ASSESSING THE MERITS OF THE CTBT

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The Treaty on the Non-Proliferation of Nuclear Weapons and the nonproliferation regime have been weakened; perhaps no other issue demonstrates this as dramatically as the status of the Comprehensive Nuclear-Test-Ban Treaty (CTBT), the ratification of which the U.S. Senate rejected in October 1999. Despite the U.S. rejection, the test ban has strong international support—the most recent vote to promote the CTBT in the UN General Assembly passed overwhelmingly, with 175 votes to 1 (the United States) and three abstentions. The Obama administration favors U.S. ratification of the CTBT, but this is no guarantee that Washington will ratify the test ban. Members of Congress must weigh the benefits and risks of signing the treaty; however, these calculations can sometimes be difficult to carry out. This article examines whether a return to nuclear testing would in fact benefit the United States, or if a test ban would be a greater contribution to U.S. national security.

KEYWORDS: Comprehensive Nuclear-Test-Ban Treaty; United States; nuclear weapons

When considering whether to ratify an arms control treaty, U.S. senators should cast their votes based on the treaty's net benefit. After evaluating all aspects of the agreement, they should consider whether the treaty, taken as a whole, will increase or decrease national security. In the case of the Comprehensive Nuclear-Test-Ban Treaty (CTBT), this involves asking a series of questions, including: would a resumption of nuclear testing help or hinder efforts to strengthen the Treaty on the Non-Proliferation of Nuclear Weapons (NPT)? If the United States resumed testing, would other countries follow suit, and would this diminish U.S. security? Is nuclear testing essential to maintaining the nuclear stockpile? And is the CTBT effectively verifiable via the International Monitoring System and National Technical Means?

When the Senate first considered the CTBT in 1999, a majority of senators concluded that it would not enhance national security, and it was rejected. The Obama administration reportedly plans to resubmit the treaty for ratification next year, before the start of the 2010 NPT Review Conference.[1] Much has changed over the last decade, including views about nuclear weapons. Significant progress has also been made in deploying technologies to verify compliance with the CTBT [see "Verifiability, Reliability, and National Security: The Case for U.S. Ratification of the CTBT," in this issue]. This viewpoint assesses the security-related aspects of the treaty from a U.S. perspective and seeks to counter the claims of treaty opponents that ratification of the CTBT would diminish rather than strengthen U.S. national security.

Nuclear Testing and the Modernization of Nuclear Forces

If nuclear testing ever resumes, China has the most to gain. China has tested only forty-five times, compared to 1,030 U.S. tests. China's intercontinental ballistic missile (ICBM) force of some two dozen liquid-fueled missiles could attack the western United States with single-warhead missiles. There is increasing speculation that China would like to miniaturize its nuclear weapons in order to carry multiple warheads on its ICBMs, but this would be possible only if China conducts additional tests. Thus, the CTBT will help prevent further technological advances in Chinese warheads.

Russia is planning to retain as many as 1,500 deployed strategic warheads.[2] Russia's liquid-fueled ICBMs are scheduled to be withdrawn by about 2020. A return to testing would give the Russian military leaders political leverage to modernize and expand their aging nuclear forces.

India and Pakistan are actively improving their nuclear forces, and additional nuclear tests would allow India (followed by Pakistan) to develop smaller, more sophisticated thermonuclear bombs. North Korea probably has about a half-dozen nuclear weapons (and has conducted two low-yield tests). Although it poses only a modest security threat at present, both because North Korea has no reliable delivery system and because there is some question as to whether either of its nuclear tests were fully successful, further testing could change that.

The Stockpile Stewardship Program

In 2002, a U.S. National Academy of Sciences (NAS) panel determined that U.S. warheads could remain safe and reliable without testing if the United States could meet certain conditions, among them maintaining a high-quality workforce, using the Stockpile Stewardship Program (SSP) to examine weapons components, and refurbishing old weapons by remanufacturing them to original specifications.[3]

The NAS panel repeatedly asked weapon designers during classified briefings on the enduring stockpile whether testing was needed to resolve problems encountered or likely to be encountered with the arsenal and the scientists, and engineers always responded that testing was not necessary.[4] (The most likely potential source of nuclear-related degradation is the possibility that the primary yield falls below the minimum level needed to ignite the secondary. The National Nuclear Security Administration [NNSA] has concluded that plutonium pits have a minimum lifetime of 45–60 years [now 100 years] with "no life-limiting factors as yet recognized.") The NAS panel concluded:

> Although a properly focused SSP is capable, in our judgment, of maintaining the required confidence in the enduring stockpile under a CTBT, we do not believe that it will lead to a capability to certify new nuclear subsystem designs for entry in the stockpile without nuclear testing—unless by accepting a substantial reduction in the confidence in weapon performance associated with the certification up until now, or a return to earlier, simpler, single stage design concepts such as gun-type weapons. . . .

