Executive Summary

This committee's charge was to review the state of knowledge about the three main technical concerns raised during the Senate debate of October 1999 on advice and consent to ratification of the Comprehensive Nuclear Test Ban Treaty (CTBT), namely:

(1) the capacity of the United States to maintain confidence in the safety and reliability of its nuclear stockpile—and in its nuclear-weapon design and evaluation capability—in the absence of nuclear testing;

(2) the capabilities of the international nuclear-test monitoring system (with and without augmentation by national technical means and by instrumentation in use for scientific purposes, and taking into account the possibilities for decoupling nuclear explosions from surrounding geologic media); and

(3) the additions to their nuclear-weapon capabilities that other countries could achieve through nuclear testing at yield levels that might escape detection—as well as the additions they could achieve without nuclear testing at all—and the potential effect of such additions on the security of the United States.

This unclassified Executive Summary provides a synopsis of findings presented at greater length in the unclassified report that follows. Additional detail and analysis are provided in a classified annex.

Confidence in the Nuclear-Weapon Stockpile and in Related Capabilities

We judge that the United States has the technical capabilities to maintain confidence in the safety and reliability of its existing nuclear-weapon stockpile under the CTBT, provided that adequate resources are made available to the Department of Energy's (DOE) nuclear-weapon complex and are properly focused on this task. The measures that are most important to maintaining and bolstering stockpile confidence are (a) maintaining and bolstering a highly motivated and competent work force in the nuclear-weapon laboratories and production complex, (b) intensifying stockpile surveillance, (c) enhancing manufacturing/remanufacturing capabilities, (d) increasing the performance margins of nuclear-weapon primaries, (e) sustaining the capacity for development and manufacture of the non-nuclear components of nuclear weapons, and (f) practicing "change discipline" in the maintenance and remanufacture of the nuclear subsystem.

(a) Attracting and retaining a high-quality work force in the nuclear-weapon complex will require adequate budgets, other clear signals about future program direction and scope, long-term program commitments to technically challenging assignments, and greater attention to quality-of-work-life issues (including the nature of the burdens imposed by necessary protection of national-security secrets). The lack of requirements for new nuclear-weapon designs and the end of nuclear-explosive tests have eliminated some of the traditional technical opportunities in the nuclear-weapon field, but there are many professional challenges and opportunities in maintaining and developing the nuclear-weapon technology and science base for stockpile stewardship under a CTBT and in preparing for possible future weapon development, and there are increasingly powerful diagnostic, analytical, and computational techniques available that can make working on these challenges exciting and productive. A CTBT, in itself, need not prevent attracting and retaining the needed high-quality work force.

(b) The first line of defense against defects in the stockpile that would adversely affect safety and reliability is an aggressive surveillance program. Accordingly, the Stockpile Stewardship Program (SSP) includes an Enhanced Surveillance activity that involves increased focus on the nuclear components, an increased number of diagnostic procedures applied to the weapons that are randomly withdrawn from the stockpile, and increased technical depth of the inspections. While it is prudent to expect that age-related defects affecting stockpile reliability may occur increasingly as the average age of weapons in the stockpile increases in the years ahead, and that such defects may combine in a nonlinear or otherwise poorly specified manner, nuclear testing is not needed to discover these problems and is not likely to be needed to address them.

(c) Remanufacture to original specifications is the preferred remedy for the age-related defects that materialize in the stockpile. This makes it essential that a capability to remanufacture and assemble the nuclear subsystems for nuclear weapons be maintained in the U.S. production complex, with a capacity consistent with best estimates of component lifetimes, stockpile trends, and allowances for occasional unexpected problems. Current estimates, based on projections of the size of the enduring stockpile, indicate that the technical challenges of ongoing repair and remanufacture can be met at existing production-complex sites, provided that their facilities are brought up to and maintained at modern standards of operation. Establishment of a limited-quantity production capability for certified pits at Los Alamos is a particular necessity, as no other facility for this exists in the United States.

