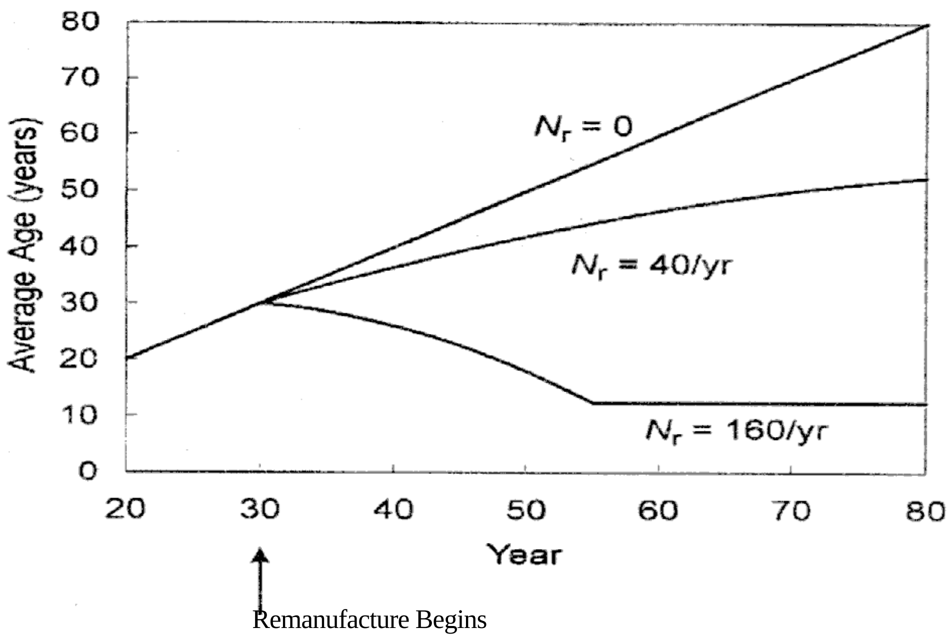


Figure 2: Sample calculations of average age of stockpile warheads assuming that remanufacture starts at a time when the average age is t_0=30 years. The average is calculated for a 4000 warhead stockpile, assuming replacement rates of N_r=0, 40, and 160 per year. See the JASON report on Remanufacture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

Scientists will always welcome more quality data, but the question is what is necessary, not what makes the job easier or what is merely useful. It was the unanimous conclusion of independent classified technical studies supported by the government – performed by JASON[78] with four leading designers of the present U.S. arsenal among the participants, and with the cooperation of DOE's weapons labs – that low-yield underground nuclear explosions have little to contribute, and nothing essential, relative to what U.S. scientists are presently learning from a multi-faceted, well supported stewardship program.

There are qualified people who disagree with that conclusion, and the most serious arguments come in the following forms:

- Without testing, the cadre of U.S. nuclear weapons scientists will inevitably lose competence;
- The United States is already losing confidence in its deterrent because of the lack of testing since 1992; and
- The United States has in the past found by testing that weapons already deployed in the stockpile had to be withdrawn and refurbished or redesigned because of problems that developed and were only detected subsequently, some on the basis of test explosions.

Clearly these questions have to be better addressed by the political process than they have been to date before a consensus for the CTBT can be established. As regards the first concern about retaining

[78] The unclassified Summary and Conclusion of the JASON report on Nuclear Testing (JSR-95-320, August 3, 1995) is included as Appendix B to this White Paper.

competence, based on my own long-term experience as a scientist and deputy director of a major national lab (SLAC – Stanford Linear Accelerator Center), my extensive interactions and long familiarity with the programs and scientists at the weapons labs, and work on the Chiles Commission on Maintaining Nuclear Weapons Expertise, I am confident that a strong science-based SSP that challenges the scientists to develop a deeper understanding of what goes on during an explosion, that trains them with solid grounding and mentoring based on past experience, and that also provides them with advanced diagnostic and computer tools, will challenge, attract, and sustain top notch weapons scientists at Livermore, Los Alamos, and Sandia National Labs.

As far as losing confidence in the U.S. deterrent, today I actually have more confidence in the long-term credibility of our stockpile than was possible five years ago. This conclusion is based upon what has been learned from the SSP over the last five years, and the on-going formal reviews that require the laboratory directors to certify annually, to the President, the Secretary of Energy, and the Secretary of Defense, that U.S. weapons are meeting stated military requirements. The data being derived from the SSP, as described earlier, is far more important for understanding the enduring arsenal, and maintaining confidence in its performance, than continued underground, very low-yield testing. The United States now knows much more, based on real data, about how Pu, high explosives, and other weapon components age. With such knowledge we can extend the anticipated lifetimes of the warheads for a good many more years than was formerly possible, perhaps to lifetimes of 50 years or longer. The challenge to DOE and the management of the national labs is to make the necessary priority choices to insure that the United States can meet the key requirement of stockpile maintenance and stewardship. This calls for balancing the manufacturing, revalidation and R&D aspects.

Box 3
Solving Problems with the SSP

In 1997 in response to a question from Senator John Kyl regarding problems with the stockpile, Dr. Siegfried Hecker, the former Director of Los Alamos National Laboratory, wrote:

> "Yes, there have been several instances since the cessation of nuclear testing in September 1992 where we have found problems, either age related or otherwise, for which in the past we would have turned to a nuclear test in the kiloton range to resolve. In the absence of testing, we have used the methodology of [Stockpile Stewardship] to evaluate the problem and suggest fixes if required. This has included more extensive calculation, non-nuclear laboratory experiments, comparison to previous nuclear tests data, and extensive experience of our designers and engineers…. If our confidence in the fixes were not sufficiently high, we would not certify the stockpile. Our experience to date in resolving suspected problems has increased our confidence in [Stockpile Stewardship] and in the process of annual certification."

Enclosure to letter to Senator Kyl from S.S. Hecker, September 24, 1997, response to Question 7. Cited in "Managing the U.S. Nuclear Weapons Stockpile," Dr. Robert Civak, p. 21.

There have been several allegations that in the past the United States found that some of its weapons introduced into the stockpile had subsequently developed problems and were withdrawn. The 1995 JASON study on Nuclear Testing,[79] including the four weapons designers mentioned previously, analyzed

[79] See Footnote 78.

the facts on this carefully. The unclassified summary of a classified comprehensive technical study concluded that:

> "For the weapon types planned to remain in the enduring stockpile we find that the device problems which occurred in the past, and which either relied on, or required, nuclear yield tests to resolve, <u>were primarily the result of incomplete or inadequate design activities</u>. In part, these were due to the more limited knowledge and computational capabilities of a decade, or more, ago. We are persuaded that those problems have been corrected and that the weapon types in the enduring stockpile are safe and reliable in the context of explicit military requirements." [Emphasis added]

The issue of warhead safety was thoroughly reviewed in 1990 at the request of Congress by a committee that I chaired, working with Drs. Johnnie Foster and Charlie Townes. Our report found that the enduring stockpile meets the rigorous safety criteria. Questions raised then have since been addressed. There are no remaining safety issues.

To conclude, neither science nor scientists can guarantee that things will not change in the future – either politically or due to technical surprises – as U.S. weapons get older. Therefore the U.S. remanufacturing and refurbishing program must be maintained to meet potential requirements and enable the nation to be prepared to respond promptly as needed. The U.S. safeguards associated with the CTBT must give confidence that the nation will respond.[80]

Subsequent debate on the CTBT should revisit these three points of contention. Perhaps additional safeguards need to be devised so that any treaty review that may be mandated by Congress, whether it occurs every 10 years – or 5 years, as it does for the Non-Proliferation Treaty – will be a rigorous technical one, and will provide confidence that any problems, should they arise, will be fully and aggressively addressed. This concern notwithstanding, it is important to bear in mind that, relative to other countries, the U.S. SSP is the most advanced one in existence. With unsurpassed diagnostic/simulation tools and capabilities, it affords the United States an important advantage in managing and maintaining confidence in the enduring stockpile. It is adequate to the task!

[80] Safeguard F calls explicitly for withdrawal in the interests of U.S. national security if need be. See Box 1 for the complete list of six safeguards.

Chapter VI

Clandestine Testing Under a CTBT

Richard L. Garwin

The Bottom Line Comes First

Complex technical issues should not be allowed to obscure the following important conclusions about a CTBT that result from a balanced assessment:

- In assessing the merits of the CTBT it is essential to bear in mind the difference between fission weapons of the Hiroshima-Nagasaki variety and thermonuclear weapons which are used on all deployed U.S., Russian and Chinese strategic nuclear weapons;

- 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;

- Under a CTBT the nuclear weapon states will be unable to test or have confidence in radically new designs of nuclear weapons, such as the nuclear explosion-pumped X-ray laser;

- While tests with yields vastly smaller than Hiroshima may evade detection, such tests would be useless to Russia and China who have already deployed thermonuclear weapons, and very difficult to use for confirming the validity of a clandestinely developed fission weapon (see Box 5);

- If secret information regarding thermonuclear weapons has been acquired by others, as has been alleged in regard to China, or may be so acquired in the future, this information cannot be turned into a deployable weapon without undertaking tests forbidden by the CTBT;

- 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 (see Chapter V). The nuclear (or physics) package itself can be remanufactured to original specifications should surveillance reveal deterioration. The stewardship program SSP 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; and

- Given that nuclear proliferation is probably the most serious threat to U.S. national security, and given the confidence that the U.S. deterrent can and will be fully maintained under the CTBT, it is clear that the United States will run fewer dangers with the CTBT in force than without it.