> It seems to us that the argument to the contrary—that is, the argument that improvements in the capabilities that underpin confidence in the absence of nuclear testing will inevitably lose the race with the growing needs from an aging stockpile—underestimates the current capability for stockpile stewardship, underestimates the effects of current and likely future rates of progress in improving these capabilities, and overestimates the role that nuclear testing ever played (or would be ever likely to play) in ensuring stockpile reliability.[5]

In light of the fact that the United States has not needed to test in the last seventeen years (since the moratorium began), the panel's conclusions make sense. As I have summarized previously, "Each year the U.S. government has stated that it is 'confident that the stockpile is safe and reliable, and there is no requirement at this time for nuclear tests.'[6] The annual certification on stockpile readiness requires the secretary of defense (after advice from Strategic Command and the military services) and the secretary of energy (after advice from the three weapons laboratory directors and the NNSA administrator) to determine whether all safety and reliability requirements are being met without the need for nuclear testing. These reports have always certified that the stockpile does not need testing for reasons of safety or reliability."[7] The NAS panel also concluded that testing is not necessary, provided that the United States maintains a robust SSP, there are no new weapon designs, and the United States reserves the right to withdraw from the CTBT if it determines nuclear testing is in its national security interest.

The enduring U.S. stockpile is projected to consist of more than 5,000 warheads (about 50 percent operational and 50 percent in reserve) with seven different types (two gravity bombs, two ICBM warheads, two SLBM warheads, and one cruise missile warhead).[8] Collectively, these warheads have been tested some 150–200 times.[9] There has been considerable progress in the SSP, including the following:

- The Life Extension Programs for the W76 and W87 warheads have been successful;
- Los Alamos National Laboratory reestablished its ability to fabricate new pits (for the W88 warhead).
- The NNSA (reviewed by the JASONs) determined that plutonium pits will not have aging effects for at least 85 to 100 years.
- Aging problems with non-nuclear components can be tested; in the past, warheads were rarely tested for reliability.
- A more robust tritium transfer system has been devised.
- The margins-to-uncertainties ratio has improved as margins have been increased and uncertainties reduced.
- Progress has been made in three-dimensional calculations, using the Dual Axis Radiographic Hydro-Test Facility at Los Alamos and the National Ignition Facility at Lawrence Livermore National Laboratory.

Owing to conservative planning criteria, the yield delivered to any given target is usually much larger than what is actually needed to destroy it, so the only primary issues are: does the weapon explode, and is the delivery system sufficiently accurate? Since there are seven warhead types in the enduring stockpile, a failure of one type would shift responsibility to some of the other six types. NNSA does not consider the criteria for nuclear missions in any depth, since targeting is left to the Strategic Command (and, in any case, delivery system accuracy does not require nuclear testing).

There are some common misunderstandings when it comes to assessing warhead reliability. The United States has not conducted enough full-scale tests on each warhead type to determine reliability with high statistical confidence, and it has certainly not accounted for the effects of aging. If we assume ten reliability tests were performed on each warhead and all ten were successful, the reliability is not 100 percent with 100 percent confidence. Instead there is a 30 percent chance that reliability is less than 90 percent and a 10 percent chance that reliability is less than 80 percent.[10] Thus, even when the United States was testing weapons dozens of times each year (or more), it has never known warhead reliability with precision at the time the warhead entered the stockpile, nor has it searched sufficiently for aging effects with confidence tests. In other words, when a few successful tests give the design yield, the reliability of a warhead type is defined as 1.0, but *without* a confidence level. If problems arise, the reliability is reduced somewhat arbitrarily.