(d) A primary yield that falls below the minimum level needed to drive the secondary to full output is the most likely potential source of serious nuclear-performance degradation. Because primary yield margins in these weapons can be increased by changes that would not require nuclear testing, it is possible to use enhanced margins to provide a degree of insurance against minor aging effects and changes in material or process specifications arising in the refurbishment of the weapons. We urge that this be done.

(e) Based on past experience, it is probable that the majority of aging problems will be found in the non-nuclear components of stockpile weapons. Since the non-nuclear components and subsystems can be fully tested under a CTBT, it is possible to incorporate new technologies in these weapon parts as long as these can be shown not to have any adverse effect on proper functioning of the nuclear subsystem. If technologies involved in the non-nuclear components become prohibitively difficult to support with the passage of time because they are no longer utilized in the private sector, needed replacements can be based on current materials, technologies, and manufacturing processes. This does require, however, the provision of adequate resources to provide not only the needed manufacturing capability and capacity but also for the associated engineering R&D and systems integration capabilities, on an ongoing basis.

(f) It is important that a rigorous, highly disciplined process be instituted for controlling changes in the nuclear components. Such a process must discourage deviations from the original specifications. Before adopting deviations that are judged necessary, they must be analyzed thoroughly for potential performance impacts. In the long term, the process must also protect against performance degradations due to cumulative effects of multiple small changes in materials and/or processes that may be introduced in the course of periodic refurbishment operations. The required change-control process must begin with a thorough documentation of the original design and manufacturing specifications. Any subsequent deviations must be thoroughly documented. The resulting audit trail should make it possible to include consideration of possible cumulative effects in judging the acceptability of any proposal for further change. In order to avoid the introduction of interference effects between nuclear and non-nuclear components, prudence dictates that a similar discipline be practiced in regard to any changes in design or location of non-nuclear components situated in proximity to the nuclear subsystem.

Confidence in the safety and reliability of stockpiled nuclear weapons depended far more on activities in the first five categories just described than on nuclear testing even when numbers and kinds of nuclear tests were essentially unconstrained. (The sixth category did not play a large role in the past, because weapons were generally replaced by new tested designs before cumulative changes could become a concern.) Most U.S. nuclear tests were focused on the development of new designs; the other major roles of testing were exploring weapon physics and investigating weapon effects. The so-called stockpile confidence tests were limited to only one per year and–with two exceptions (involving weapon types retired soon after the tests)–they involved new-production units, so they would better be described as “production verification” tests. Even in the absence of constraints on nuclear testing, no need was ever identified for a program that would periodically subject stockpile weapons to nuclear tests.

Stockpile stewardship by means other than nuclear testing, then, is not a new requirement imposed by the CTBT. It has always been the mainstay of the U.S. approach to maintaining confidence in stockpile safety and reliability. The fact that older nuclear designs are no longer being replaced by newer ones means, however, that the average age of the nuclear subsystems in the stockpile will increase over time beyond previous experience. (The average age will eventually reach a maximum that depends on the rate at which weapons are remanufactured or retired.) This means that the enhanced surveillance activities that are part of the current SSP will become increasingly important. But that would be so whether nuclear testing continued or not. Nuclear testing would not add substantially to the SSP in its task of maintaining confidence in the assessment of the existing stockpile.

An important component of the Stockpile Stewardship Program is the development of a broad spectrum of advanced diagnostic tools in support of the surveillance function. These tools are intended to yield a more complete understanding of weapon performance and potential failure modes for nuclear as well as non-nuclear components and subsystems. This effort represents a continuation of the traditional knowledge-based approach to problem solving in the nuclear-weapon program, albeit at a significantly accelerated rate of progress. The SSP can already point to significant successes in that regard, as seen, for example, in the implementation of numerous new, relatively small-scale, measurement and analysis techniques ranging from new bench-top inspection instruments to larger-scale laboratory facilities (including, e.g., accelerated aging tests, novel applications of diamond-anvil cells and ultrasonic resonance, synchrotron-based spectroscopy and diffraction, and subcritical and hydrodynamic tests). All of these provide additional assurance that defects due to design flaws, manufacturing problems, or aging effects will be detected in time to enable evaluation and corrective action if such is deemed necessary.