Why A Treaty?

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 cost to the United States includes constraining tests of U.S. nuclear weapons. The greatest benefit of the CTBT comes from constraining other countries from testing nuclear weapons; it therefore helps to prevent their proliferation. The Treaty does this directly by banning nuclear explosion tests and indirectly by keeping nations on board the Nuclear Non-Proliferation Treaty (NPT). The United States does not want additional states to have nuclear weapons, nor do the other members of the NPT.

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 4000 kg, with a yield of 15 to 20kt. The Hiroshima bomb used an artillery-gun assembly of 60 kg of enriched uranium, which was not tested before its use.[81] The Nagasaki bomb, tested three weeks beforehand in the New Mexico desert, was an implosion device and contained some 6 kg of plutonium.[82] Compare these weapons with a two-stage thermonuclear bomb tested in 1957 that weighed some 180 kg with a yield of 74kt; its diameter was a mere 12 inches and its length some 42 inches.

While it is possible to produce implosion-type weapons without a nuclear explosion test, they might work or they might not; real organizations of real people would not have much confidence in a stockpile of such untested weapons. Nor should they. Anyone seeing the unclassified pictures of mangled steel tubes that were supposed to be uniformly imploded by early U.S. attempts at implosion designs begins to get a feeling for the problems inherent in an indigenous – and under the CTBT, clandestine – nuclear weapons program.

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, their improved safety, and additional options for their delivery.

A sophisticated proliferator might put into its stockpile without testing a pure U-235 fission weapon of 200kt yield which, at 10% efficiency, would require some 120 kg of U-235 and the chemical explosive might weigh 1800 to 3600 kg. Normal weapon-grade Pu could not be used in such a large pure fission weapon because of the large probability of pre-initiation resulting in greatly reduced yield. That amount of Pu would suffice for 20 thermonuclear weapons, each of which could be in the megaton class and weigh less than 450 kg. 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 its allies, even if nations overtly or clandestinely pursue nuclear weaponry without explosive tests.

Low-Yield 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, 10kt? No, but tests above 1kt are almost certain to be detected and the utility of such tests below that level to a weapons program has been thoroughly explored and found to be minimal.

It is useful to recall the August 3, 1995 report of JASON chaired by Dr. Sidney Drell, of which I was a co-author (see Chapter V and the Appendix B). Conclusion 6 of that study refers to a nuclear weapon test

[81] A gun-barrel assembly is one in which two sub-critical masses of fissile material are brought together in some milliseconds by ordinary propellant such as is used to propel artillery shells.
[82] An implosion assembly is one in which a high explosive with similar energy content to a propellant, but with a much higher speed of reaction (detonation), is used to assemble and compress fissile materials to exceed a critical mass at higher density in a time measured in microseconds rather than milliseconds.

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 10kt." That is clearly verifiable by the CTBT's International Monitoring System, with its seismic, hydroacoustic, and infrasound sensors, and its radionuclide detectors of radioactive gases and particles (see Chapters III and IV).

The JASON 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 U.S. nuclear weapon laboratories.

A proliferant country might well want to acquire fission weapons of 5kt yield, but the chance of detonating such a weapon undetected is small. The 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 1kt – and in many portions of the world the detectability is much better (see Chapter IV). 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 1 ton (<u>not</u> 1kt) 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 pounds of high explosive equivalent. These are banned under the CTBT; they would very likely not be detected by the IMS. It is clearly impossible seismically to distinguish a test that may have had 200 pounds of high explosive from a test with 200 pounds of high explosive and 1 pound of nuclear yield. However, 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 device 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. Russia might build these without testing, or they might be tested unobserved by U.S. sensors, with or without a CTBT. These would not pose a threat to U.S. national security. In no case would the United States need to 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 clandestine 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 IMS, 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: a clandestine test cannot be used to intimidate other states.

Additional Means To Detect Violations

In addition to the IMS discussed above and in Chapters III and IV, 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 the more than 10,000 research seismometers that can augment and in many cases greatly improve the sensitivity of the IMS. There is good reason to be confident that the CTBT can be effectively verified. This means that experimental validation of a nuclear weapon by nuclear explosion testing cannot be accomplished by a state that is party to the CTBT. As discussed in Chapters III and IV, in the vicinity of the Russian nuclear test site of Novaya Zemlya and the Chinese test site at Lop Nor, since these are the focus of much interest, even a 1kt fully "decoupled" explosion – that is, in a rock cavity at 1 km depth and with a diameter exceeding 50 meters (164 feet) – would still have a high likelihood of being detected by the seismological monitoring community.

Box 4
What Could be Accomplished by Clandestine Tests?

At their test sites, China, Russia, India, or Pakistan could not conduct tests above about 10 tons of yield without substantial risk of detection by the seismic monitoring arrays focused on these sites of interest – unless the explosions are conducted in large cavities in the rock. With very large cavities at sufficient depth, explosions up to 500 tons might escape detection by seismic means. Away from such test sites, cavities large enough to hide 1 – 2kt might be built. Only underground tests might escape detection in this way, and even these could be vulnerable to detection as a result of inadequate decoupling or leakage of radioactive fission products. A proliferator might attempt a test of a few tons on a ship in the ocean in the hope it would escape attribution to a particular nation, but such a test is likely to be detected.

With a long series of subcritical (permitted) experiments, a sophisticated nuclear weapon state, like Russia or China, could explore the safety of its weapons against accidental detonation. A few tests banned by the CTBT, with a fission yield of a few pounds of high explosive, would reduce the technological challenge of such one-point safety tests.

A nuclear weapons state could design and might even fully test a fission weapon of a yield of tens of tons if it felt that such a weapon test or series of tests was worth the risk of detection. It could do this in modest cavities at its test site, or without such precautions underground away from the test site. With existing small yield weapons already in its arsenal, it is unclear why a nuclear weapons state would risk the political fallout from such tests.

Without testing at levels above several kilotons, a sophisticated nuclear weapons nation, even the United States, could not gain confidence in the performance or reliability of a new thermonuclear weapon design, nor could it possibly develop or have confidence in directed energy-type weapons such as the X-ray laser.

A sophisticated proliferator, such as South Africa or Israel, might design a thermonuclear weapon, but testing limited to a kiloton would not provide any confidence that it would work.

A technologically less-sophisticated proliferator could build a gun-assembled uranium weapon – perhaps considerably less massive than the one the US used to destroy Hiroshima, but a test below one kiloton would not improve confidence in a typical 10 – 20kt weapon beyond what could be achieved without violating the CTBT.

Reducing the size and mass of an implosion weapon to make it lighter and smaller than the first-generation U.S. weapons (for MIRVing or to facilitate long-range missile delivery) might be accomplished with different explosive systems and configurations of plutonium or enriched uranium. Numerous sub-critical experiments permitted by the CTBT might give some confidence in this approach, but care would be needed to avoid a higher yield; testing in the few-ton range would require similar cautions but would be technically easier – if more risky. If evasive testing could confidently be conducted in the 500 ton range, the uncertainty in the full-scale performance of an implosion device would be reduced but not eliminated. Sub-kiloton evasive tests could be used to evaluate "hardness" of other nuclear weapons but would not affect US security, since the US has no nuclear-armed interceptors and no plans to build any. Such tests might be used to evaluate hardness of battlefield electronics, but would not add much to the understanding obtained from analysis and simulation.

While an advanced nuclear weapon state might develop a sub-kiloton “enhanced radiation" weapon and risk its evasive testing, the military utility of such a weapon in comparison with simpler weapons of higher yield is questionable.

A Balanced Assessment

The nonproliferation and arms control benefits to the United States of a CTBT are substantial; the adherence of other nations to the NPT and to the CTBT is fundamentally influenced by U.S. ratification of the CTBT. A state 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.

U.S. nuclear weapons will be maintained reliable and safe under a CTBT, thanks to the SSP 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 (see Box 1).

On the basis of my experience in the nuclear weapons program, and in light of the benefits to the United States to be gained from a worldwide ban on nuclear testing, I strongly believe that U.S. national security will be enhanced by ratification of the CTBT.

Chapter VII

The CTBT and Nuclear Proliferation

George Bunn

Some argue that the failure of the United States to ratify the CTBT will not affect whether or not other countries acquire nuclear weapons. They say that all countries except Cuba that do not have nuclear weapons have joined the Nuclear Non-Proliferation Treaty (NPT) which prohibits them from acquiring – and by extension, testing – nuclear weapons. The only important countries not already prohibited by the NPT from acquiring and testing nuclear weapons are the three nuclear weapons-capable states that are not members of the NPT, India, Israel and Pakistan, and the five nuclear-weapon states party to the NPT: China, France, Russia, the United Kingdom and the United States. Therefore, some CTBT opponents contend, the CTBT would not stop testing except by countries that already have nuclear weapons and would have no effect on slowing the spread of nuclear weapons to other countries.

But gaining the adherence of India, Israel and Pakistan to the CTBT would clearly inhibit the continued development by these countries of advanced weapon designs suitable for delivery by missile warheads.[83] Indeed, one reason the CTBT is very much in the U.S. interest is that U.S. weapon designs are very advanced, and if nuclear tests are resumed the current U.S. technological advantage could be narrowed and its security diminished.