Because nuclear weapons have on the whole proven extremely reliable, the Department of Energy (DOE) historically only conducted about one test per year to examine the reliability of all the deployed warhead types. Contrary to popular belief, nuclear testing has not played a large role in determining the reliability of nuclear weapons. Rather, non-explosive monitoring and testing has played the dominant role in assessing the confidence in the reliability of nuclear weapons.

The NNSA had a fiscal 2008 budget of $6.6 billion for weapons activities, including the SSP, which is significantly greater than the Cold War budgets (in inflation-adjusted dollars). Testing data obtained from DOE with a Freedom of Information Act (FOIA) request is discussed below.[11] These and other data suggest that primary/secondary stages do not show significant aging problems once they have been in the field for a few years. The average age of discovery for warhead retrofits was 1.8 years after the first production unit. Sidney Drell and Robert Peurifoy discussed the technical issues involved with a nuclear test ban.[12] They quantified warhead reliability as follows: ''Since the start of the current stockpile evaluation and reliability assessment program in 1958, about 13,000 weapon evaluations have been conducted. During this period, the failure rate of the non-device hardware suggests an expected weapon failure rate of 1–2% for the stockpile.''

When is Testing Required?

To mitigate the effect of potential nuclear bomber-related accidents, the B61 gravity bomb was reconfigured to use insensitive high explosives. In addition, the W80 was modified to handle the extremely cold temperatures encountered during flight. The NAS panel stated:

> The question of whether nuclear testing might ever be needed to correct problems discovered in weapons certification and deployment generated some controversy in the

1980s. However it was shown that almost all of the problems cited in support of this proposition were either of a kind not requiring nuclear testing or represented cases where testing had been inadequate during development. In relating these experiences to the current situation it is also important to note that the observed failures all occurred within three years after entry into the stockpile. The weapons in today's active stockpile have long passed the age where anomalies in initial production units are a significant problem. Furthermore, they are all based on tested designs that have taken advantage of lessons learned from older vintages.[13]

Non-nuclear components, which can be examined, tested, and replaced without the need for detonating a warhead, represent the main threat to warhead reliability. Some of the problem areas that have been identified include: degradation of high explosives, insufficient tritium, corrosion of fissile materials, faulty cables, and pilot parachutes.[14]

Reliability for Nuclear Weapon Missions

The NNSA annually certifies the reliability of the U.S. nuclear stockpile, without considering nuclear targeting or delivery systems. As I explained in an earlier work, "the ability to destroy a target depends on: the hardness (H) of the target (minimum destruction pressure); the yield (Y) of the weapon; the accuracy of the weapon (CEP, circular error probable); the reliability (R) of the weapon system (0–1); and the number (n) of warheads attacking a target (taking into account fratricide).[15] The single-shot-kill-probability (SSKP) is the kill probability of a single warhead on a known target with perfect reliability of $R = 1$."[16] For warheads with less than perfect reliability, the kill probability of one warhead on a target is $P_1 = \mathrm{SSKP} \times R$. I initially assume very lethal warheads with SSKP = 1, giving a kill probability for one warhead of $P_1 = R$. "If *n* independent warheads from *n* missiles are used on a target without fratricide [when one incoming weapon destroys another], the kill probability is $P_n = 1 - (1 - R)^n$. Reliability of $R = 0.5$ gives [$P_1 = 0.5$,] $P_2 = 0.75$ and $P_3 = 0.88$, and $R = 0.25$ gives [$P_1 = 0.25$,] $P_2 = 0.44$ and $P_3 = 0.58$. Except for the case of a pre-emptive attack against a large force, additional warheads on a target can be used" when there are uncertainties.[17]

What's important to understand is that even a reduction by a factor of two in the yield does not have much of an impact on the desired results of the mission. Consider two cases—the W88 warhead of 455 kilotons (kt) and the W76 warhead of 100 kt. In both cases we will assume a 100-meter accuracy attacking a 2,000 pounds per square inch–hardened silo with 0.9 reliability. Table 1 lists the P_1, P_2, and P_3 probabilities for yields of the W88 (455 kt), the W88-2 (228 kt), the W76 (100 kt), and the W76-2 (50 kt).

TABLE 1
Kill probability versus yield.