While the smaller-scale diagnostic developments will remain key to a robust surveillance function, and therefore require continued emphasis, to date most of the debate over the need for new diagnostic tools has focused on larger-scale, capital-intensive experimental and computational facilities currently under development or being planned for the future. Current programs include the Dual Axis Radiographic Hydro Test (DARHT) facility, the National Ignition Facility (NIF), and the Advanced Simulation and Computing (ASC) program. In the immediate future, because of the enormous scientific and engineering challenges associated with the development and eventual utilization of these tools, they can play an important role in helping the nuclear-weapon laboratories attract and retain essential new technical talent. In the longer term they can also be expected to strengthen the scientific underpinnings of nuclear-weapon technology, and thus offer the potential for enlarging the range of acceptable solutions to any stockpile problems that might be encountered in the future. The initial capabilities achieved in the DARHT and ASC programs have already proven to be of value.

Despite these obvious benefits, the importance of this class of tools to the immediate core functions of maintaining an enduring stockpile should not be overstated. In particular, it would be very unfortunate if confidence in the safety and reliability of the stockpile under a CTBT in the next decade or so were made to appear conditional on the major-tool initiatives having met their specified performance goals. Most importantly, their costs should not be allowed to crowd out expenditures on the core stewardship functions, including the capacity for weapon remanufacture, upon which continued confidence in the enduring stockpile most directly depends.

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 into the stockpile without nuclear testing—unless by accepting a substantial reduction in the confidence in weapon performance associated with certification up until now, or a return to earlier, simpler, single-stage design concepts, such as gun-type weapons. Our belief that the introduction of new weapons into the stockpile will be restricted to nuclear designs possessing a credible test pedigree is not predicated on any conjectures as to the likelihood of DARHT, NIF, ASC or other major facilities achieving their design goals. Thus, we do not share the concern that has been expressed by some that these facilities will undermine the CTBT's important role in buttressing the non-proliferation regime.

In the event that quantity replacements of major components of the nuclear subsystem should become necessary, prudence would indicate the desirability of formal peer reviews. Evaluation of the acceptability of age-related changes relative to original specifications and the cumulative effect of individually small modifications of the nuclear subsystem should also be subject to periodic independent review. Such reviews, involving the three weapon laboratories and external reviewers, as appropriate, would evaluate potential adverse effects on system performance and the possible need for nuclear testing.

Nuclear-weapon design activities are not prohibited under the CTBT, and preserving the capability to develop new designs—in case such are ever needed—is a stated goal of U.S. policy, and is one means by which the knowledge of retiring designers is retained. The use of ever more capable computational tools and more realistic material models to understand the relevant data base from past nuclear tests, together with the use of advanced hydrodiagnostic techniques to study stockpile-related issues, is an important part of preserving this design capability. The associated design and evaluation expertise will aid in interpreting and perhaps anticipating foreign activities in nuclear-weapon development. We do not believe that nuclear testing is essential to maintaining these design and evaluation capabilities, even though such testing *would* be essential to certifying the performance of new designs at the level of confidence associated with currently stockpiled weapons.

Some have asserted, in the CTBT debate, that confidence in the enduring stockpile will inevitably degrade over time in the absence of nuclear testing. Certainly, the aging of the stockpile combined with the lengthening interval since nuclear weapons were last exploded will create a growing challenge, over time, to the mechanisms for maintaining confidence in the stockpile. But we see no reason that the capabilities of those mechanisms—surveillance techniques, diagnostics, analytical and computational tools, science-based understanding, remanufacturing capabilities—cannot grow at least as fast as the challenge they must meet. (Indeed, we believe that the growth of these capabilities—except for remanufacturing of some nuclear components—has more than kept pace with the growth of the need for them since the United States stopped testing in 1992, with the result that confidence in the reliability of the stockpile is better justified technically today than it was then.) 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 capabilities 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 ever be likely to play) in ensuring stockpile reliability.

Capabilities for Monitoring Nuclear Testing

Detection, identification, and attribution of nuclear explosions rest on a combination of methods, some being deployed under the International Monitoring System (IMS) established under the CTBT, some deployed as National Technical Means (NTM), and some relying on other methods of intelligence collection together with openly available data not originally acquired for treaty monitoring. The following conclusions presume that all of the elements of the IMS are deployed and supported at a level that ensures their full capability, functionality, and continuity of operation into the future.