Gaining the adherence to the CTBT of the eight nations that have nuclear weapons is legally necessary to bring the Treaty into force for *any country.* Furthermore, if the United States does not ratify, its ability to convince India, Israel, Pakistan and others to join the CTBT as well as to persuade others such as Iraq, Iran, and perhaps eventually Japan not to withdraw from the NPT will be greatly weakened. In addition, bringing the CTBT into force would inhibit nations that already possess nuclear weapons from developing advanced weapons and narrowing the advantage in this area that the United States currently enjoys. Moreover, the Senate's refusal to consent to the CTBT was a devastating blow to the U.S. campaign to gain acceptance of stronger International Atomic Energy Agency (IAEA) safeguards to verify that non-nuclear weapon NPT States Parties are not clandestinely making nuclear weapons – as Iraq was under the earlier, weaker IAEA safeguards. Finally, failure of the Senate to give its consent has weakened the ability of the United States to convince other countries to observe strong nuclear export controls. These arguments will be discussed in more detail below.

Bringing The CTBT Into Force

Before the CTBT can come into force, 44 countries with nuclear reactors that were members of the Conference on Disarmament at the time of negotiation must sign and ratify – including the U.S. Of these 44, all except India, North Korea and Pakistan have signed and 30 have ratified including France, Russia and the United Kingdom. Probably the most important of the 11 states that have signed but not yet ratified – besides China and the United States – are Egypt, Indonesia, Iran, Israel and Ukraine.

India and Pakistan are unlikely to sign the Treaty if they doubt the U.S. Senate will approve it. The Prime Ministers of both India and Pakistan made statements to the U.N. General Assembly (UNGA) after their

[83] Though crude "beginners" weapons such as the Hiroshima bomb can be made without testing, experienced U.S. weapon designers agreed long ago that sophisticated, easily transportable weapons with diameter of as little as one to two feet and weight of as little as several hundred pounds required testing. The number of tests will of course depend upon how many kinds of weapons are desired, how small they must be to be used, for example, as missile warheads, and how successful the first designs are shown to be in their initial tests. See Chapter VI above and J. Carson Mark, et. al., "Can Terrorists Build Nuclear Weapons?" in Paul Leventhal and Yonah Alexander, eds., *Preventing Nuclear Terrorism* (Lexington, MA: Lexington Books, 1987), pp. 55, 63-65.

1998 tests suggesting that their countries would not impede the CTBT's entry into force – implying that if the rest of the 44 ratifications necessary for entry into force took place by the end of September 1999, the first date the CTBT could come into effect by its terms, India and Pakistan would sign and ratify.

India's Prime Minister Atal Bihari Vajpayee told the UNGA in September 1998 that India was "…prepared to bring discussions to a successful conclusion so that entry into force of the [CTBT] is not delayed beyond September 1999."[84] After the Senate vote, the Indian foreign minister said, "There is no denying that this negative vote by the U.S. Senate does have a bearing on the future of the treaty. I would, therefore, consider it natural for India also to disaggregate its decision."[85] During his September 2000 visit to the United States, Prime Minister Vajpayee indicated that India intended to abide by its testing moratorium.

As for Pakistan, its then prime minister, Nawaz Sharif, told the General Assembly in September 1998 that "Pakistan is...prepared to adhere to the CTBT" before the special CTBT Conference then expected at the end of September 1999. But, just before the Senate vote in October 1999, a military coup overthrew Sharif. After the Senate vote, the new Pakistani government said it would not be the first to test in South Asia but that it would not even *sign* the CTBT until all U.S. economic sanctions against it resulting from its tests and from the military coup were lifted.[86]

Given the position of India and Pakistan, the rejection of the Treaty by the U.S. Senate, and President Clinton's inability this year to persuade either country to sign the CTBT, the prospects that either country will join if the Senate fails to approve it seem slight.[87] Indeed, after his return from India and Pakistan, President Clinton said the United States had "lost all leverage" to persuade them to do so when the Senate voted down the CTBT.[88]

North Korea, the other non-signatory necessary for entry into force of the CTBT, has made no public promise to sign. But, after Senate rejection of the Treaty, it may be difficult for U.S. representatives to be very persuasive with North Korea during the on-going informal bilateral discussions. If the Senate eventually approves the CTBT, negotiating with North Korea to get it to join the CTBT makes sense. But if the Senate does not, such a negotiation may be pointless.

Egypt, Iran, Iraq and Israel have all signed but not ratified the CTBT. Egypt, Iraq and Iran are likely to wait at least until Israel ratifies. Egypt has been a leader of Arab and other Muslim states at NPT conferences in demanding that Israel join the NPT as a non-nuclear weapon state.[89] In its statement at the

[84] G. Bunn with Rebecca Johnson and Daryl G. Kimball, *Accelerating the Entry into Force of the Comprehensive Test Ban Treaty*, (Washington, DC: Coalition to Reduce Nuclear Dangers, 1999), p.16.

[85] Interview with Foreign Minister Jaswant Singh published in *The Hindu* newspaper of November 29, 1999, and reproduced in *Arms Control Today* (Dec. 1999), pp.17-18 "Disaggregate" must mean in this context that, like the United States, India could sign but would not ratify the CTBT.

[86] Statement in mid-November 1999 by Pakistani Foreign Minister Abdul Sattar, News Briefs, "Pakistan Says It Will Not Be the First to Test," *Arms Control Today* (Nov. 1999), p.28. Subsequent Pakistani statements have been consistent with this one. Prime Minister Sharif's statement is in Bunn, et. al.,op. cit., Footnote 84.

[87] See Daryl G. Kimball, "How the Senate Rejected CTBT Ratification," *Disarmament Diplomacy* 40 (Sept./Oct. 1999), p.13.

[88] Sean Howard, "News Review," *Disarmament Diplomacy*, 45 (April 2000), p.61.

[89] Egypt was the leader of the effort by Arab countries to gain adoption of a resolution at the 1995 NPT Extension Conference calling for universal acceptance of the NPT in the Middle East. See NPT/CONF.1995/32/Res.1. For the next five years, it led the successful efforts to get all Arab states that had not joined the NPT to do so in order to put pressure on Israel to join. See "Implementation of the resolution of 1995 on the Middle East: Working paper submitted to Main Committee by Egypt," NPT/CONF.2000/MC.II/WP.9/Rev.1; G. Bunn, " The Nonproliferation Treaty under Siege," (CISAC Working Paper, Sept. 1999), pp.7-9. As a result of Egypt's efforts (among others), the

October 1999 special CTBT conference of States Parties, Egypt made similar demands – adding that Israel should now ratify the CTBT. Unless other Arab and Islamic countries step ahead of Egypt on this issue –as they have not done so far – states such as Iran and Iraq are unlikely to ratify the CTBT before Egypt and Egypt is unlikely to do so before Israel.

What is Israel likely to do? At the October 1999 special CTBT conference, the Israeli representative expressed concern both about protecting Israeli sovereignty in the face of possible on-site inspections under the CTBT and about prior ratification of the Treaty by other states than Israel in the Middle East.[90] He made no promise that Israel would ratify and Washington is unlikely to convince Israel to ratify unless the Senate consents.

Weakening Both the NPT and U.S. Leadership

The most immediate effect on the NPT of the Senate's refusal to give advice and consent to the CTBT was to slow agreement by many NPT countries to the new tougher IAEA inspections for all non-nuclear-weapon NPT parties. After the Gulf War, as a result of Iraq's success in hiding its clandestine nuclear-weapon activities, the U.S. helped lead an effort at the IAEA to strengthen its safeguards to detect clandestine activities in the territory of non-nuclear-weapon NPT parties. The more intrusive safeguards were finally adopted as policy by the IAEA Board of Governors and General Conference in 1997, but each country then had to negotiate an amendment to its safeguards agreement with the IAEA to make the more intrusive safeguards applicable to itself. Recently, the Director General of the IAEA said, "The Senate vote against the ban on nuclear tests was a devastating blow to our efforts to gain acceptance of more intrusive inspections of nuclear facilities around the world."[91] By an IAEA count in July 2000, only 14 of 137 non-nuclear-weapon parties to the NPT with IAEA safeguards had ratified the new, more intrusive safeguards agreements with the IAEA. While not all were expected to – especially those like North Korea that are suspect, some 60 countries signed new agreements after the 1997 IAEA decision. Following the Senate's vote on the CTBT, the ratification process slowed markedly.

A senior IAEA expert explained that "innovations like this require diplomatic momentum, and without the U.S. in the lead, momentum disappears." He added that even "reliable countries are dragging their feet asking why they should accept new burdens if America is turning its back on nuclear disarmament." Until reliable countries accept the new IAEA safeguards, he said, the IAEA cannot put much pressure on suspect countries.[92] According to the American ambassador to the IAEA: "The greatest danger is not that the NPT will dissolve but that it will atrophy…"[93]

Already, according to State Department officials who follow the implementation by other countries of export controls required by the NPT, some countries are acting as if the NPT requirements had been relaxed. These NPT States Parties appear not to be enforcing with the same rigor NPT prohibitions on exports of nuclear materials, equipment and related technologies to states that do not accept full-scope IAEA safeguards over their nuclear activities. Are these NPT States Parties saying: "If the United States is not going to enforce proliferation prevention measures such as the CTBT on itself, why should we enforce other non-proliferation requirements on ourselves?"

