STEWARDSHIP OF TEST-FREE NUCLEAR ARSENALS

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FOREWORD

According to Cold War-era nuclear wisdom, weapons' testing helps guarantee the safety and reliability of nuclear devices. However, this practice has been losing ground.

For the past 10 years, none of the nuclear powers recognized by the NPT have carried out nuclear tests - the most recent tests occurred in 1996 by France and China, the United States last tested in 1992, and Great Britain in 1991 (while the USSR was the first nuclear power to become "test-free" in 1990).

Arguably this decade's lack of nuclear testing is a result of discussions surrounding the Comprehensive Test Ban Treaty (CTBT), a multilateral treaty against weapons testing, which opened for signing in 1996, but has yet to go into effect. For various political reasons, its chances of coming to fruition are minimal. Nevertheless, treaty or no treaty, nuclear powers have not been eager to resume nuclear field tests.

In the time of the CTBT signing, the prevailing view was that without field tests, new types of munitions could not be developed. This view was seen as a positive step for arms control and nonproliferation. Nevertheless, maintaining nuclear arms in the current policy environment that frowns upon weapons testing coexists with a set of unresolved and disquieting issues regarding the disposition of test-free arsenals.

In lieu of today's nuclear policy debate, several questions arise:

- Why did the nuclear powers finally decide to negotiate the creation of the CTBT after 30 years of empty promises to cease testing?
- Can nuclear arsenals be kept safe and combat-ready without tests?
- Might one of the nuclear powers initiate the resumption of tests? Who would win and who would lose in this situation?
- And on the contrary, who would win and who would lose if tests were not resumed? Do all nuclear powers have equal technological conditions for maintaining and modernizing their arsenals?
- Will the moratorium on nuclear tests become an instrument of a new nuclear arms race, that is, a race to maintain an arsenal without testing it?
- What are the existing and potential political combinations surrounding the issue of prohibiting nuclear tests?
- Finally, how does the world avoid unnecessary confrontations and excessive competition? Can the leading nuclear powers cooperate to maintain the safety and security of nuclear arsenals without field testing?

The answers to these questions are significant to the international nuclear policy debate. In this paper the authors will present the "Russian perspective" with hopes that other global citizens will follow this example. We hope that sharing perspectives will lead to an active effort towards understanding each others' views and, in the end, provide crucial steps towards an effective international agreement on nuclear policy.

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THE SIGNIFICANCE OF NUCLEAR TESTING

The sixty-year history of nuclear weapons is inseparable from nuclear tests. A total of 2,058 test nuclear explosions have taken place throughout the world. Nuclear tests were conducted to maintain the reliability and safety of the nuclear arsenal, as well as to develop new designs of weapons.

Table 1. Nuclear Tests Worldwide

Country	Number of Tests	Last Test
United States	1030	1992
Russia	716	1990
France	210	1996
China	45	1996
Great Britain	44	1991
India	5*	1998
Pakistan	6*	1998
Israel South Africa	1**	1979

Notably, Great Britain carried out its nuclear tests in the United States, at the Nevada test site, in close cooperation with U.S. experts. This close relationship allowed both countries to share knowledge such as test results. Thus the experiences of the United States and Britain can be thought of as complementary and combined.

Nuclear Tests and Reliability/Safety

Maintaining nuclear devices requires two considerations to bear in mind regarding their operating regime: reliability and safety. This means that under no circumstances can they detonate (reliability) and release nuclear energy in a non-standard situation (safety). As long as nuclear weapons exist, countries that possess them must maintain a high level of reliability and safety throughout the life-cycle of the nuclear charge: assembly, storage, transportation, exploitation and dismantlement. Nuclear tests were the traditional method for maintaining reliability and safety.

Nuclear Tests and New Weapons

The overwhelming majority of tests (about 80 percent) were held to develop new designs of charges and to research the use of new materials and production technologies.

Throughout the post-World War II period, the United States and the Union of Soviet Socialist Republics (USSR) worked intensively to perfect their arsenals, and played a special

* Some experts say that India and Pakistan held two tests each, because the testing went on for two days (May 11 and May 13, 1998, for India; May 28 and May 30, 1998, for Pakistan). However, several explosions were made during the two days.

** In September 1979, American satellites recorded a flash of light in the South Atlantic that could really be a nuclear explosion. Special ships dispatched to the region of the flash did not find radioactive traces. However, some experts believe that Israel tested an explosive device in September 1979 in cooperation with South Africa.

role in developing new types of nuclear weapons. The powerful scientific, technical and experimental bases of the nuclear superpowers allowed them to carry out a wide range of nuclear tests. Research centers in both countries provided scientific and technological support for the tests, amassing significant data, which was ultimately the main objective of the tests.