In the absence of special efforts at evasion, nuclear explosions with a yield of 1 kiloton (kt) or more can be detected and identified with high confidence in all environments. Specific capabilities in different environments are as follows:

- Underground explosions can be reliably detected and can be identified as explosions, using IMS data, down to a yield of 0.1 kt (100 tons) in hard rock if conducted anywhere in Europe, Asia, North Africa, and North America. In some locations of interest such as Novaya Zemlya, this capability extends down to 0.01 kt (10 tons) or less. Depending on the medium in which the identified explosion occurs, its actual yield could vary from the hard rock value over a range given by multiplying or dividing by a factor of about 10, corresponding respectively to the extremes represented by a test in deep unconsolidated dry sediments (very poor coupling) and a test in a water-saturated environment (excellent coupling). Positive identification as a nuclear explosion, for testing less than a few kilotons, could require on-site inspection unless there is detectable venting of radionuclides. Attribution would likely be unambiguous.

- Atmospheric explosions can be detected and identified as nuclear, using IMS data, with high confidence above 500 tons on continents in the northern hemisphere and above 1 kt worldwide, and possibly at much lower yields for many sub-regions. While attribution could be difficult based on IMS data alone, evaluation of other information (including that obtained by NTM) could permit an unambiguous determination.
- Underwater explosions in the ocean can be reliably detected and identified as explosions, using IMS data, at yields down to 0.001 kt (1 ton) or even lower. Positive identification as a nuclear explosion could require debris collection. Attribution might be difficult to establish unless additional information was available, as it might be, from NTM.
- Explosions in the upper atmosphere and near space can be detected and identified as nuclear, with suitable instrumentation, with great confidence for yields above about a kiloton to distances up to about 100 million kilometers from Earth. (This capability is based on the assumption that relevant instruments that have been proposed for deployment on the follow-on system for the DSP satellites will in fact be funded and installed.) Such evasion scenarios are costly and technically difficult to implement. If they materialize, attribution will probably have to rely upon NTM, including interpretation of missile-launch activities.

The capabilities to detect and identify nuclear explosions without special efforts at evasion are considerably better than the "one kiloton worldwide" characterization that has often been stated for the IMS. If deemed necessary, these capabilities could be further improved by increasing the number of stations in networks whose data streams are continuously searched for signals.

In the history of discussions of the merits of a CTBT, a number of scenarios have been mentioned under which parties seeking to test clandestinely might be able to evade detection, identification, or attribution. With the exception of the use of underground cavities to decouple explosions from the surrounding geologic media and thereby reduce the seismic signal that is generated, none of these scenarios for evading detection and/or attribution has been explored experimentally. And the only one that would have a good chance of working without prior experimentation is masking a nuclear test with a large chemical explosion nearby in an underground mine. The experimentation needed to explore other approaches to evasion would be highly uncertain of success, costly, and likely in itself to be detected.

Thus, the only evasion scenarios that need to be taken seriously at this time are cavity decoupling and mine masking. In the case of cavity decoupling, the experimental base is very small, and the signal-reduction ("decoupling") factor of 70 that is often mentioned as a general rule has actually only been achieved in one test of very low yield (about 0.4 kt). The practical difficulties of achieving a high decoupling factor—size and depth of the needed cavity and probability of significant venting—increase sharply with increasing yield. And evaders must reckon with the high sensitivity of the global IMS, with the possibility of detection by regional seismic networks operated for scientific purposes, and with the chance that a higher-than-expected yield will lead to detection because their cavity was sized for a smaller one.

As for mine masking, chemical explosions in mines are typically ripple-fired and thus relatively inefficient at generating seismic signals compared to single explosions of the same total yield. For a nuclear explosion that is not also cavity-decoupled to be hidden by a mine explosion of this type, the nuclear yield could not exceed about 10 percent of the aggregate yield of the chemical explosion. A very high yield, single-fired chemical explosion could mask a nuclear explosion with yield more comparable to the chemical one, but the very rarity of chemical explo sions of this nature would draw suspicion to the event. Masking a nuclear yield even as large as a kiloton in a mine would require combining the cavity-decoupling and mine-masking scenarios, adding to the difficulties of cavity decoupling already mentioned.

