The Comprehensive Nuclear Test Ban Treaty: Technical Issues for the United States

ISBN
978-0-309-14998-3

204 pages
8 1/2 x 11
PAPERBACK (2012)

Committee on Reviewing and Updating Technical Issues Related to the Comprehensive Nuclear Test Ban Treaty; Policy and Global Affairs; National Research Council

EXECUTIVE SUMMARY

This report is a review and update of the 2002 National Research Council report, *Technical Issues Related to the Comprehensive Nuclear Test Ban Treaty (CTBT)* (hereafter the *2002 Report*). The committee was asked to assess:

- plans to maintain the safety and reliability of the U.S. nuclear stockpile without nuclear-explosion testing;
- the U.S. capability to detect, locate, and identify nuclear explosions;
- commitments necessary to sustain the stockpile and the U.S. and international monitoring systems; and
- potential technical advances countries could achieve through evasive testing and unconstrained testing.

Provided that sufficient resources and a national commitment to stockpile stewardship are in place, the committee judges that the United States has the technical capabilities to maintain a safe, secure, and reliable stockpile of nuclear weapons into the foreseeable future without nuclear-explosion testing. The Administration, in concert with Congress, should formulate and implement a comprehensive plan that provides a clear vision and strategy for maintaining the nation's nuclear deterrence capabilities and competencies, as recommended in the 2010 Nuclear Posture Review and related studies. Sustaining these technical capabilities will require action by the National Nuclear Security Administration (NNSA), with the support of others, on at least the following elements:

- a strong scientific and engineering base maintained through a continuing dynamic of experiments linked with analysis;
- a vigorous surveillance program;
- adequate ratio of performance margins to uncertainties;
- modernized production facilities; and
- a competent and capable workforce with a broad base of nuclear security expertise.

The United States has technical capabilities to monitor nuclear explosions in four environments—underground, underwater, in the atmosphere and in space. Technical capabilities have improved significantly in the past decade, although some operational capabilities are at risk. Seismology, the most effective approach for monitoring underground nuclear-explosion testing (the environment in which all known nuclear-explosion tests have been conducted since 1980), now provides much more sensitive detection, identification, and location of explosions. Most of the seismic stations of the International Monitoring System (IMS) under the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) are operating now, and the 90 percent confidence levels for IMS seismic detection are well below 1 kiloton (kt) worldwide for fully coupled explosions. With the inclusion of regional monitoring and improved understanding of backgrounds, an evasive tester in Asia, Europe, North Africa, or North America would need to restrict device yield to levels below 1 kt (even if the explosion were fully decoupled) to ensure no more than a 10 percent probability of detection by the IMS.

The United States' global monitoring capabilities, or national technical means (NTM), provide monitoring capability that is superior to that of the IMS and can focus on monitoring countries of concern to the United States. However, the IMS provides valuable data to the United States, both as an augmentation to the U.S. NTM and as a common baseline for international assessment and discussion of potential violations when the United States does not

wish to share NTM data. Thus, the United States should support both the completion of the IMS and its operations, training and maintenance, whether or not the Comprehensive Nuclear Test Ban Treaty (CTBT) enters into force.

Constraints placed on nuclear-explosion testing by the monitoring capabilities of the IMS, and the better capabilities of the U.S. NTM, will reduce the likelihood of successful clandestine nuclear-explosion testing, and inhibit the development of new types of strategic nuclear weapons. The development of weapons with lower capabilities, such as those that might pose a local or regional threat, or that might be used in local battlefield scenarios, is possible with or without the CTBT for countries of different levels of nuclear sophistication. However, such developments would not require the United States to return to testing in order to respond because it already has—or could produce—weapons of equal or greater capability based on its own nuclear-explosion test history. Thus, while such threats are of great concern, the United States would be able to respond to them as effectively whether or not the CTBT were in force.

A technical need for a return to nuclear-explosion testing would be most plausible if the United States were to determine that adversarial nuclear activities required the development of weapon types not previously tested. In such a situation, the United States could invoke the supreme national interest clause and withdraw from the CTBT.