NPT 2000 Review Conference urged Israel (as well as Cuba, India, Pakistan) to join the NPT and reiterated its call upon states such as Israel that operate unsafeguarded nuclear facilities and have not acceded to the NPT to reverse their policies of pursuing weapons development. Final Document, NPT/CONF.2000/28, paras. 8 and 11.

[90] Israel has made it clear that it will not ratify the Treaty until it is satisfied that on-site inspection provisions have been satisfactorily worked out in the OSI Operational Manuals called for in the Treaty.

[91] Statement of Director General Mohamed Elbaradei quoted in William Drozdiak, *Washington Post*, June 15, 2000, p. A-14.

[92] Ibid.

[93] Ibid.

If the Senate is unwilling to approve the CTBT in the years ahead, what will happen? First, as the preceding discussion suggests, the NPT will be substantially weakened. This clearly would be detrimental to U.S. security, as the NPT has been critical both in constraining the spread of nuclear weapons to new nations and in rolling back proliferation in nuclear weapons capable countries such as Belarus, Kazakhstan, South Africa and Ukraine.

Second, the CTBT will not go into effect for any country because the United States is a necessary party. Third, India and Pakistan may well resume testing. If India tests, China may use that, and the failure of the United States to ratify, as reasons for it to resume testing. There is good reason to believe that China may want to produce smaller nuclear warheads so that its missiles can carry multiple warheads and decoys to confuse and overwhelm interceptor missiles from the proposed U.S. national missile defense and theatre defense systems. If China tests, and North Korea has neither joined the CTBT nor permitted a full accounting to be made by the IAEA of its earlier nuclear activities, what would Japan and South Korea do?[94]

Japan has been a leader in trying to bring the CTBT into force at the earliest possible date. But if India, Pakistan and China resume testing, if North Korea is still frustrating full IAEA inspections, and if the CTBT can not go into effect because of the Senate rejection, how long will it be before the Japanese government starts a secret program to build nuclear weapons? Japan felt threatened in 1998 by the combination of the Indian-Pakistani nuclear tests in May and a North Korean Taepo Dong rocket that flew over Japan a few months later. A parliamentary vice minister for defense in Japan was forced to resign in 1999 when he suggested that Japan build nuclear weapons after these events. Although officially Japan remains steadfastly against becoming a nuclear weapons state, he was certainly not the only one in Japan with this view.[95] Japan, like other NPT States Parties, has the right to withdraw from the NPT on three-months notice "if it decides that extraordinary events, related to the subject matter of this treaty, have jeopardized the supreme interests of its country."

If Japan withdrew from the NPT, would South Korea be far behind? South Korea has been invaded by both China and Japan. It could well feel threatened if full inspections were still stalled in North Korea, if China had resumed testing, and if Japan had withdrawn from the NPT. South Korea had a nuclear-weapon program in the 1970s but was dissuaded from pursuing it by the United States. If it withdrew from the NPT, it could produce nuclear weapons in a short time. North Korea would likely not be far behind and a dangerous nuclear weapons spiral would be under way in Northeast Asia.

Will results comparable to these take place in other parts of the world, the Middle East for example? As we have seen, of the states in that region essential for entry into force, Egypt and Iran are likely to wait on Israel before ratifying, and Israel is likely to wait on the U.S. and on the Middle East peace process. But Egypt is developing a uranium mine, Iran is acquiring a nuclear power reactor and both have trained nuclear experts. Failure of the U.S. to ratify the CTBT is thus likely to contribute to the potential spread of nuclear weapons to several countries in the Middle East now prohibited from making them by the NPT.

Finally, in addition to the slowdown in acceptance of stronger IAEA safeguards and the possible withdrawals by non-nuclear weapons states from the NPT, the Treaty will be weakened in another way.

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[94] Under the US-North Korea Agreed Framework of October 1994, North Korea is obligated to permit routine IAEA inspections of the spent fuel recently taken from its shut-down reactors but is not obligated for some time to permit a search for the undeclared spent fuel that 1993-94 IAEA inspections and satellite intelligence suggest were taken from a reactor before the Agreed Framework was negotiated. Its obligation to permit such broader inspections comes later, after major progress has been made toward providing it with new light-water reactors.

[95] Michael J. Green and Katsuhisa Furakawa, "New Ambitions, Old Obstacles: Japan and Its Search for an Arms Control Strategy," *Arms Control Today* (July/Aug. 2000), p. 17.

U.S. failure to ratify the CTBT casts doubt on the credibility of the commitment in the NPT, ratified by the U.S. Senate, to "negotiate in good faith on effective measures relating to the cessation of the nuclear arms race at an early date and to nuclear disarmament." In this context "cessation of the nuclear arms race" included a CTBT. This is clear from the preamble of the NPT.[96]

At the 1995 NPT Extension Conference, the United States and the other four NPT nuclear-weapon parties agreed that they would complete negotiation of a CTBT by 1996.[97] This was probably the single most important promise made to gain wide support from non-nuclear weapons states for making the treaty permanent, a decision perceived as very much in the U.S. interest. For many nations, carrying out this promise was a test of the sincerity of the United States and the other NPT nuclear-weapon states with respect to their NPT obligation to "negotiate in good faith" to halt the nuclear arms race and reduce their nuclear weapons. This obligation is what many non-nuclear-weapon parties have long relied upon to reduce what they perceive as discrimination against them authorized by the NPT: Five nuclear-weapon NPT States Parties may test and possess nuclear weapons but none of the other 182 NPT States Parties may do so.

The NPT obligation to "negotiate in good faith" has become more and more important to non-nuclear-weapon NPT parties with the end of the Cold War and the belief of many that nuclear weapons should be reduced and eliminated, not tested. Failure of the United States to ratify the CTBT will be perceived by many non-nuclear-weapon NPT parties as walking back on the U.S. promise to "negotiate in good faith" to halt the nuclear arms race and as an intentional frustration of the 1995 U.S. promise to finish negotiating a CTBT.

Conclusion

The U.S. Senate's vote has weakened the NPT, jeopardized implementation of the IAEA's more intrusive safeguards system, weakened U.S. ability to persuade others to ratify the CTBT and observe strong nuclear export controls and increased the likelihood that more countries will drift away from the NPT and consider going nuclear. Indeed, it has given countries slow to sign or ratify the CTBT a good excuse for not doing so since the CTBT cannot go into effect for any country because of the Senate vote. If India, Pakistan and China resume testing, others are likely to follow and the non-proliferation regime will be further weakened. If we are to avoid this series of events and if the United States is to renew its leadership and bargaining leverage in its efforts to stop the spread of nuclear weapons, then U.S. adherence to the CTBT is essential.

[96] NPT, para. 10. It is also clear from the agreement in 1968, just after the NPT was signed, to place "*cessation of nuclear testing*" in the first position on the agenda of measures to be negotiated by the Conference on Disarmament under the heading "*cessation of the nuclear arms race*," language from the NPT obligation just quoted. Treaties that limited but did not end testing were then negotiated during the Nixon and Ford administrations (the TTBT and PNET) and progress toward a treaty banning all tests was made later (see Chapter I).

[97] Principles and Objectives for Nuclear Non-Proliferation and Disarmament, NPT/CONF.1995/32/DEC 2, para. 4 (a).

Chapter VIII

Russia, China and the CTBT

Thomas Graham, Jr.

Stemming the proliferation of nuclear weapons is unquestionably the greatest challenge facing the United States and its allies now and for the foreseeable future. As President Jacques Chirac of France, Prime Minister Tony Blair of the United Kingdom and Chancellor Gerhard Schroeder of Germany noted in an October 1999 *New York Times* op-ed: "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."[98] The costs and benefits of the CTBT should thus be weighed in the context of this overarching national security objective – preventing nuclear proliferation.

Preventing nuclear proliferation is not the only benefit of a CTBT, however. Moscow and Beijing, and more specifically the nature of U.S. 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. Despite the current debate over whether the United States needs a national missile defense to address the possible future missile/WMD threat from states of "concern" such as Iraq, Iran and North Korea, it is important to recognize that Russia and China are the only potentially adversarial nations with the capability of challenging U.S. interests around the globe or striking the United States with long-range nuclear-armed ballistic missiles.

Freezing Nuclear Weapon Development

The ability of Russia and China to maintain and modernize – and in the case of China, significantly increase – their strategic nuclear arsenals and the impact that the CTBT would have on those efforts should be a central element of the U.S. 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 by the conduct of well over 1,000 nuclear explosive tests – 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.[99]

Modern nuclear weapons, with thousands of individual parts, 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 thermonuclear weapon. No responsible political leadership, 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. France reportedly used as many as 22 tests.[100] Thus, the CTBT would keep new designs for advanced weapons out of the stockpiles of Russia and China. This will help ensure that the U.S. arsenal would continue to consist of the world's most advanced weapons. In addition, no nation is better prepared to maintain the reliability of nuclear weapons in a non-testing environment

[98] Jacques Chirac, Tony Blair and Gerhard Schroeder, "A Treaty We All Need," *New York Times*, October 8, 1999.
[99] The Soviet Union/Russia conducted 715 tests and China 45. The United Kingdom, which has had access to US test data, has conducted 45 tests. France has conducted 210.
[100] Robert Norris, "French and Chinese Nuclear Weapon Testing," *Security Dialogue*, Vol. 27(1), 1996, pp. 39-54.

than the United States (see Chapter V). The information gathered by U.S. scientists through the nation's extensive nuclear testing program contributes to the effectiveness of the Stockpile Stewardship Program (SSP) 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. The global leadership of the United States in the realm of supercomputer development, which is essential to the success of the SSP, further ensures this advantage. In effect, under a CTBT, no other nation will be more capable than the United States of maintaining its arsenal without testing.