	455 kt	228 kt	100 kt	50 kt
P_1	0.90	0.88	0.80	0.67
P_2	0.9894	0.9849	0.957	0.888
P_3	0.9983	0.9981	0.991	0.963

For the case of a 50 percent reduction in the 455 kt yield of the W88 larger weapon, there is only a small reduction in the kill probabilities. A reduction to 228 kt reduces P_1 by 2 percent, from 0.90 to 0.88, but P_2 drops only 0.5 percent, and P_3 drops even less at 0.05 percent. For the case of a reduction of 50 percent in the 100 kt yield of the W76 small weapon, the effect is larger, but certainly manageable. A reduction to 50 kt reduces P_1 by 16 percent, from 0.80 to 0.67, and P_2 drops by 7 percent and P_3 drops even less at 3 percent. The 450 ICBM warheads with yields of mostly 335 kt are closer to the case of the W88. Thus, major reductions in yield of up to 50 percent do not change the outcomes of the strategic weapon attacks.

Today, there is strong agreement that the main mission of nuclear weapons is to deter nuclear attacks by other nations, and that nuclear weapons do not deter terrorists who are non-state actors. Ivan Oelrich, acting president of the Federation of American Scientists and director of its Strategic Security Program, examined fifteen missions for nuclear weapons.[18] Fourteen of the missions can be handled with multiple warheads on each target. Only the fifteenth mission, a pre-emptive attack on Russia, requires an extremely reliable nuclear force structure with many counterforce warheads.

Nuclear Weapons Safety

Nearly every publicly acknowledged U.S. strategic nuclear accident has involved aircraft (twenty-nine cases out of thirty-two total). Just one U.S. nuclear weapon accident has occurred since 1968, when a dropped wrench fell onto a liquid-fueled Titan II ICBM in a silo in Arkansas, triggering an explosion that destroyed the silo and the missile but did not spread radioactivity. Two aircraft-related accidents (in 1966 and 1968) spread significant amounts of radioactivity. However, accidents involving aircraft are no longer relevant, since aircraft no longer carry nuclear weapons unless they are placed on a special national security alert (or are being transported).

A 1992 law required the Defense Department to carry out a cost–benefit analysis (without specifying criteria) on the addition of new safety features that require nuclear testing to ensure high reliability. Officials from both the George H.W. Bush administration (Robert Barker in 1992) and the Bill Clinton administration (John Deutch and Rear Admiral John Mitchell in 1993) testified the enhanced safety measures were not needed because the costs were significant and the benefits were minor. There is a consensus that there are no significant safety problems requiring modifications that in turn need nuclear testing to confirm their status.[19]

The Survivability of U.S. Strategic Forces

The Strategic Offensive Reductions Treaty (SORT, commonly known as the Moscow Treaty) allows the United States and Russia 2,200 strategic operational warheads by 2012 with the freedom to mix basing modes. The United States reached the 2,200 limit in February 2009. The new Strategic Arms Reduction Treaty (START) will lower this number, to perhaps 1,500.

The U.S. strategic force is likely to maintain the traditional triad of fourteen Trident submarines (twelve operational and two in maintenance), 450 Minuteman III ICBMs, and fifty-six B-52 and twenty B-2 heavy bombers. The 2,200 operational warheads will reside on: Tridents (1,440), Minutemen III (450), and heavy bombers (some 300).[20] The United States also maintains 2,500 non-operational warheads with a combination of two Tridents (240) in overhaul, tactical bombs on mostly F-15E aircraft (500) and in inactive reserve (790), submarine-launched cruise missiles (100) and inactive reserve (200), and air-launched cruise missile and bombs (700).[21] Thus, the total number of U.S. warheads will be about 5,000.

Russian strategic forces are projected to have 1,500 operational strategic warheads in 2025, assuming that all SS-18s and SS–19s have been dismantled.[22] Russia currently is building ten SS–27s (Topol-M) per year, probably with three warheads each. There continues to be slow progress in three areas: Borey submarines, Bulava submarine-launched ballistic missiles (SLBMs), and Tu-160 (Blackjack) heavy bombers. It is projected that Russia's strategic forces of 2025 might consist of 1,500 warheads with 400 warheads on SS-27 missiles, perhaps 600–700 on eight submarines (with difficulty) and 400–500 warheads on 30 Tu-160 heavy bombers.[23] This number could be reduced with a new strategic arms control treaty.