THE HISTORY OF NUCLEAR TEST PROHIBITION

India made the first official proposals to forbid nuclear testing to the United Nations (UN) in 1954. In July 1956, the USSR offered the United States and Great Britain (France and China were not yet nuclear powers) to begin negotiations on stopping nuclear tests, but the offer was declined. On March 31, 1958, the USSR announced a unilateral moratorium on all nuclear tests. However, within 1958 the United States carried out the largest series of tests in history with 62 air and underwater detonations, as well as 15 underground detonations.

Technical experts met in Geneva in the summer of 1958 to discuss nuclear control and concluded that, from the scientific and technical point of view, there were no insurmountable obstacles to an agreement on the cessation of nuclear testing, but that goodwill would be the main requirement. The USSR fully concurred with the conclusions of the experts; the United States and Great Britain announced that they were ready to consider their opinion. In March 1958, the USSR proclaimed a moratorium on nuclear testing; the United States and Great Britain joined it in November (the moratorium was effective until September 1961). In November 1958, the USSR also submitted a draft for an agreement to stop all nuclear testing and later proposed the establishment of a verification system, but these ideas were not developed. In February 1960, France began testing nuclear weapons. The Soviet government announced in August 1961 that it would suspend the moratorium and resume nuclear testing. In December 1962, the USSR once again unilaterally declared that it was stopping nuclear detonations.

To avoid differences of opinion on the issue of control, in July 1963, Soviet diplomats proposed that the first step could be an agreement on the cessation of nuclear testing in three environments, the atmosphere, outer space and under water, where it was practically impossible to carry out testing covertly. Negotiations were quite active and within two weeks all contentious issues were resolved. The Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water (also known as the Partial Test Ban Treaty, or PTBT) was signed in Moscow in August 1963. The USSR, the United States and Great Britain were the first members of the treaty, but soon over 120 countries joined them.

France and China did not sign the Partial Test Ban Treaty[1]. They continued airborne testing (France until 1974 and China until 1980) and stopped it out of goodwill, rather than in accordance with diplomatic obligations.[2]

In 1974, the USSR and the United States signed a bilateral Treaty on the Limitation of Underground Nuclear Testing. The treaty banned the testing of charges with a power of over 150 kilotons and limited the number of tests. However, when the treaty was signed, the new limitations no longer played a very significant role. The permitted charge did not limit development of the types of weapons in both countries.

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[1] In discussing the role of China in treaties on nuclear testing, it is important to keep in mind that in the 1960s the majority of the international community recognized Chiang Kai-shek (Taiwan) as the head of China. The diplomats of the Chiang Kai-shek government represented China in the UN Security Council until October 1971. Taiwan joined the Partial Test Ban Treaty in 1964.

[2] Great Britain carried out its last airborne test in 1958, the USSR in 1962 and the United States in 1963.

In May 1976, the Soviet-American Treaty on Civilian-Use Nuclear Testing was signed, allowing the industrial and agricultural use of nuclear detonations: creating underground oil and gas condensate storage areas, rock fragmentation, making canals, dams, etc.[3]

Trilateral (USSR, United States, Great Britain) discussions on the prohibition of nuclear testing were held in 1977-1980, but yielded no results.

In May 1984, the leaders of six countries (Argentina, Greece, India, Mexico, Sweden and Tanzania), spoke out with the Five-Continent Initiative for Peace. Then, in 1985, they called for the immediate cessation of nuclear testing and the preparation of an agreement on the complete abandonment of nuclear testing. In August 1986, the heads of those countries announced: "We are still convinced that the most urgent and important problem today is the banning of all nuclear tests. The qualitative improvement as well as quantitative enlargement of nuclear arsenals speeds up the arms race, which can only be stopped by a complete prohibition of nuclear testing."[4]

At a meeting in Reykjavik, Iceland, in 1986, Soviet and American leaders spent a lot of time on the issue of nuclear testing, discussing limits on the power and number of detonations. The United States was in favor of tying the decrease in the number and maximum power of nuclear detonations to the general reduction of strategic weapons. Former-U.S. President Ronald Reagan argued that the complete abandonment of nuclear testing was only possible upon the total liquidation of nuclear weapons.

To ease control over nuclear testing, Soviet and American scientists conducted a joint experiment on control in 1988. Two underground nuclear explosions were carried out at the Nevada test site in August and at the Semiplatinsk polygon in September. The results showed that scientists would be able to detect even relatively low-yield nuclear explosions.[5]

The end of the Cold War and the de-escalation of the military confrontation between the USSR and the United States allowed the two countries to stop nuclear tests. .