Making The Most Out Of The Testing Moratorium

The current testing moratorium by the P-5 – which for the United States has been in effect since 1992 – is at present only a political commitment. 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 possible Russian and Chinese nuclear test.

The establishment of this international ban on testing, together with the monitoring network that would be in place, would come at little additional cost to the United States. Whether or not the CTBT enters into force, political realities are such that unless the other major nuclear powers resume testing (and three of them, France, the U.K. and Russia have already ratified the CTBT), the United States is unlikely to ever test nuclear weapons again. This situation was reinforced by the agreement of all NPT parties at the 2000 Review Conference, including the United States, to a testing moratorium pending entry into force of the CTBT. This would make the unilateral resumption of testing a violation of an NPT-related commitment. Thus, in a world of no U.S. nuclear tests, this nation would be much better off if Russia and China were bound by an international agreement not to test as well.

Verification and Access to Testing Facilities

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 IMS established by the CTBT will enhance 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 on-site inspection as well as the first truly high-tech arms control treaty verification regime relying on seismic monitoring, radionuclide sensing (i.e. environmental sampling), a hydroacoustic network, and an atmospheric infrasound network (see Chapters III and IV).

There remains, nevertheless, concern among opponents of the test ban that nations will be able to hide nuclear explosive tests in environments that will "decouple" their seismic signatures or otherwise prevent their detection. However, only nations with advanced nuclear testing programs and extensive underground testing experience are likely to be able to conduct such deceptive tests whose preparation and yields would have to be carefully controlled. This rules out India, Pakistan and Israel as well as the so-called "states of proliferation concern." The United Kingdom cannot conduct any tests as long as the U.S. test site is closed. France has not tested on its European territory and could not expect to test abroad in the wake of international reaction to its 1995 tests. As a result, decoupling is a concern that can realistically only be directed toward Russia and China. 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 the CTBT and its IMS than without.

This is not to say that detecting deceptive tests of sub-kiloton yield will be easy. Since it is assumed that the United States as an open society would not be able to do such tests, this could be translated into a strategic disadvantage for the United States under the test ban. Of course, the same problem of undetectable low-yield tests arises today under the moratorium, the only difference being that the United States cannot avail itself of a fully deployed CTBT verification system. As the 1995 JASON Report makes clear, while testing at one-half kt could confer some marginal benefits, it would only be meaningful if testing went undetected over a long period of time.[101] Russia and China might be able to conduct a few low-yield tests and evade detection, but an extended series, which is the only way any benefits could be derived from such tests, would not be possible to hide. Six IMS stations detected the Kara Sea seismic event near Novaya Zemlya in 1997 with a magnitude 3.5 on the Richter scale, which corresponds to a nuclear explosion with a yield of less than 1kt. This is a good indication that the IMS, which has been improved in the three years since that event and which will continue to be upgraded, can reasonably be expected to detect even very low-level events in regions of concern.

Box 5
Enforcement

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

Some international arms control treaties establish implementation organizations. The Standing Consultative Commission is associated with the Antiballistic Missile Treaty, the Organization for the Prohibition of Chemical Weapons with the Chemical Weapons Convention and the Comprehensive Test Ban Treaty Organization with the CTBT, but these are not enforcement bodies. While the UN 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.

There are no enforcement mechanisms for two reasons. First, there is no world government and therefore no world police force to enforce its rules. Secondly, *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, 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 other Treaty members.

Like it or not, for Russia and China to hope to play a role in the development of the security framework of the 21st century, they must be members in good standing of the various treaties that comprise the international arms control and non-proliferation regime. To the degree that deliberately breaching a major arms control treaty risks a loss of political power and influence greater than any technological gain, these international treaties are self-enforcing.

Conclusion

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 already impressive U.S. global monitoring system for detecting nuclear tests and make it more difficult for any 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 by situating both countries more firmly in the nuclear non-proliferation regime.

[101] See Appendix B.

Chapter IX

Is a CTBT in the National Interest?

Jack Mendelsohn

"I believe the United States Senate made a serious error in failing to ratify [the CTBT] last year and I hope it will do so next year." President Clinton, September 1, 2000

In assessing whether or not to ratify the CTBT, the basic question is whether the agreement will enhance or degrade U.S. national security. Would U.S security interests be better served if the United States were to abandon its current moratorium, resume the testing, design, manufacture and deployment of new nuclear warheads, and delay indefinitely fulfilling its commitment to complete a CTBT which was assumed in connection with the indefinite extension of the NPT in 1995? Or would it be strategically more advantageous for the United States to ratify the CTBT, rely on careful stewardship of the enduring stockpile to ensure the safety and reliability of nuclear weapons, and focus arms control efforts on strengthening the NPT regime and constraining the proliferation of nuclear weapons?

This chapter argues that the latter course is, by far, the best for U.S. national interests. A CTBT would, in several important respects, *enhance* U.S. security. In other areas, the United States would, at a minimum, *preserve* vital capabilities and maintain all its options and interests. Finally, ratifying the CTBT would enable the United States to *regain* its leadership role in the arena of arms control and nuclear non-proliferation, a critical component of U.S. security.

Could Testing Resume?

The United States is by far the most powerful nation in the world – a "hyperpower" in the words of the French Foreign Minister Hubert Vedrine,[102] with preeminent military forces and no serious political or economic challenger in the foreseeable future. The enduring nuclear stockpile is in excellent shape (see Chapter V). There is no military requirement for new, advanced nuclear warhead designs nor is there any significant public, political or military constituency, at home or abroad, for the resumption of nuclear tests. In fact, there is a very strong domestic and international bias *against* nuclear weapons testing. This is underscored by the universal commitment to a CTBT undertaken by the States Parties to the NPT at the NPT Review and Extension Conference in 1995 and by the moratorium on nuclear testing pending CTBT ratification agreed to by all NPT parties, including the United States, at the 2000 NPT Review Conference.

Even the opponents of a CTBT recognize this anti-testing bias. When trashing the Treaty, they stop short of pressing for the United States to resume its test program at this time. They argue, however, that the strategic challenge of the past, which came from the Soviet Union and was met with ICBMs and SLBMS, is not the challenge of the future: that will come from regional powers threatening U.S. interventionary forces and allies with weapons of mass destruction. The United States, they forewarn, will need to respond to this threat with smaller yield, earth-penetrating nuclear weapons that can attack the hardened, underground hideouts of the leaders of "states of proliferation concern."[103]

These critics notwithstanding, given the current security environment and the domestic and international implications of abandoning the current moratorium, any president would find it extremely difficult to resume testing unless there were a demonstrably serious threat to U.S. national security. Even then, a

[102] Speech at the Eighth Conference of French Ambassadors, Paris, France, August 29, 2000.

[103] The United States has recently modified – without testing – an existing B61gravity bomb into an earth-penetrator for this purpose.

president would have to reckon with the fact that if the United States were to break its moratorium, then Russia and China (as well as the other P-5 nations[104]) would come under increasing – and probably irresistible – pressure from their own national security establishments to resume testing.[105] This would place the United States in the position of having relegitimized nuclear tests and, in the process, undermined its own long-term national security interests.

Enhancing Security

If, indeed, a U.S. president is constrained by political realities from resuming nuclear tests for the foreseeable future, then the CTBT would create a more stable and favorable long-term security situation for the United States than either the current moratorium or a return to unrestricted testing.[106] Bringing the CTBT into force would convert the current collection of unilateral but reciprocated moratoria into a legally binding and verifiable obligation by the other P-5 states and most of the rest of the world. This international legal norm against nuclear testing would be consistent with the overwhelming will of the international community and would create a legitimate basis for a coordinated international response, be it political or military, to any treaty violation in the future.

In addition to establishing an international norm for nuclear behavior, the CTBT would enhance U.S. national security in several other ways. First, and most importantly, in a world without nuclear testing the United States would retain indefinitely its undisputed advantage in nuclear weapons technology. The U.S. has currently the most sophisticated nuclear arsenal, the best warhead yield-to-weight ratios, the most advanced computers, a wealth of test data from which to construct diagnostic codes, and an enviable capability to create and implement a stockpile stewardship program. Given its current technological leadership and ability to maintain its arsenal, no nation would benefit more than the United States from the freeze that the CTBT would impose on advanced nuclear weapons development by other nations.

Second, a ban on nuclear tests would reduce the likelihood that significant new qualitative threats to the United States would arise from proliferating nations seeking to acquire nuclear weapons. Under a test ban it would be impossible for clandestine proliferators to introduce thermonuclear weapons into their arsenals or for technologically sophisticated nuclear powers (like Russia and China) to develop and deploy the next generation of “special effects” weapons (with heightened radiation).[107] In addition, potential proliferators – who could build simple fission weapons without tests – would be prevented from acquiring sophisticated, lightweight warheads for missile delivery.

Third, as regards the verification of a testing ban, the U.S. ability to track testing activities worldwide will be importantly augmented by the IMS and the right to on-site inspection. While no monitoring system is absolutely foolproof, the CTBT’s world-wide, multi-technique sensor system, together with similar and unparalleled U.S. capabilities, will make it exceedingly difficult for nations seeking to acquire nuclear weapons clandestinely to conduct nuclear weapons test explosions without being detected. The political constraints of an international norm, together with very high likelihood of detection by the world-wide monitoring system, will clearly exercise a valuable restraining influence on potential proliferators.