Taking all factors into account and assuming a fully functional IMS, we judge that an underground nuclear explosion cannot be confidently hidden if its yield is larger than 1 or 2 kt.

Evasion scenarios have been suggested that involve the conduct of nuclear tests in the atmosphere or at the ocean surface where the event would be detected and identified but attribution might be difficult. NTM of the United States and other nations might provide attribution, without being predictable by the evader.

The task of monitoring is eased (and the difficulty of cheating magnified), finally, by the circumstance that most of the purposes of nuclear testing—and particularly exploring nuclear-weapon physics or developing new weapons—would require not one test but many. (An exception would be the situation in which an aspiring nuclear weapon state had been provided the blueprints for a weapon by a country with greater nuclear weapon capabilities, and might need only a single test to confirm that it had successfully followed the blueprints.) Having to conduct multiple tests greatly increases the chance of detection by any and all of the measures in use, from the IMS, to national technical means, to sensors in use for other purposes.

It can be expected, in future decades, that monitoring capabilities will significantly improve beyond those described here, as instrumentation, communications, and methods of analysis improve, as data archives expand and experience increases, and as the limited regions associated with serious evasion scenarios become the subject of close attention and better understanding. Of course, the realization of this expectation depends on continued U.S. public and policy maker recognition of the importance of this country's capacity to monitor nuclear testing, with concomitant commitments of resources to the task.

Potential Impact of Foreign Testing on U.S. Security Interests and Concerns

The potential impact on U.S. security interests and concerns of the low-yield foreign nuclear tests that could plausibly occur without detection in a CTBT regime can only be meaningfully assessed by comparison with two alternative situations—the situation in the absence of a CTBT, and the situation in which a CTBT is being strictly observed by all parties. The key questions are: How much of the benefit of a strictly observed CTBT is lost if some countries test clandestinely within the limits imposed by the capabilities of the monitoring system? In what respects is the case of limited clandestine testing under a CTBT better for U.S. security—and in what respects worse—than the case of having no CTBT at all? If some nations do not adhere to a CTBT and test openly, how do the technical and political impacts differ from a no-CTBT era?

In these comparisons, two kinds of effects of nuclear testing by others on U.S. security interests and concerns need to be recognized: the *direct* effects on the actual nuclear-weapon capabilities and deployments of the nations that test, with implications for military balances, U.S. freedom of action, and the possibilities of nuclear-weapon use; and the *indirect* effects of nuclear testing by some states on the aspirations and decisions of other states about acquiring and deploying nuclear weapons, or about acquiring and deploying non-nuclear forces intended to offset the nuclear weapons of others. A CTBT, to the extent that it is observed, brings security benefits for the United States in both categories—limitations on the nuclear-weapon capabilities that oth ers can achieve, and elimination of the inducement of states to react to the testing of others with testing and/or deployments of their own.

In the reference case of no CTBT at all, the Nuclear-Weapon States Party to the Non-Proliferation Treaty (NPT) would be able to test without legal constraint in the underground environment (except for the 150-kt limit agreed to by the United States and Russia under the bilateral Threshold Test Ban Treaty), and non-parties to the NPT would similarly be able to test without constraint. Non-Nuclear-Weapon-States Party to the NPT would be constrained legally from testing. In this circumstance:

- China and Russia might use the option of testing to make certain refinements in their nuclear arsenals. In the case of Russia, it is difficult to envision how such refinements could significantly increase the threats to U.S. security interests that Russia can pose with the previously tested nuclear-weapon types it already possesses.
- In the case of China, further nuclear testing might enable reductions in the size and weight of its nuclear warheads as well as improved yield-to-weight ratios. Such improvements would make it easier for China to expand and add multiple independently targetable re-entry vehicles (MIRV) to its strategic arsenal if it wanted to do so, and changes in these directions would affect U.S. security interests. But China could also achieve some kinds of improvements in its nuclear weapons without nuclear testing, and if it wanted to do so it could achieve considerable expansion and MIRVing of its arsenal using nuclear-weapon types it has already tested.
- India and Pakistan could use their option of testing, as non-parties to the Non-Proliferation Treaty, to perfect boosted fission weapons and thermonuclear weapons, greatly increasing the destructive power available from a given quantity of fissile material and the destructive power deliverable by a given force of aircraft or missiles. (Of course they might also do this under a CTBT that they had not signed, but the absence of a CTBT and the resumption of testing by others would make it politically much easier for them to do so.) The likelihood that either of these countries would use nuclear weapons against the United States seems very low, but the United States and its allies would nonetheless have serious concerns about the increase in nuclear-weapons dangers and arms-race potential in and around South Asia that such developments would portend.
- Plausibly larger than the direct effects of testing by Nuclear-Weapon States and non-parties to the NPT in the absence of a CTBT is the potential indirect effect of such testing in the form of a breakdown of the NPT regime, manifested in more widespread testing (by such countries as North Korea, Iraq, and Iran, for example), which could lead in turn to nuclear weapons acquisition by Japan, South Korea, and many others.

A future no-CTBT world, then, could be a more dangerous world than today's, for the United States and for others. In particular, the directions from which nuclear attack on the United States and its allies would have become conceivable—and the means by which such attack might be carried out (meaning not only intercontinental ballistic missiles (ICBM) but also, among others, ship-based cruise missiles, civilian as well as military aircraft, and truck bombs following smuggling of the weapons across U.S. borders)—would have multiplied alarmingly.

In our second reference case of a CTBT scrupulously observed, nuclear threats to the United States could still evolve and grow, but the range of possibilities would be considerably constrained. Boosted fission weapons and thermonuclear weapons would be confined to the few countries that already possess them and to those to which such weapons might be transferred, or to which designs might be communicated with sufficient precision that a trusting and competent recipient might be able to reproduce them. Other countries might have less stringent confidence requirements than does the United States, but, in general, they also are much more limited in the technology available for pursuing an exact reproduction; substitution of materials or techniques might bring uncertainty or even failure. Perhaps most importantly, in a world in which nuclear testing had been renounced and the NPT remained intact, nuclear proliferation would be opposed by a powerful political norm in which Nuclear-Weapon States and other parties to the NPT and CTBT would find their interests aligned.

In the case we now wish to compare to the no-CTBT and rigorously-observed-CTBT reference cases—that of clandestine testing under a CTBT, within the limits imposed by the monitoring system—we distinguish between two classes of potential cheaters, those with greater prior nuclear testing experience and/or design sophistication and those with lesser prior testing experience and/or sophistication. The purposes and plausible achievements for testing at various yields by countries with lesser versus greater prior nuclear test experience and/or design sophistication are summarized in the following table. Table ES-1 describes what could be done, not necessarily what will be done.

Table ES-1 Purposes and Plausible Achievements for Testing at Various Yields

Yield	Countries of lesser prior nuclear test experience and/or design sophistication*	Countries of greater prior nuclear test experience and/or design sophistication
Subcritical testing only (permissible under a CTBT)	• Equation-of-state studies • High-explosive lens tests for implosion weapons • Development & certification of simple, bulky, relatively inefficient unboosted fission weapons	same as column to left, plus • limited insights relevant to designs for boosted fission weapons
Hydronuclear testing (yield < 0.1 t TNT, likely to remain undetected under a CTBT)	• one-point safety tests (with difficulty)	• one-point safety tests • validation of design for unboosted fission weapon with yield in 10-ton range
Extremely-low-yield testing (0.1 t < yield <10 t, likely to remain undetected under a CTBT)	• one-point safety tests	• validation of design for unboosted fission weapon with yield in 100-ton range • possible overrun range for one-point safety tests
Very-low-yield testing (10 t < yield < 1-2 kt, concealable in some circumstances under a CTBT)	• limited improvement of efficiency & weight of unboosted fission weapons compared to 1st-generation weapons not needing testing • proof tests of compact weapons with yield up to 1-2 kt (with difficulty)	• proof tests of compact weapons with yield up to 1-2 kt • partial development of primaries for thermonuclear weapons
Low-yield testing (1-2 kt < yield < 20 kt, unlikely to be concealable under a CTBT)	• development of low-yield boosted fission weapons • eventual development & full testing of some primaries & low-yield thermonuclear weapons • proof tests of fission weapons with yield up to 20 kt	• development of low-yield boosted fission weapons • development & full testing of some primaries & low-yield thermonuclear weapons • proof tests of fission weapons with yield up to 20 kt
High-yield testing (yield > 20 kt, not concealable under a CTBT)	• eventual development & full testing of boosted fission weapons & thermonuclear weapons	• development & full testing of new configurations of boosted fission weapons & thermonuclear weapons