COMPREHENSIVE TEST BAN TREATY

The United States, USSR and Great Britain agreed to work towards the end of nuclear testing in 1963. The Preamble to the Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water (1963) stated: "The Governments of the United States of America, the United Kingdom of Great Britain and Northern Ireland, and the Union of Soviet Socialist Republics [...] seeking to achieve the discontinuance of all test explosions of nuclear weapons for all time, determined to continue negotiations to this end..." This quote shows that the three countries clearly expressed a desire to attain the complete abandonment of nuclear testing. However, there are no obligations with regard to timing. The nuclear powers were reminded about their aspirations during negotiations on the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). Upon the initiative of non-nuclear powers, the Preamble to the NPT included the following statement: "recalling the determination expressed

[3] The use of nuclear detonations for industrial and agricultural needs was a very popular topic in the 1960s and 1980s. In negotiating the Treaty for the Non-proliferation of Nuclear Weapons, or the NPT, the non-nuclear countries even "negotiated" for the right to ask nuclear powers to carry out civilian detonations (Article 5, "On Civilian-Use Nuclear Detonations"). However, no one ever took advantage of this right. R.M. Timerbayev. Russia and Nuclear Nonproliferation. Moscow, 1999, pp. 303-307.

[4] "Disarmament," *UN periodic review*, Fall 1986, N3, vol.IX, p. 1-26.

[5] A. Kalyadin. "Novye idei i predlozheniua po ogranicheniyu i prekrashcheniyu ispytanii yadernogo oruzhiya," *Mir Nauki,* 1988, No. 1, p. 13.

by the Parties to the 1963 Treaty banning nuclear weapon tests in the atmosphere, in outer space and under water in its Preamble to seek to achieve the discontinuance of all test explosions of nuclear weapons for all time and to continue negotiations to this end."

The USSR, the United States and Great Britain really did work toward prohibiting testing (for example, there was a period of negotiation from 1977 to 1980), but with little success. Obligations on the ban on testing in the 1963 and 1968 treaties were not binding, since they were contained in the preambles rather than the bodies of the treaties, making them more like declarations of intent.

It was also important that only three out of the five nuclear powers expressed the intention to give up tests. Remember that France and China did not join the PTBT, and in fact, they both waited until 1992 before joining the NPT. Naturally, it doesn't make sense for only three out of five nuclear powers to give up testing: such limitations must be universal.

At the 1995 conference to review and extend the NPT, non-nuclear governments harshly criticized the actions of the nuclear powers and demanded the immediate completion of work on an agreement on the comprehensive prohibition of nuclear testing.

The 25-year term of the NPT ended in 1995. In accordance with Article 10, paragraph 2 of the Treaty, it was supposed to be extended permanently for a new term. The Clinton administration decided to try for permanent, as well as unconditional (no amendments), extension. A treaty on the prohibition of nuclear testing (what would later become the CTBT) was supposed to become a signal to non-nuclear powers that nuclear powers were prepared to abide by their disarmament obligations.

During the negotiations on the CTBT at the Geneva Conference for Disarmament, U.S. diplomats insisted on setting a limit of 500 tons for testing. France championed a limit of 200 tons, while Russia pushed for 10 tons. The Chinese delegation was in favor of a zero-limit, but at the same time allowing civilian-use testing.

Finally, the CTBT was formulated on the following basic premises:

1. Every member state pledges to carry out no test detonations of nuclear weapons or other nuclear tests, and to prohibit and prevent any such detonations at any site under its jurisdiction or control.

2. Every member state pledges to refrain from prompting, encouraging or otherwise participating in any test detonations of nuclear weapons or other nuclear tests in the future.

The final version of the CTBT was a zero-yield, no-civilian-use treaty. Unlike voluntary moratoriums, this included banning hydronuclear testing.

To control compliance with the Treaty, a global monitoring system was to be created, including 50 primary and 120 supporting seismic stations, as well as 60 infrasound, 80 radioactive nuclide and 11 hydro-acoustic stations that covered all regions of the Earth. The distributed, multi-mode monitoring system would ensure that any nuclear detonation, even a super low-yield detonation, would be detected, with all of the ensuing consequences for the violator.

After going into effect, the Treaty would have been permanent, though states would have had the right to exit it if their supreme national interests were threatened. At the time, to go into effect, the Treaty must be signed and ratified by 44 states involved in nuclear activity.[6]

[6] Appendix 1 includes a list of these countries and their status of CTBT ratification.

The CTBT encountered problems almost immediately after the negotiations on the contents were completed. India did not agree with the terms of the Treaty and vetoed its approval at the Conference for Disarmament, where decisions are made by consensus agreement. As a result, the UN General Assembly had to make a decision via majority vote: the Treaty was approved and opened for signing in September 1996.

Russia signed the CTBT in 1996 and ratified it in 2000. China signed the CTBT in 1996, but has yet to ratify it. There were some disagreement concerning the treaty in Russia and China, but these did not result in large-scale strategic debates. At the same time, both countries carefully followed debate within the United States over the CTBT and the future of nuclear weapons.

The United States signed the CTBT in 1996, but in October 1999, the U.S. Senate refused to ratify it, despite the open and insistent support of the Clinton administration, and sealed the treaty's doom.