If, nonetheless, there were some undetected low-yield tests carried out in defiance of a CTBT, these could not readily be translated into militarily significant improvements in nuclear weapons. Even a

[104] The P-5 all ceased testing by 1996 or earlier. India and Pakistan did, of course, test in 1998.

[105] The other P-5 members may well choose to delay their reaction and let the United States absorb as much political heat as possible before they undertake their own tests.

[106] There are some legal restrictions on testing imposed by the LTBT and the TTBT, practical restrictions imposed by geography, as well as political restrictions imposed by international reaction (as demonstrated during the last French test series).

[107] It is, of course possible, that potential proliferators may acquire advanced weapons technology from existing nuclear powers. Such has reportedly been the case in the past between Israel and France and Pakistan and China.

technologically sophisticated potential proliferator could not, at the low yield levels that might evade detection, proof-test a thermonuclear weapon, increase yield-to-weight ratios or introduce new weapons with electromagnetic pulse or enhanced radiation effects (see Chapters V and VI). Moreover, a technologically less sophisticated nation could derive little useful information from low-yield testing about a first-generation (Hiroshima-type) fission weapon (which the United States used in World War II without an explosive test). As a result, even an undetected clandestine test program – which would have to be kept to low yield levels and carried out in constant danger of detection – would not erode U.S. technological superiority nor pose a threat qualitatively different from that already in existence.

Box 6
The Stockpile

The U.S. stockpile of operational weapons currently consists of eight basic nuclear warhead designs deployed on strategic nuclear delivery systems. Two of those same warhead designs are also deployed on non-strategic (or tactical) delivery systems. One additional warhead design is in the inactive reserve stockpile.

If START II enters into force, multiple-warhead ICBMs would be banned and it is likely that two of the current three ICBM warhead types (the W62 and W78) would be withdrawn from the operational forces.

Delivery Systems	Warhead	Year Deployed	Yield	Number
Strategic:				
ICBMs	W62	1970	170kt	600
	W78	1979	335kt	900
	W87	1986	300kt	500
SLBMs	W76	1979	100kt	3072
	W88	1990	475kt	384
Bombers/	B61	1967*	0.3-170kt	600
ALCMs	B83	1984	up to 1200kt	650
	W80	1981	5-150kt	800
Non-strategic:				
SLCMs	W80	1984	5-150kt	320
Bombers	B61	1979*	0.3-170kt	1350
Inactive:				
GLCMs	W84	1983	0.2-150kt	400

ALCM – air-launched cruise missile; ICBM – intercontinental ballistic missile; SLBM – submarine-launched ballistic missile; SLCM – sea-launched cruise missile; GLCM – ground-based cruise missile; kt – kiloton; * – several modifications introduced in subsequent years.

Adapted from NRDC Nuclear Notebook, *The Bulletin of the Atomic Scientists*, May/June, 2000.

Preserving Security

A CTBT would allow the United States to fully preserve its nuclear deterrent through implementation of the SSP and adoption of the six safeguards (see Box 1). The United States has more knowledge about and confidence in the condition of the weapons in its arsenal today than was possible five years ago and it is now believed that the weapons in the stockpile may have effective lifetimes of 50 years or longer. Clearly, there can be no guarantee that critical problems with the stockpile will not develop over time. But all indications are that the United States can, with high confidence, maintain a safe and reliable deterrent force for the foreseeable future if it continues to support a comprehensive SSP and the industrial and scientific base for the remanufacture of existing weapons.[108]

Even if one of the nine or so warhead designs in the enduring stockpile fails, the United States would not necessarily need to resume testing. Although the political pressures to leave the Treaty would be great, each of the strategic delivery systems in the "triad" has two or more warheads available (see Box 6) and the failure of one warhead design could be compensated for by the deployment of additional numbers of the other design. The failed warhead in question could then simply be phased out of the arsenal. It is also important to keep in mind that, overall, basic deterrence would not be undermined by the malfunction of any particular U.S. warhead. With a deployed force of ca. 2000 weapons, a potential adversary is not likely to challenge the United States on the assumption that some unknown fraction of U.S. arsenal might not work.

Box 7
"Militarily Significant" Improvements in Weapons

Militarily significant modernization of nuclear weapons that would be inhibited or prevented by a CTBT includes:

- Streamlining the shapes of warheads;
- Increasing the yield-to-weight ratio;
- Producing new military capabilities like low-yield and lightweight warheads for tactical battlefield uses creating large electro-magnetic pulse (EMP) and enhanced radiation (ER) options;
- Improved safety (some of this work would not be restricted under a CTBT); and
- Improved reliability for the thousands of non-nuclear components outside of the physics package (this work would not be restricted under a CTBT).

As a last resort, the United States has the option of withdrawing from the Treaty under Safeguard F (see Box 1). This provision, which would be part of any resolution of ratification approved by the U.S. Senate, calls for the United States to invoke the "supreme national interests" clause and withdraw from the agreement if relevant officials can no longer certify a "high level of confidence" in the "safety or reliability of a nuclear weapons type … *consider[ed] critical* to [the] nuclear deterrent." [Emphasis added.]

Minor but resolvable uncertainties regarding the enduring stockpile will inevitably arise from time to time in the future. More dangerous problems or crippling failures of U.S. nuclear weapons, while unlikely, would not go undetected if they did occur. This is because the United States is eminently well prepared to maintain its arsenal for an indefinite period within the constraints of the CTBT. If, as is expected, the SSP can confidently maintain the safety, reliability and deterrent value of the arsenal, or warn us if it cannot, then U.S. security will be fully preserved under a CTBT and in the absence of nuclear testing.

[108] The extent and capabilities of the SSP have been criticized by both opponents and proponents of the CTBT. The opponents find it not sufficient to maintain the stockpile confidently over time and would prefer to have the option to test weapons as necessary. Some of the proponents of a CTBT, on the other hand, find the SSP over-funded and overly capable and suspect it might be intended and able to design and certify new weapons for the arsenal. Those in the middle of the debate tend to believe that the SSP, if adequately and steadily funded, to be sufficient scientifically to the task of maintaining the enduring arsenal and necessary politically to gain the support of the Congress and defense officials.

Regaining Leadership in Arms Control

The only genuine threat to the survival of the United States is nuclear weapons. Controlling their numbers, spread and use has been – and remains – a vital security interest of the nation. But rejection of the CTBT by the Senate last fall severely undercut U.S. leadership in the field of arms control and hampered the ability of this country to persuade other nations to respect the obligations of the nuclear non-proliferation regime. It is quite clear, for example, that unless the United States is prepared to demonstrate its willingness to forgo testing, efforts to convince India and Pakistan to constrain their own nuclear programs, let alone to bring those states and Israel into the NPT regime, will not succeed (see Chapter VII).

If the United States wishes to reassert its leadership of the international effort to stem proliferation, it will have to ratify the CTBT. Support for the Treaty will demonstrate to the world that the United States is committed to arms control, prepared to fulfill its NPT obligations and willing to rein in its own nuclear programs. Moreover, while ratifying and bringing into force the Treaty will not eliminate all threats, it will contribute to the process of delegitimizing nuclear weapons and shifting the burden of defense to conventional weapons.[109] Such a delegitimization of nuclear weapons would clearly be in the long-term security interests of the United States for two reasons: because these weapons are the great "equalizers" of the modern battlefield and because the United States cannot hope to constrain the further proliferation of nuclear weapons if it is perceived as placing a high value on their continued development. Conventional weapons, on the other hand, do not threaten the survival of society and civilization if used and the United States is the world's preeminent and predominant conventional power.

Conclusion

The United States possesses the most sophisticated nuclear arsenal of any nation and enjoys an unsurpassed deterrent capability. Under a CTBT the United States can, with confidence, scientifically steward these weapons, preserve its technological advantage, and maintain deterrence. On the one hand, there is no political or military requirement for the United States to acquire new nuclear weapons and, on the other hand, a CTBT would constrain the development of thermonuclear weapons by any potential proliferator and the growth of any serious new threats to U.S. security. If the United States can maintain its arsenal through the SSP – as certainly seems to be the case, then why should it not do so and take the benefits of the Treaty rather than suffer the political, strategic and environmental downsides of a return to testing (as France did in 1995/96).

The United States also possesses the most extensive and capable monitoring system of any nation. This system, reinforced by the IMS and the option for intrusive, on-site inspections established under the CTBT, would make it extremely difficult for any potential proliferator to evade detection. Additional monitoring capabilities are provided by a growing number of civilian scientific seismic networks. In the event a potential proliferator's very low-yield tests went undetected, they would not result in militarily significant advances in nuclear weaponry. On the other hand, clandestine testing would be a violation of an international obligation and would justify (and provoke) an international response which could range from sanctions to military intervention.

Ratifying the CTBT would allow the United States to reassert, credibly and authoritatively, its leadership of the arms control process and the efforts to stem proliferation. A CTBT would also help to delegitimize the most destructive weapons in existence without jeopardizing their deterrent value. This is vital to U.S. security as only nuclear weapons truly threaten the survival of the nation.

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[109] Other examples of the process of delegitimization include, i.a., expansion of nuclear-weapons-free zones, adoption of a 'no-first-use' policy, a cut-off of the production of fissile material and the opinions of the International Court of Justice on the legality of nuclear weapons use.