Only Russia is capable of launching a significant preemptive attack on U.S. strategic forces, but such an attack would be suicidal and unsuccessful. Analysts usually employ worst-case analysis, assuming that the attack is effective, without practice on real, multiple targets. Russia could easily destroy all U.S. heavy bombers at their three or four bases, as they usually are not on alert. A preemptive attack could destroy 33–50 percent of SLBMs (or 500–700 of 1,440 warheads). Russia could destroy, at best, some 80 percent of U.S. ICBMs (or 360 of 450 warheads). Table 2 displays, using calculations based on a worst-case scenario, a surviving U.S. force of 800–1,100 warheads, plus reserves.

The Senate Foreign Relations Committee (SFRC) considered the effects from very large violations of START I and II.[24] A surviving U.S. force of 1,000 warheads would have few Russian strategic targets, since Russian launchers would be empty. U.S. forces could be supplemented with a responsive/reserve force of up to 1,000 warheads, but with wide variations in how quickly such weapons could be made ready. The survivable U.S. force of 1,000 warheads would not be meaningfully affected by unobserved CTBT testing

TABLE 2
U.S. surviving warheads under SORT.
A worst-case analysis is used to determine the strength of the U.S. response force.

U.S Destroyed	**U.S. Survived**
300 (all heavy bombers off alert)	0
500–700 (33–50 percent of SLBMs)	700–1,000
350 (80 percent of ICBMs)	100
Total	
1,150–1,350	**800–1,100 + reserves**

Source: David Hafemeister, *Physics of Societal Issues* (New York: Springer, 2007), Ch. 2.

violations at very small yields. The SFRC reports considered breakouts of the following types: numbers of warheads, mobile missiles and other missiles, modernization, numbers of re-entry vehicles on a missile, cheating on downloading, and failure to destroy missiles and nuclear weapons. The potential violations to the two START treaties were shown to be not militarily significant, since a response force of 1,000 warheads would not be jeopardized by massive cheating. In short, the CTBT is effectively verifiable because CTBT violations are far less threatening to U.S. strategic forces than potential violations under START, which has been shown to be effectively verifiable.

Net Benefit Analysis and Conclusion

The NAS panel considered three scenarios—a CTBT (with compliance), no CTBT, and CTBT (with evasion) for seven nations (Russia, China, India, Pakistan, North Korea, Iraq, and Iran). It concluded, "The worst-case scenario under a no-CTBT regime poses far bigger threats to US security interests—sophisticated nuclear weapons in the hands of many more adversaries—than the worst-case scenario of clandestine testing in a CTBT regime, within the constraints posed by the monitoring system."[25]

In 2001, General John Shalikashvili, former chairman of the Joint Chiefs of Staff, delivered a report that examined the net benefit of the CTBT by considering all aspects, including the ramifications of a world with and without a CTBT.[26] The benefits of U.S. ratification of a test ban treaty "clearly outweighed" the risks. The advantages as Shalikashvili saw them included:

- The Test Ban Treaty will complicate and slow down the efforts of aspiring nuclear states, especially regarding more advanced types of nuclear weapons.
- It will hamper the development by Russia and China of nuclear weapons based on new designs and will essentially rule out certain advances.
- It will add to the legal and political constraints that nations must consider when they form their judgments about national defense policies.
- The Test Ban Treaty is vital to the long-term health of the nuclear Non-Proliferation Treaty, and will increase support for other elements of a comprehensive non-proliferation strategy.
- The United States is well positioned to sustain its nuclear deterrent under the Test Ban Treaty.
- The verification regime established under the Treaty will enhance the United States' own very capable nuclear test monitoring system and foster new techniques to improve verification.
- The Treaty will make it easier to mobilize domestic and international support for clarifying ambiguous situations and for responding vigorously if any nation conducts a nuclear test. [27]

Though Shalikashvili's assessment was written nearly a decade ago, his benefit analysis has stood the test of time. Ratifying the CTBT and seeing it enter into force remain strongly in the U.S. national security interest—a conclusion supported by the above analysis as well.

Both the NPT and the CTBT regimes are weakened by a United States that fails to ratify the CTBT. Without U.S. ratification of the test ban, China and Russia are more likely to return to testing and to modernization that depends on testing, thus reigniting the nuclear arms race, and without ratification of the CTBT, the United States also has less leverage against the nuclear transition states of Iran, North Korea, India, Israel, and Pakistan. The president can withdraw from the CTBT with a pen stroke; if a return to testing is required in the future, the United States can do so. There is greater global consensus on the positive merits of the CTBT than on any other arms control treaty; the time for Washington to act is now.