The international community criticized America's refusal to ratify the CTBT. UN Under-Secretary-General for Disarmament Jayantha Dhanapala noted that many countries agreed to permanently extend the NPT in 1995 only because the nuclear countries confirmed in writing that they would ratify the CTBT and take other steps towards nuclear disarmament.[7]

Going forward, the Clinton administration did not try to submit the CTBT to be ratified again, since this was quite unlikely with a Republican-led Senate. And the George W. Bush administration, in which many well-known critics of the CTBT hold high-ranking positions, announced that it would neither rescind the signature on the Treaty nor try to get it ratified. This leaves it in a nebulous area where it cannot progress to come into force.

Without going into the details of the American discussions regarding the CTBT, we will simply note that the Clinton administration tried to "sell" it to the Senate as, above all, an agreement on the non-proliferation of nuclear weapons.[8] The Clinton administration emphasized that the CTBT would prevent new countries from obtaining nuclear weapons, and that the doors of the nuclear club would be sealed shut if testing were cancelled. The events that followed refuted, rather than confirmed that argument, when in 2003 North Korea announced that it was a nuclear power without carrying out any tests. The critics of the CTBT stressed that the treaty was aimed at disarmament rather than nonproliferation in that its main goal was keeping existing nuclear powers from introducing new designs of weapons rather than preventing new countries from joining the nuclear club.[9] Naturally, opponents questioned whether it would be useful to take on new disarmament obligations, especially since some viewed them as the first step to a non-nuclear world and complete abolition of nuclear weapons.

According to Article 6 of the NPT, "Each of the Parties to the Treaty undertakes to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a Treaty on general and complete disarmament under strict and effective international control." Non-government organizations that promoted nuclear disarmament often viewed the CTBT as the first step to full nuclear

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7 Jayantha Dhanapala was quoted by Shannon Kile in "Nuclear Arms Control and Non-Proliferation," SIPRI Yearbook, 2000, p. 449.

8 For example, see Bill Clinton's statement on Oct. 5, 1999, upon the signing of the 2000 defense budget (National Defense Act) (http://www.clw.org/archive/coalition/clinton100599.htm); Clinton's statement during a meeting with religious leaders on Oct. 7, 1999; and Madeleine Albright's interview on "This Week," *ABC*, Oct. 10, 1999.

9 For example, see Baker Spring: "The Comprehensive Test Ban Treaty and U.S. Nuclear Disarmament." *Backgrounder* No. 1330, The Heritage Foundation, Oct. 6, 1999.

disarmament, believing that since the CTBT would prevent countries from perfecting new weapons while old weapons were becoming obsolete, new weapons would not appear and old weapons would be rejected. Under this interpretation of the CTBT, technical problems related to maintaining arsenals will most likely be viewed as a plus, rather than a minus, since they would make the path towards nuclear disarmament shorter.[10]

U.S. discussions of the CTBT seem to show that the critics of the Treaty did not really believe that the Clinton administration intended to maintain the nuclear arsenal under the CTBT: the administration was suspected of trying to speed up nuclear disarmament. Opponents therefore stressed that the CTBT was at heart a disarmament treaty. The Clinton administration was unable to convince the Republican-led Senate that the goal of the treaty was to prevent new nuclear powers from appearing, rather than disarm existing nuclear powers.

Six countries (the United States, China, Israel, Iran, Indonesia, Egypt and Columbia) signed but did not ratify the treaty. North Korea, India and Pakistan did not sign the CTBT. Without them, the Treaty cannot go into effect. Attempts had been made to convince the "new nuclear powers" to join the treaty, but yielded no results. Indian and Pakistani nuclear tests in 1998 dealt a serious blow to the CTBT.

There is no reason to expect the CTBT to go into effect in the foreseeable future. The Iranian and North Korean nuclear problems must be solved and an acceptable balance of power must be achieved in the China-India-Pakistan triangle. The CTBT may be an element towards a solution for all these problems, or fall victim if they aren't solved.

However, even though the CTBT remains an "inactive treaty," the countries that signed and/or ratified it are not rushing to officially leave it. There is also another point of view: some countries signed and ratified the treaty only after it became clear that it was "harmless" -- the Treaty had no chances of going into effect. In any case, the CTBT has a psychological effect on international politics. Violations of the basic precepts of this "inactive treaty" are viewed as a foreign policy problem.

ALTERNATIVES TO NUCLEAR TESTING

Three scientific-technical methods are currently considered to constitute replacement for nuclear testing: the physical modeling of different stages of the nuclear detonation, carried out on laboratory equipment; non-chain reaction test; and computer modeling on a supercomputer. Every method yields certain types of information; together, they can form a systemic approach to receiving the characteristics of the overall state and potential functions of the charge under study.

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[10] The supporters of nuclear disarmament called for the rejection of technologies that could replace nuclear testing. The following demands were formulated for nuclear powers:

- give up nuclear tests forever;
- openly and unambiguously give up designing new nuclear warheads;
- cease the construction of new laboratory test sites;
- give up loopholes such as hydrodynamic, subcritical and other testing, as well as the modification of the CTBT to allow "civilian" nuclear explosions in the future.