As the most powerful nation on earth, it should be evident that the United States has everything to gain by placing limits on the testing of the only weapons that threaten its national survival. By this measure alone, the CTBT is clearly in the security interests of the United States and the Senate should advise and consent to its ratification as early as possible in the next administration.

Appendix A

Statement by former Secretary of Defense William Perry
to the LAWS/Stanford CTBT Roundtable
July 19, 2000[110]

"… I want to go back to about 1995 to review the debate that occurred when the Department of Defense was asked to support the CTBT,… At the time, I was persuaded that there were important benefits for our ongoing security relations with China and Russia … and to our nonproliferation goals... (I) therefore concluded that I should support this [treaty] 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… 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 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 CTBT which did not allow low yield testing… (B)oth General Shalikashvili 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[111] … 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…

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…

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. …(W)e 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 judgment was definitive in causing myself and General Shalikashvili to back off the view that we should hold out for low yield tests. And everything that we have learned since then … ha[s] 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… [W]e thought that in order to provide the right environment for that decision, if it ever had to be made, that we

[110] Remarks to a July 19, 2000 roundtable discussion at Stanford University. Published in "The Comprehensive Test Ban Treaty: Next Steps," LAWS and the Center for International Security and Cooperation, pp. 44-5.
[111] Former senior official at Sandia National Laboratory and a member of the JASON group.

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 any president in the face of a failure to certify would shrink from his obligation to take whatever 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 the 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…."

Appendix B

AUGUST 3, 1995 JASON REPORT ON NUCLEAR TESTING

Summary and Conclusions

Sidney Drell, Chair
John Cornwall
Freeman Dyson
Douglas Eardley
Richard Garwin
David Hammer
John Kammerdiener
Robert LeLevier
Robert Peurifoy
John Richter
Marshall Rosenbluth
Seymour Sack
Jeremiah Sullivan
Fredrik Zachariasen

JSR-95-320

August 3, 1995

JASON
The MITRE Corporation
7525 Colshire Drive
McLean, Virginia 22102-3481
703-583-6997

(U) SUMMARY AND CONCLUSIONS

(U) We have examined the experimental and analytic bases for understanding the performance of each of the weapon types that are currently planned to remain in the U.S. enduring nuclear stockpile. We have also examined whether continued underground tests at various nuclear yield thresholds would add significantly to our confidence in this stockpile in the years ahead.

(U) Our starting point for this examination was a detailed review of past experience in developing and testing modern nuclear weapons, their certification and rectification processes, their performance margins,[112] and evidence of aging or other trends over time for each weapon type in the enduring stockpile.

Conclusion 1:

> (U) The United States can, today, have high confidence in the safety, reliability, and performance margins of the nuclear weapons that are designated to remain in the enduring stockpile. This confidence is based on understanding gained from 50 years of experience and analysis of more than 1000 nuclear tests, including the results of approximately 150 nuclear tests of modern weapon types in the past 20 years.

(U) Looking to future prospects of achieving a Comprehensive Test Ban Treaty (CTBT), a stated goal of the United States Government, we have studied a range of activities that could be of importance to extending our present confidence in the stockpile in the future. We include among these activities underground experiments producing sub-kiloton levels of nuclear yield that might be permitted among the treaty-consistent activities under a CTBT.

(U) Three key assumptions underlie our study:

1. (U) The U.S. intends to maintain a credible nuclear deterrent.
2. (U) The U.S. remains committed to the support of word-wide non-proliferation efforts.
3. (U) The U.S. will not encounter new military or political circumstances in the future that cause it to abandon the current policy – first announced by President Bush in 1992 – of not developing any new nuclear weapon designs.

Conclusion 2:

> (U) In order to maintain high confidence in the safety, reliability, and performance of the individual types of weapons in the enduring stockpile for several decades under a CTBT, whether or not sub-kiloton tests are permitted, the United States must provide continuing and steady support for a focused, multifaceted program to increase understanding of the enduring stockpile; to detect, anticipate and evaluate potential aging problems; and to plan for refurbishment and remanufacture, as required. In addition the U.S. must maintain a significant industrial infrastructure in the nuclear program to do the required replenishing, refurbishing, or remanufacturing of age-affected components, and to evaluate the resulting product; for example, the high explosive, the boost gas system, the tritium loading, etc. Important activities in a stockpile stewardship program that will sustain a strong

[112] Defined as the difference between the minimum expected and the minimum needed yields of the primary.

> scientific and technical base, including an experienced cadre of capable scientists and engineers, are described in the body of this study.

(U) The proposed program will generate a large body of technically valuable new data and challenging opportunities capable of attracting and retaining experienced nuclear weapons scientists and engineers in the program. This is the intent of DOE's currently planned stockpile stewardship program.[113] For the success of this program, the management of the three weapons laboratories (LANL, LLNL, SNL) must motivate, support, and reward effort in an area that has lost some of its glamour and excitement in the absence of new nuclear design and test opportunities.

(U) Nevertheless, over the longer term, we may face concerns about whether accumulated changes in age-affected weapons components, whose replacements might have to be manufactured by changed processes, could lead to inadequate performance margins and reduced confidence in the stockpile.

(U) Enhancements of performance margins will add substantially to long-term stockpile confidence with or without underground tests. To cite one example, we can adjust the boost gas fill or shorten the time interval between fills. (This is discussed more fully in the classified text).

Conclusion 3:

> (U) The individual weapon types in the enduring stockpile have a range of performance margins, all of which we judge to be adequate at this time. In each case we have identified opportunities for further enhancing their performance margins by means that are straightforward and can be incorporated with deliberate speed during scheduled maintenance or remanufacturing activities. However greatest care in the form of self-discipline will be required to avoid system modifications, even if aimed at "improvements," which may compromise reliability.

(U) This brings us to the issue of the usefulness, importance, or necessity of reduced-yield (less than 1kt) underground tests for maintaining confidence in the weapon types in the U.S. stockpile over a long period of time.

(U) For the U.S. stockpile, testing under a 500 ton yield limit would allow studies of boost gas ignition and initial burn, which is a critical step in achieving full primary design yield. The primary argument that we heard in support of the importance of such testing by the U.S. is the following: the evidence in several cases and theoretical analyses indicate that results of a sub-kiloton (~500 tons) test of a given primary that achieves boost gas ignition and initial burn can be extrapolated to give some confidence in the yield of an identical primary with full boosting. Therefore, if a modified or remanufactured primary is introduced into the stockpile in the future to correct some aging problem, such tests on the modified system would add to confidence that the performance of the new primary is still adequate.

(U) It follows from this argument that the utility to the U.S. of testing at yields of up to approximately 500 tons depends on such tests being performed on a continuing basis and yielding reproducible results. If they are permitted only for a few years, such tests could add to the theoretical understanding of the boosting process and the reliability of the computer-codes that attempt to describe it, but would not contribute directly to the reliability of the weapon in the enduring stockpile in view of the

[113] See the 1994 JASON Report JSR-94-345 on "Science Based Stockpile Stewardship."

possible manufacturing changes made at a later date. To gain evidence as to whether long-term changes in age-affected weapons components have any impact on boost-performance the tests would have to be made with the remanufactured weapons themselves.

Conclusion 4:

> (U) In order to contribute to long term confidence in the U.S. stockpile, testing of nuclear weapons under a 500 ton yield limit would have to be done on a continuing basis, which is tantamount to remaking a CTBT into a threshold test ban treaty. While such ongoing testing can add to long term stockpile confidence, it does not have the same priority as the essential stockpile stewardship program endorsed in Conclusion 2, nor does it merit the same priority as the measures to enhance performance margins in Conclusion 3. In the last analysis the technical contribution of such a testing program must be weighed against its costs and its political impact on the non-proliferation goals of the United States.

Conclusion 5:

> (U) Underground testing of nuclear weapons at any yield level below that required to initiate boosting is of limited value to the United States. However experiments involving high explosives and fissionable material that do not reach criticality are useful in improving our understanding of the behavior of weapons materials under relevant physical conditions. They should be included among treaty consistent activities that are discussed more fully in the text.
>
> (U) This conclusion is based on the following two observations.
>
> (U) [a)] So-called hydronuclear tests, defined as limited to a nuclear yield of less than 4 lbs TNT equivalent, can be performed only after making changes that drastically alter the primary implosion. A persuasive case has not been made for the utility of hydronuclear tests for detecting small changes in the performance margins for current U.S. weapons. At best, such tests could confirm the safety of a device against producing detectable nuclear yield if its high explosive is detonated accidentally at one point. We find that the U.S. arsenal has neither a present nor anticipated need for such re-confirmation. The existing large nuclear test data base can serve to validate two- and three-dimensional computational techniques for evaluating any new one-point safety scenarios, and it should be fully exploited for this purpose.
>
> (U) [b)] Testing with nominal yields up to a 100-ton limit permits examination of aspects of the pre-boost fission process. However, this is at best a partial and possible misleading performance indicator.

(U) An agreement to limit testing to very low yields raises the issue of monitoring compliance. We have not made a detailed study of this issue, but note the following: Cooperative, on-site monitoring would be necessary, and relevant measurements, including for example neutron yields, could be made without compromising classified information on bomb designs.

(U) We have reviewed the device problems which occurred in the past and which either relied on, or required, nuclear yield tests to resolve.