NOTES

1. Associated Press, "U.S. Aiming to Ratify Nuke Test Ban Treaty by Next Spring: Sources," August 7, 2009.
2. Pavel Podvig, "Russia's New Arms Development," *Bulletin of the Atomic Scientists*, January 16, 2009, <thebulletin.org/web-edition/columnists/pavel-podvig/russias-new-arms-development>.
3. NAS, *Technical Issues Related to the Comprehensive Nuclear Test Ban Treaty* (Washington, DC: National Academy Press, 2002), pp. 1–4 and Chapter 1.
4. I have discussed this and other related ideas previously; see David Hafemeister, "How Much Reliability Is Enough for the Comprehensive Test Ban Treaty?" *Physics and Society* 36 (April 2007), pp. 3–8.
5. NAS, *Technical Issues Related to the Comprehensive Nuclear Test Ban*, pp. 29, 34.
6. Linton F. Brooks, "Testimony of Linton F. Brooks before the Senate Armed Services Committee Subcommittee on Strategic Forces," NNSA, April 4, 2005.
7. David Hafemeister, "How Much Reliability Is Enough for the Comprehensive Test Ban Treaty?," pp. 3–8.
8. See Robert S. Norris and Hans Kristensen, "The U.S. Nuclear Stockpile, Today and Tomorrow," *Bulletin of the Atomic Scientists*, September/October 2007, pp. 60–63.
9. Sidney Drell, "The Future of the CTBT," 2009 Carnegie NonProliferation Conference, April 7, 2009, Washington, DC.
10. Steve Fetter, *Toward a Comprehensive Test Ban* (Cambridge, MA: Ballinger, 1988), pp. 89–105.
11. E.A. Barfield, Department of Energy Freedom of Information Act Office, Number 95–207–C, January 5, 1996. FOIA, see Arjun Makhijani, Institute for Energy and Environmental Research, Takoma Park, MD, <www.ieer.org>.
12. Sid Drell and Robert Peurifoy, "Technical Issues of a Nuclear Test Ban," *Annual Review of Particle Science 44*, 1994, pp. 285–327; Hafemeister, "How Much Reliability Is Enough for a Comprehensive Nuclear Test Ban Treaty?"
13. NAS, *Technical Issues Related to the Comprehensive Nuclear Test Ban Treaty*, p. 21.
14. E.A. Barfield, DOE Freedom of Information Officer, Albuquerque, NM, January 5, 1996.
15. David W. Hafemeister, *Physics of Societal Issues* (New York: Springer, 2007), Chapter 2.
16. Hafemeister, "How Much Reliability Is Enough for the Comprehensive Test Ban Treaty?"
17. Ibid.
18. Ivan Oelrich, "Missions for Nuclear Weapons after the Cold War," Federation of American Scientists, Occasional Paper No. 3, January 2005.
19. Hafemeister, "How Much Reliability Is Enough for the Comprehensive Test Ban Treaty?"
20. Department of Defense, "Nuclear Posture Review [Excerpts]," January 8, 2002, <www.globalsecurity.org/wmd/library/policy/dod/npr.htm, www.nrdc.org/nuclear>.
21. Robert S. Norris and Hans M. Kristensen, "U.S. Nuclear Forces," *Bulletin of the Atomic Scientists*, March/April 2008, pp. 50–53.
22. Podvig, "Russia's New Arms Development."
23. See Robert S. Norris and Hans Kristensen, "Nuclear Notebook: Russian Nuclear Forces: 2009," *Bulletin of the Atomic Scientists,* May/June 2009, pp. 55–63.

24. U.S. Senate Foreign Relations Committee reports on ratification, ''The START Treaty,'' Executive Report 102–53, September 1992, pp. 49–64; and ''START II Treaty,'' Executive Report 104–10, pp. 29–37.
25. NAS, *Technical Issues Related to the Comprehensive Nuclear Test Ban Treaty*, pp. 70–78.
26. General John M. Shalikashvili, special adviser to the president and the secretary of state for the CTBT, ''Letter to the President and Report on the Findings and Recommendations Concerning the Comprehensive Nuclear Test Ban Treaty,'' Washington, DC, January 4, 2001, pp. 29–33.
27. Ibid.