A. Makhidzhani, "DVZYaI i "yadernaya pyaterka": problemy ostayutsya," *Yadernyi Kontrol*, 1996, N 22.

De facto, this program for stimulating the "extinction" of nuclear weapons, is designed to keep nuclear powers from maintaining their arsenals under the CTBT.

Physical Modeling (Laboratory Experiments)

A physical model of processes that take place at different stages of the nuclear detonation is created with special laboratory equipment. No chain reaction occurs.

Lab experiments modeling nuclear weapons have been conducted since scientists worked on the very first nuclear bomb. The results of such experiments have been decisive for the design of nuclear weapons when nuclear tests could not be carried out, or were very rare. Unique equipment, which made it possible for scientists to receive very important information about the different stages of the nuclear detonation, was consistently being created and improved in labs in the United States and USSR. The role of lab experiments increased significantly in the 1990s.

Lab experiments provide good results in the study of technical problems related to the primary stage of the nuclear chain reaction: nuclear criticality, deuterium-tritium fusion, 3D pictures at a later stage with the formation of a hollow core, etc.

As part of the lab experiments, the effect of ageing on the physical properties of materials, above all plutonium and uranium, is tested. Computer modeling methods based on lab experiments can create models that predict the changing characteristics of materials as they undergo fission.

The secondary stage of nuclear detonation (effect of production flaws and changing characteristics of materials with ageing) are very difficult to recreate in the lab.

Non-Chain Reaction Tests (Hydronuclear and Subcritical)

In Russia, hydronuclear and subcritical detonations are usually put into one category. Although they differ in the sense that hydronuclear tests produce yield, while subcritical are zero-yield, they share the important characteristic of avoiding a chain reaction.

A Hydronuclear experiment use chemical explosives to prompt the combustible compression of fissile nuclear matter of such power that plutonium loses its mechanical stability and begins to behave like a liquid. A small amount of plutonium undergoes fission, which results in the emission of energy equivalent to about 2 kilograms of TNT. At the same time, plutonium does not turn into plasma, which would initiate a nuclear chain reaction.

Hydronuclear experiments have a long history. The USSR carried out 89 hydronuclear tests. In the mid-1990s, hydronuclear tests were resumed, and came to be viewed as an alternative to field tests.

A series of hydronuclear tests with a total power of 10 kilograms of TNT equivalent were carried out at the Severnaya Zemlya test site from 1994 to 1995. First Deputy Minister of Atomic Energy Lev Ryabev declared that these experiments were intended “to confirm the safety levels of existing nuclear arsenals, to check the effectiveness of additional measures for improving the reliability and safety of nuclear munitions developed earlier, and to study the possibility of extending the guaranteed service life".[11] According to former Minister of Atomic Energy Viktor Mikhailov, the results of the experiments were “more than positive.”[12] A series of similar tests were conducted in the United States in 1995, and they were planned (before CTBT) to last through 2010.

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[11] Vinogradov, M.O. “O neobhodimosti ogranicheniya rabot po modernizatsii sushchestvuyushchih yadernyh vooruzhenii i pri razrabotke novyh yadernyh boyepripasov,” *Yadernyi Kontrol,* March-April 2000.

[12] Khalturin et al. “Obzor sovetskih yadernyh ispytanii na Novoi Zemle v 1955-1990 godah,” *Nauka i Vseobshchaya Bezopasnost*, 2005, volume 13, issue 2.

Hydronuclear tests are currently considered violations of the CTBT. Initially, the United States and Great Britain held another position, but they were forced to admit that it was incompatible with the spirit and letter of the Treaty. A hydronuclear test, despite not being powerful, is still a nuclear explosion with a nuclear yield.

Hydronuclear tests were replaced with subcritical tests. In such a test, a subcritical plutonium shell is surrounded with a couple of kilograms of chemical explosives. The energy produced is therefore quite low (0.1 micrograms in TNT equivalent). The test uses a chemical explosive, a small amount of fissile nuclear material, and other weapon elements. At the same time, there are no conditions for an exponentially growing nuclear chain reaction.

The United States carried out subcritical tests at the Nevada polygon in an underground LYNER complex, which was originally designed for hydronuclear tests.

In December 1998, five subcritical tests were held at the Novaya Zemlya polygon. According to Lev Ryabev, the tests met the requirements of the CTBT. The experiments were supposed to test nuclear munitions with a service life of 13 to 14 years. According to Colonel General Igor Valykin, now chief of 12 GUMO – a prominent Russian nuclear facility – these munitions will be modernized. [13]

Hydronuclear and subcritical tests are not registered by remote seismic control. Only on-site control with gamma-ray measuring equipment can prove or disprove the subcritical nature of the tests.

Hydronuclear tests may be continued by countries that are not bound by the CTBT. Since hydronuclear tests can be concealed (or disguised as subcritical tests) deception attempts cannot be ruled out.

Computer Modeling (Virtual Nuclear Tests)

The computer modeling of nuclear explosive processes becomes particularly important in view of the moratorium on nuclear tests. Mathematical modeling must be based on field tests in order to accurately represent the explosion processes.