Conclusion 6:

(U) For the weapon types planned to remain in the enduring stockpile we find that the device problems which occurred in the past, and which either relied on, or required, nuclear yield tests to resolve, were primarily the result of incomplete or inadequate design activities. In part, these were due to the more limited knowledge and computational capabilities of a decade, or more, ago. We are persuaded that those problems have been corrected and that the weapon types in the enduring stockpile are safe and reliable in the context of explicit military requirements.

(U) Should the U.S., in the future, encounter problems in an existing stockpile design (which we do not anticipate at present) that are so serious as to lead to unacceptable loss of confidence in the safety, effectiveness, or reliability of a weapon type, it is possible that testing of the primary at full yield, and ignition of the secondary, would be required to certify a specified fix. Useful tests to address such problems generate nuclear yields in excess of approximately 10kt. DOE's currently planned enhanced surveillance and maintenance program is intended to alert us to any such need that may arise. A "supreme national interest" withdrawal clause that is standard in any treaty to which this nation is a signatory would permit the U.S. to respond appropriately should such a need arise.

Conclusion 7:

(U) The above findings, as summarized in Conclusions 1 through 6, are consistent with U.S. agreement to enter into a Comprehensive Test Ban Treaty (CTBT) of unending duration, that includes a standard "supreme national interest" clause. Recognizing that the challenge of maintaining an effective nuclear stockpile for an indefinite period without benefit of underground tests is an important and also a new one, the U.S. should affirm its readiness to invoke the supreme national interest clause should the need arise as a result of unanticipated technical problems in the enduring stockpile.

Biographic Notes

George Bunn, a member of the LAWS Board of Directors, was the first General Counsel of the U.S. Arms Control and Disarmament Agency (ACDA: 1961-1969). He helped negotiate the nuclear Non-Proliferation Treaty, and later became U.S. Ambassador to the Geneva Disarmament Conference. He has also taught at the U.S. Naval War College and the University of Wisconsin Law School, and served as dean of that law school. He has a degree in electrical engineering from the University of Wisconsin and law from Columbia University (Class of 1950). In his almost 20 years as a Washington lawyer, he worked for the U.S. Atomic Energy Commission, the U.S. Nuclear Regulatory Commission, and a major Washington law firm as well as for ACDA. In recent years, he has spoken at many international conferences dealing with the proliferation of nuclear weapons, including the October 1999 Vienna conference of the countries that had signed or ratified the Comprehensive Test Ban Treaty where he was the spokesman for participating non-governmental organizations.

Dr. Sidney D. Drell is a Professor of Theoretical Physics (Emeritus) at the Stanford Linear Accelerator Center, Stanford University and a senior fellow, by courtesy, at the Hoover Institution. He was also the Deputy Director of SLAC until retiring in 1998. He did his undergraduate studies at Princeton University and his graduate work at the University of Illinois. In 1984 he was awarded a prize fellowship of the John D. and Catherine T. MacArthur Foundation. Since 1960, Dr. Drell has been active as an advisor to the executive and legislative branches of the U.S. government on national security and defense technical issues. He is currently a member of the President's Foreign Intelligence Advisory Board, and the Non-Proliferation Advisory Panel. He is a founding member of JASON, a group of academic scientists who consult for the government on issues of national importance.

Dr. Richard L. Garwin is currently Philip D. Reed Senior Fellow for Science and Technology at the Council on Foreign Relations, New York and IBM Fellow Emeritus at the Thomas J. Watson Research Center, Yorktown Heights, New York. After three years on the faculty of the University of Chicago, he joined the IBM Corporation in 1952, and was until June 1993 IBM Fellow at the Thomas J. Watson Research Center; Adjunct Research Fellow in the Kennedy School of Government, Harvard University; and Adjunct Professor of Physics at Columbia University. In addition, he is a consultant to the U.S. government on matters of military technology and arms control. He has been Director of the IBM Watson Laboratory, Director of Applied Research at the IBM Thomas J. Watson Research Center, and a member of the IBM Corporate Technical Committee. He has also been Professor of Public Policy in the Kennedy School of Government. He has been a member of the Scientific Advisory Group to the Joint Strategic Target Planning Staff and was in 1998 a Commissioner on the 9-person "Rumsfeld" Commission to Assess the Ballistic Missile Threat to the United States. In 1996 Dr. Garwin received the Enrico Fermi Award from the President and the Department of Energy for his work in nuclear weapons. He currently chairs the Arms Control and Nonproliferation Board of the Department of State.

Thomas Graham, Jr. is the President of LAWS. Ambassador Graham served as the Special Representative of the President for Arms Control, Non-Proliferation, and Disarmament from 1994-1997. He led U.S. government efforts to achieve a permanent Nuclear Non-Proliferation Treaty (NPT) prior to and during the 1995 Review and Extension Conference of the NPT. Ambassador Graham headed the U.S. Delegation to the 1996 Review Conference of the Conventional Armed Forces in Europe (CFE) Treaty. He also headed the U.S. Delegation to the 1993 ABM Treaty Review Conference. In addition, he led a number of delegations to foreign capitals in the period 1994-1996, first to persuade countries to support the indefinite extension of the NPT, and in 1996 to urge the conclusion of the CTBT negotiations. Ambassador Graham was the General Counsel of ACDA from 1977 to 1981 and from 1983 to 1993. From January 20, 1993 until November 22, 1993, he served as the Acting Director of ACDA, and from November 23, 1993 to August 29, 1994 as the Acting Deputy Director of the Agency.

Daryl G. Kimball is the executive director of the Coalition to Reduce Nuclear Dangers. The Coalition is a consortium of 17 of the nation's leading arms control and non-proliferation organizations working together to strengthen national and international security by reducing the threats posed by nuclear weapons. From 1989 to 1997, Mr. Kimball was associate director and, later, the director of security programs for Physicians for Social Responsibility (PSR). Mr. Kimball has written extensively about nuclear weapons production and testing issues, the CTBT, and nuclear disarmament. He is a 1986 graduate of Miami University of Ohio and a former Herbert R. Scoville Peace Fellow (1989).

Damien J. LaVera is a security analyst and Director for Publications and Domestic Programs of the Lawyers Alliance for World Security (LAWS). He serves as principal speechwriter for LAWS President Ambassador Thomas Graham Jr. and coordinates LAWS Domestic Program activities around the country. He is a recipient of a 2000 Presidential Management Internship award and holds a Masters degree in Security Policy Studies from the Elliott School of International Affairs at George Washington University and a Bachelor's degree in Political Science from Binghamton University (SUNY Binghamton).

Jack Mendelsohn is the Vice President and Executive Director of LAWS/CNS. During the 1998-99 academic year, he served as the Olin Professor of National Security Affairs at the United States Naval Academy and is currently an Adjunct Professor at George Washington University. From 1985 to 1998, he was Deputy Director of the Arms Control Association. Prior to his tenure there, Mr. Mendelsohn was a Senior Foreign Service Officer (1963-85) and served as Deputy Assistant Director of the Strategic Programs Bureau at the Arms Control and Disarmament Agency (ACDA), as Senior ACDA Representative on the U.S. START I Delegation and as Special Assistant to the Chief of the U.S. SALT II Delegation. He writes and speaks extensively on national security and arms control issues. Mr. Mendelsohn was co-author of an Olive Branch Award-winning article in *Technology Review* and recipient of an *Aviation Week and Space Technology* Laurels Award.

Dr. Paul G. Richards, Mellon Professor of Natural Sciences at Columbia University, currently works with the Lamont-Doherty Earth Observatory. He held the Chair of the nationally renowned Earth Sciences Department at Columbia from 1980-1983. Dr. Richards started out in research with an interest primarily in the theory of seismic wave propagation and in methods to understand how the recorded shapes of seismic waves are affected by processes of diffraction, attenuation and scattering. From such scientific work are learnt the details of the Earth's internal structure and of fault motion in earthquakes as rock spontaneously fractures and moves to reduce stress. Dr. Richards holds a B.A. in Mathematics from the University of Cambridge, and a M.S. in Geology and Ph.D. in Geophysics from California Institute of Technology. Dr. Richards was a Foster Fellow with the U.S. Arms Control and Disarmament Agency (ACDA) from 1984-1985 and 1993-1994, a MacArthur Fellow from 1981-1986.

Dr. Amy Sands is Deputy Director of the Center for Nonproliferation Studies and Director of the Center's Monitoring Proliferation Threats Project at the Monterey Institute of International Studies. She plays a pivotal role in the management and oversight of the substantive direction and operations of the Center. From August 1994 to June 1996, she was Assistant Director of the Intelligence, Verification, and Information Management Bureau at the U.S. Arms Control and Disarmament Agency (ACDA). Reporting directly to the ACDA Director, she was responsible for managing the development of verification and compliance policy for relevant arms control and nonproliferation activities and for liaison with the intelligence community. Upon leaving the government, Dr. Sands received ACDA's Distinguished Honor Award and the On-Site inspection Agency's Exceptional Civilian Service Medal. Before joining ACDA, she had headed the Proliferation Assessments Section in Z Division at the Lawrence Livermore National Laboratory where she worked for 11 years. Dr. Sands holds a B.A. in political science from the University of Wisconsin and earned her M.A, M.A.L.D., and Ph.D. from the Fletcher School of Law and Diplomacy. She is a member of the Council on Foreign Relations.

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The Lawyers Alliance for World Security
Committee for National Security

1901 Pennsylvania Avenue, N.W., Suite 201
Washington, DC 20006
Tel. 202-745-2450; Fax 202-667-0444
Web Site: www.lawscns.org