States with extensive prior test experience are the ones most likely to be able to get away with any substantial degree of clandestine testing, and they are also the ones most able to benefit

* That is, lacking an adequate combination of nuclear-test data, advanced instrumentation, and sophisticated analytical techniques, and without having received assistance in the form of transfer of the relevant insights.

technically from clandestine testing under the severe constraints that the monitoring system will impose. But the only states in this category that are of possible security concern to the United States are Russia and China. As already noted, the threats these countries can pose to U.S. interests with the types of nuclear weapons they have already tested are large. What they could achieve with the very limited nuclear testing they could plausibly conceal would not add much to this.

If Russia or China were to test clandestinely, within the limits imposed by the monitoring system, because they thought they needed to do so to maintain the safety or reliability of their enduring stockpiles, this would not add to the threat they would have posed to the United States in the circumstance that they were able to maintain the safety and reliability of their stockpiles without testing. Clandestine testing by Russia or China to maintain their confidence in their stockpile—although in violation of the CTBT, threatening to the non-proliferation regime, and not to be condoned—might actually be *less* threatening to the United States than either their losing confidence in the reliability of their weapons and building up the size of their arsenal to compensate, or their openly abrogating a CTBT in order to conduct the testing they thought necessary to maintain or modernize their stockpiles.

U.S. security could reasonably be judged to be threatened by clandestine Russian and Chinese testing for stockpile reliability only if the Russians and Chinese were able to maintain the reliability of their stockpiles by means of this cheating while the United States, scrupulously adhering to the CTBT, was unable to maintain the reliability of its own stockpile. This is precisely what has been hypothesized by some critics of the CTBT, but we judge (Chapter 1) that the United States has the technical capabilities to maintain the reliability of its existing stockpile without testing. If really serious reliability problems that only could be resolved through testing did materialize in the Russian or Chinese arsenal, moreover, it is unlikely that the degree of testing needed to resolve them could be successfully concealed.

In contrast to the cases of Russia or China, where their substantial prior experience with testing makes it at least plausible that they might be able to conceal some substantial degree of testing at yields below the threshold of detection, states with lesser prior test experience and/or design sophistication are much less likely to succeed in concealing significant tests. This is in part because of the importance of test experience in constructing cavities that can achieve seismic decoupling without leaking radioactivity, and in part because considerable weapon-design experience is required to achieve low yields. Countries with lesser prior test experience and/or design sophistication would also lack the sophisticated test-related expertise to extract much value from such very-low-yield tests as they might be able to conceal. They could lay some useful groundwork for a subsequent open test program in the event that they left the CTBT regime or it collapsed, but they would not be able to cross any of the thresholds in nuclear-weapon development that would matter in terms of the threat they could pose to the United States.

In relation to two of the key "comparison" questions posed at the beginning of this section about the implications of potential clandestine testing, we therefore conclude as follows:

- Very little of the benefit of a scrupulously observed CTBT regime would be lost in the case of clandestine testing within the considerable constraints imposed by the available monitoring capabilities. Those countries that are best able to successfully conduct such clandestine testing already possess advanced nuclear weapons of a number of types and could add little, with additional testing, to the threats they already pose or can pose to the United States. Countries of lesser nuclear test experience and design sophistication would be unable to conceal tests in the numbers and yields required to master nuclear weapons more advanced than the ones they could develop and deploy without any testing at all.

- The worst-case scenario under a no-CTBT regime poses far bigger threats to U.S. security—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.