A successful computer model requires the following:

- thorough understanding of the physical processes of a nuclear explosion;
- mathematical programs designed to describe the process of the nuclear explosion in 3D, with nanosecond resolution;
- superfast computers; and
- significant analytical statistics on numerous parameters of nuclear tests carried out in the past;

Computer modeling methods were first developed in the United States in the 1970s, although at that point computers could only provide certain elements of the total explosion model.

During nuclear tests at the Mururoa Atoll in 1996, French experts not only tested a warhead for M45 submarine-launched ballistic missiles (SLBMs) for Triumphant-class subs, but also carried out research into the computer modeling of nuclear detonations. There were reports that France shared the results of its research with the United States, which expressed interest in the experiments. [14]

[13] Georgiev V. "Rossiya sovershenstvuyet yadernye silo," *NVO*, 1999, N19.

[14] On June 4, 1996, the United States and France signed an agreement on sharing information on nuclear weapons. The agreement was secret and its exact name is not available. The United States promised to provide data on the

In 1994, Secretary of Defense William Perry declared that the United States offered to transfer computer modeling technologies to China that would allow it to maintain the reliability and safety of its nuclear arsenal without testing, but would not allow the design of new types of nuclear charges.[15] However, according to available information, no further progress appears to have been made on this offer.

Russia presumably falls behind the United States in the computer modeling of nuclear explosions. Until the mid-1990s, Russia did not have sufficiently fast supercomputers. Before signing the CTBT, the United States promised to sell Russia supercomputers that experts needed to check the safety of nuclear munitions. However, after Russia signed the Treaty, the United States passed strict export control measures in order to prevent the sale of supercomputers to Russia. The U.S. administration feared that Russia would use computer modeling to improve its nuclear designs.

However, Russia managed to get 17 supercomputers with a speed of 3.3 billion operations per second, buying them from IBM through a subsidiary. These supercomputers were installed at the Federal Nuclear Center in Sarov.[16]

We must note that in the second half of the 1980s, when computers were already useful for modeling nuclear detonations (or specific stages), the Soviet Union regularly announced unilateral moratoriums on nuclear testing, which kept scientists from carrying out field tests to fine-tune computer modeling methods. With no field tests since 1990, Russia may have difficulties creating reliable computer models for nuclear detonations.

From 1985 to the time of the moratorium, the United States conducted one and a half times more tests than the USSR (92 vs. 57). It is quite likely that one of the objectives for the tests was addressing problems in computer modeling.

Can Nuclear Tests be Avoided?

Nuclear scientists do not have a consensus opinion on nuclear testing. A.D. Sakharov asserted: "Why we really need nuclear tests. To develop fundamentally new technical solutions. The kind that is required for SDI [Strategic Defense Initiative] or any other methods of using nuclear weapons. *De facto*, this means that a country that has resumed nuclear tests is seeking to create new types of nuclear weapons, to change the balance of power on the international arena to its favor." [17]

However, the arguments of experts who support nuclear testing remain applicable. For example, S.T. Brezkun of the RFNC-VNIIEF declares, "[T]here is currently no unified standardized methodology for calculating a nuclear charge and verifiably estimating the effect of one or another design decision on the operability of the physical charge system. Different groups of developers use different methods and even different values for physical constants.

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results of computer modeling of nuclear detonations. The goal of the agreement was cooperation in ensuring the safety and security of nuclear arsenals in the absence of nuclear testing. Reuters, June 16, 1999.

[15] William Perry's statement is available at http://www.nti.org/db/china/testchr.thm.

[16] There are even more powerful computers in Russia. The Russian Academy of Science houses an interdepartmental supercomputer center with a 16-processor Hewlett-Packard system that can perform 15 billion operations per second, as well as a 96-processor MVS-1000, developed at Russia's NII Kvant. Vinogradov, M.O. "O neobhodimosti ogranicheniya rabot po modernizatsii sushchestvuyushchih yadernyh vooruzhenii i pri razrabotke novyh yadernyh boyepripasov," *Yadernyi Kontrol*, March-April 2000.

[17] Comprehensive Nuclear Warhead Test Ban. A Report of the International Foundation, January 1991, p 3.

As a result, only field tests provide experimental facts for the accepted scientific-engineering concept for a specific charge."[18]

We must note that the argument between the supporters and opponents of nuclear tests is not just an argument among physicists with different points of view. Weapons designers, rather than theoretical physicists, are probably the strongest supporters of the resumption of nuclear testing.

All arguments for and against field tests can be summarized in the following statement: the safety and reliability of existing arsenals can be guaranteed without field tests (which is definitely not a trivial task); however, new generations of nuclear weapons cannot be created without field tests.