As long as the United States sustains its technical competency, and actively engages its nuclear scientists and other expert analysts in monitoring, assessing, and projecting possible adversarial activities, it will retain effective protection against technical surprises. This conclusion holds whether or not the United States accepts the formal constraints of the CTBT.

THE COMPREHENSIVE NUCLEAR TEST BAN TREATY—TECHNICAL ISSUES FOR THE UNITED STATES

Committee on Reviewing and Updating Technical Issues Related to the Comprehensive Nuclear Test Ban Treaty

Policy and Global Affairs

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

THE NATIONAL ACADEMIES PRESS
Washington, D.C.
www.nap.edu

THE NATIONAL ACADEMIES PRESS 500 Fifth Street, N.W. Washington, DC 20001

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This study was supported by Contract No. DE-DT0000878, TO#31 between the National Academy of Sciences and the Department of Energy, Contract No.SAQMMA09M1670 between the National Academy of Sciences and the Department of State, Grant No. B 8618 between the National Academy of Sciences and the Carnegie Corporation of New York, and by the National Academy of Sciences. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the organizations or agencies that provided support for the project.

International Standard Book Number-13: 978-0-309-14998-3
International Standard Book Number-10: 0-309-14998-3

Additional copies of this report are available for sale from the National Academies Press, 500 Fifth Street, N.W., Keck 360, Washington, DC 20001; (800) 624-6242 or (202) 334-3313; Internet, http://www.nap.edu/.

Printed in the United States of America

THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Charles M. Vest is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. Charles M. Vest are chair and vice chair, respectively, of the National Research Council.

www.national-academies.org

COMMITTEE ON REVIEWING AND UPDATING TECHNICAL ISSUES RELATED TO THE COMPREHENSIVE NUCLEAR TEST BAN TREATY

ELLEN D. WILLIAMS, *Chair*, BP
MARVIN L. ADAMS, Texas A&M University
LINTON BROOKS, Independent Consultant
THEODORE W. BOWYER, Pacific Northwest National Laboratory
DONALD D. COBB, Los Alamos National Laboratory (retired)
RICHARD L. GARWIN, Thomas J. Watson Research Center, IBM Corporation (emeritus)
RAYMOND JEANLOZ, University of California, Berkeley
RICHARD MIES, Independent Consultant
C. BRUCE TARTER, Lawrence Livermore National Laboratory (emeritus)

SUBCOMMITTEE ON SEISMOLOGY: IN SUPPORT OF THE COMMITTEE ON REVIEWING AND UPDATING THE 2002 REPORT: TECHNICAL ISSUES RELATED TO THE COMPREHENSIVE NUCLEAR TEST BAN TREATY

LYNN R. SYKES, *Subcommittee Chair*, Columbia University
HANS HARTSE, Los Alamos National Laboratory
PAUL G. RICHARDS, Columbia University
GREGORY VAN DER VINK, Terrametrics, LLC
WILLIAM R. WALTER, Lawrence Livermore National Laboratory

National Research Council Staff

GREG EYRING, Sr. Program Officer (August 2009 to June 2010)
Study Co-Director (from June 2010)
BENJAMIN J. RUSEK, Program Officer (August 2009 to June 2010)
Study Co-Director (from June 2010)
ANNE HARRINGTON, Study Director (August 2009 to June 2010)
MICAH D. LOWENTHAL, Director, Committee on International Security and Arms Control (from November 2010)
RITA S. GUENTHER, Program Officer
LA'FAYE LEWIS-OLIVER, Administrative Coordinator

PREFACE

The Office of the Vice President and the White House Office of Science and Technology Policy requested this study, which was carried out under contracts with the Department of State and Department of Energy, with additional support from the Carnegie Corporation of New York and the National Academy of Sciences. The committee formed by the National Research Council (NRC) to carry out the study has conducted a review and assessment of changes in technical issues that have occurred since the NRC's previous report on this topic, *Technical Issues Related to the Comprehensive Nuclear Test Ban Treaty* (NRC, 2002). In particular the committee was asked to address the following:

1) The risks in ensuring, over the longer term, a safe and reliable nuclear weapons stockpile absent underground nuclear-explosion testing, particularly including the experience of the U.S. stockpile stewardship program. (See Chapter 1)
2) The status of nuclear-explosion detection, taking into account the operating experience of the international monitoring system and improvements in U.S. national technical means in the last decade. (See Chapter 2)
3) The commitments required to sustain the U.S. stockpile and effective nuclear explosion monitoring. (See Chapter 3)
4) The potential technical advances to nuclear-weapon capabilities that might be gained by other countries from testing that might escape detection compared with those advances available with a return to full-yield testing in a non-test-ban environment. (See Chapter 4)

In addition, some further emphasis on certain issues was provided to the committee at its first meeting by Under Secretary of State for Arms Control and International Security, Ellen Tauscher, and Under Secretary of Energy for Nuclear Security and National Nuclear Security Administration Administrator, Thomas D'Agostino. They requested that the committee include its views in the study on (1) research that could improve or address shortfalls in monitoring capabilities, (2) the 2008 Comprehensive Nuclear-Test-Ban-Treaty Organization (CTBTO) Integrated Field Exercise and the utility of on-site inspections as a verification tool, (3) lessons learned from the 2006 and 2009 DPRK nuclear explosions, and (4) the possible effects of undetectable cheating. Items 1-3 are discussed in Chapter 2, and item 4 is discussed in Chapter 4.

In the course of this study, the committee has benefited from the invaluable assistance of many dedicated experts in different aspects of these issues, including representatives of U.S. government agencies and the Preparatory Commission of the CTBTO. Those who spoke to the committee at its meetings are listed in Appendix B. The committee was also granted access to the 2010 CTBT National Intelligence Estimate (NIE) and other intelligence reports relevant to the issues it was asked to address.

The Subcommittee on Seismology (see the biographies of members in Appendix A) was separately constituted for the purpose of providing input to the parent committee. At the direction of the committee, the subcommittee produced written input on seismology issues identified by the committee and interacted with the committee as needed. The subcommittee also raised issues to the committee that in its view had a material bearing on the committee's work. In cooperation with subcommittee members, the committee integrated the subcommittee's material into the committee's report and worked with the subcommittee to produce technical appendices to further explain certain issues related to the report. We would especially like to

thank subcommittee member William Walter of Lawrence Livermore National Laboratory for his extraordinary work to see the study to completion.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Academies' Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the process.

We wish to thank the following individuals for their review of this report: John Ahearne, Sigma Xi, The Scientific Research Society; Mona Dreicer, Lawrence Livermore National Laboratory; John Foster, Northrop Grumman Aerospace Systems; Ward Hawkins, Los Alamos National Laboratory; Stephen LaMont, Los Alamos National Laboratory; Cherry Murray, Harvard University; C. Paul Robinson, Sandia National Laboratories; Lawrence Welch, Institute for Defense Analyses; and Jay Zucca, Lawrence Livermore National Laboratory.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Richard Meserve and Russell Hemley, both from the Carnegie Institution for Science. Appointed by the National Academies, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the Academy.

In the following chapters, we review the technical changes related to the U.S. nuclear stockpile and to nuclear-explosion test monitoring that have occurred in the past ten years and place these in the context of their significance for national security. The discussion covers maintaining a safe, secure, and reliable nuclear stockpile; maintaining and expanding the ability to place clandestine testers at risk of detection via an effective monitoring capability; sustaining the U.S. human and physical infrastructure of these capabilities; and assessing the risks of undetected clandestine testing in contrast to the risks of full-yield nuclear-explosion testing unhindered by international agreements. To the extent that weapons laboratory management and contracting issues impinge on the quality of the nuclear weapons workforce and the sustainability of critical technical capabilities, the committee has commented on these issues.

The committee prepared both a classified and an unclassified version of this report. The National Research Council completed its peer review of the reports in March 2011 and then turned over the reports to the sponsoring agencies for security review. The committee updated data in the reports during the security review, but some text and figures reflect the March 2011 date the reports were sent to the agencies. The findings and recommendations are identical in the two versions, except for a few cases in which classified passages are paraphrased in the unclassified report.

For the benefit of the reader, a glossary of specialized terms from the 2010 CTBT NIE is provided as Appendix K.

Ellen D. Williams
Chair

TABLE OF CONTENTS