AVAILABILITY OF TECHNOLOGIES FOR MAINTAINING NUCLEAR ARSENALS

To a certain extent, laboratory experiments can demonstrate the safety and reliability of nuclear arsenals. These experiments can be used in the process of developing new nuclear munitions, but they cannot replace field tests. Hydronuclear and subcritical tests provide information on the safety and security of nuclear munitions and can help ascertain service life duration. Hydronuclear and subcritical tests can also make it possible to improve the design of the nuclear charge, modernize some mechanical and electronic elements, etc. However, such tests cannot provide a comprehensive picture of the physical processes of an explosion, which is necessary for developing new munitions. Computer modeling can also be used for resolving certain aspects of the safety and reliability of nuclear arsenals, as well as potentially (if reliable methods are established) for developing new munitions.

The following table presents an assessment of the availability of these technologies to nuclear states.

Table 2. Availability of technologies that serve as substitutes for field tests

<table>
<tr><td rowspan="2">Country</td><td colspan="4">Technology</td></tr>
<tr><td>Physical Modeling</td><td>Hydronuclear</td><td>Subcritical</td><td>Mathematical Modeling</td></tr>
<tr><td>Russia</td><td>+</td><td>+</td><td>+</td><td>+</td></tr>
<tr><td>United States</td><td rowspan="2">+</td><td rowspan="2">+</td><td rowspan="2">+</td><td rowspan="2">+</td></tr>
<tr><td>Great Britain</td></tr>
<tr><td>France</td><td>+</td><td>+</td><td>+</td><td>+</td></tr>
<tr><td>China</td><td>+</td><td>+</td><td>+</td><td>?</td></tr>
<tr><td>India</td><td>+</td><td>+</td><td>+</td><td>-</td></tr>
<tr><td>Pakistan</td><td>+</td><td>+?</td><td>+?</td><td>-</td></tr>
<tr><td>Israel</td><td>+</td><td>+</td><td>+</td><td>-</td></tr>
</table>

[18] S. Brezkun. "Nekotorye otsenki situatsii vokrug Dogovora o vseobyemlyushchem zapreshchenii yadernyh ispytanii," *Strategicheskaya Stabilnost*, No. 3 2002.

Russia, the United States, Great Britain, France, and India presumably have the necessary technology to maintain their nuclear arsenals. Pakistan is not as technologically advanced, and may experience difficulties with conducting hydronuclear and subcritical tests.

Russia, the United States, and France most likely have the capacity to create computer models of nuclear detonations. Still in the sphere of computer modeling, Russia may fall behind the United States and France, the latter of whom stopped nuclear tests later than Russia.

It is unclear how Israel maintains the safety and reliability of its nuclear arsenal, which is estimated between 100 to 200 warheads. Without field test experience, Israel cannot be certain about the safety and reliability of its nuclear munitions, although it most likely has access to the technologies of physical modeling, hydronuclear and subcritical detonations.

China is a separate case. China has a relatively large arsenal, but carried out relatively few field tests. China may have access to mathematical modeling, but its database of results from previous tests is not sufficient to make mathematical modeling reliable. Physical modeling, hydronuclear and subcritical technologies should be available to China. Nevertheless, previous experience in nuclear tests is extremely important for maintaining the safety and reliability of nuclear arsenals in a test-free environment. From this point of view, China may experience difficulties maintaining its arsenal without field tests.[19]

New generations of munitions cannot be created. In this sense, the nuclear arms race, abandoned in the late 1980s, cannot be resumed while there is a ban or moratorium on nuclear tests. This is another political and technical barrier to the development of nuclear weapons.

However, the leading nuclear powers (Russia, the United States and China) could be drawn into a new type of nuclear race: a race for the survival of a nuclear arsenal in a test-free environment. Maintaining the arsenal in good condition without field tests is not a simple task.

NUCLEAR TESTING IN THE RUSSIA-UNITED STATES-CHINA TRIANGLE: TWO BASIC COMPETITION SCENARIOS

Russian experts look at the financing of American programs for maintaining nuclear arsenals in a test-free environment (over $3.5 billion can be traced in the U.S. budget in fiscal year 2006 and believe that such spending has military-technological results. Former Russian Minister of Atomic Energy Viktor Mikhailov notes that in the mid-1990s, the United States began a campaign to stop all nuclear tests only after it successfully completed a wide-ranging program of field tests for modern nuclear munitions.[20]

At the same time, a common argument in the United States is that the USSR created nuclear warheads with significant performance margins: Soviet scientists chose more conservative (simpler, in a good sense) technological approaches in designing warheads, which made them more reliable in servicing. For this reason, it is easier for Russia to deal with

[19] A report submitted to the U.S. Congress in May 1999 accused China of stealing military-technological secrets from nuclear labs in Los Alamos, Livermore, Sandia and Oak Ridge. According to the report, very valuable information was stolen on the design of modern thermonuclear charges, the development of which cost the U.S. hundreds of millions of dollars and required numerous nuclear tests. Information was reportedly stolen on seven thermonuclear warheads in the arsenal of the strategic nuclear forces, including the most modern W-88 warhead for the Trident II SLBM, as well as a neutron bomb. China denied all accusations. "Spy for U.S.: China Stole Neutron Bomb Secrets," *The Moscow Times*, April 9, 1999. We note that increased espionage by China would be a rational reaction to difficulties in developing new munitions, as well as maintaining the safety and security of nuclear arsenals in a test-free environment.

[20] V. Mikhailov. "Perspektiva tekhnologii razrabotki yadernogo oruzhiya," *NVO,* No.15, 1999.

problems in a test-free environment. The theory that the USSR was less dependent on testing than the United States is supported by the United States having carried out one and a half more tests than the Soviet Union.

China has conducted only 45 tests. More than half of these tests were held before 1980, so their results are only indirectly useful to China today. In the 1980s-1990s, China held one to two tests a year (none in some years). In the first half of the 1990s, tests became more frequent. In 1994-1996, China held two tests a year for three years in a row. This was the most intensive test series in China's nuclear history. The country was clearly preparing for a test-free future. Nevertheless, we can assume that China's test infrustructure was inferior to those of Russia and the United States. Behind in the design of precise equipment and computing technologies, China could not hold tests that would be as informative as those of the United States and the USSR. Thus, China should be the first of the big three nuclear states to face problems in maintaining its nuclear arsenal in a test-free environment.

So far, Russia, the United States and China do not openly admit to problems in stewadship. However, some nuclear physicists in Russia disapprove of the ban on nuclear tests. We can assume that similar moods are present in China, although there is less public expression, since far less information is open on military-nuclear issues.

Russia and potentially China have lobbies that are calling for the rejection of the ban on nuclear tests. Experts responsible for nuclear safety and reliability argue in favor of resuming tests. The wider community of defense specialists and politicians may have to accept these arguments at some point. Thus, we see two basic scenarios.

First scenario. Supporters of a test ban could lose open debates on the future of nuclear testing. If this happens in just one country, other nations are likely to follow suit (arguing that a ban must be universal: if one nuclear country rejects it, the others simply have no choice). [21] However, even if one country accepts the arguments of the supporters of nuclear testing and withdraws from the CTBT, this country is unlikely to make "sudden moves." It is more likely that Russia, the United States and China will adopt cautious waiting positions: nervously looking at each other in the hopes that one of the others will give in first and announce the resumption of testing. Russia and China will be ready to concede the initiative to the United States, which has proved itself willing to take political risks related to rejecting important international obligations. At the same time, the United States could see the interest of Russia and China in resuming testing. In that case, the United States would most likely work towards a joint or coordinated rejection of the CTBT and unilateral moratoriums (the way the United States offered Russia to jointly leave the ABM Treaty in 2001). Thus, if forces that support the resumption of nuclear tests win in even one of the "big nuclear three" (especially in more than one), we could see complex and confusing tactical maneuvers among Russia, the United States and China: the countries will push each other towards resumption of tests. Under this scenario, the United States would probably be the first country to resume testing.

Second scenario. One of the "big nuclear three" might try to play on the weaknesses of others. A race for the maintenance of nuclear arsenals in a test-free environment would follow. This is a peculiar arms race where there is neither qualitative nor quantitative competition, but there is a "siege" of the nuclear arsenals of rivals in attempting to maintain nuclear potential in

[21] The supporters and opponents of nuclear testing are not on even ground. Those who support the resumption of field tests could win the debate in just one country (not necessarily their own), while those who are in favor of the ban must win debates in all nuclear countries.

the face of the highest limits and to "wait out" the CTBT. This type of rivalry could be as tense as a traditional arms race. Such competition would probably be accompanied by numerous espionage scandals. Information on the state of the nuclear stockpiles of rivals, for example, would be exceptionally valuable. China would probably have the most difficulties under this scenario.

There is a principal difference between the two scenarios. In the first, the countries would push each other to exit the Treaty in order to have an opportunity to carry out nuclear tests. This scenario is not compatible with the CTBT. In the second scenario, on the contrary, the countries would work to maintain the moratorium on nuclear detonation, preventing rivals from using the advantage of tests. The second scenario is compatible with the CTBT and focuses on maintaining the Treaty, because it is more detrimental to rivals.

We can currently see elements of both scenarios. It seems that the United States, Russia and China are at a crossroads, trying to choose between the two scenarios. It is important for each country to clearly understand the advantages and risks of both alternatives, as well as have a broader understanding of the problems of the non-proliferation of nuclear weapons.

We have already mentioned that the non-nuclear members of the NPT feel that the CTBT was a promise made by nuclear states based on the permanent extension of the NPT in 1995. From a legal point of view, the NPT and the CTBT are not linked (neither is a condition for the other: legally, the NPT can function without the CTBT and vice versa). However, there is a political link between the CTBT and the decision to extend the NPT. Thus, if nuclear states withdraw from the CTBT, non-nuclear states could declare that the nuclear states broke their promises and take back their agreement to extend the NPT. This could be an option for leaving the NPT without following the necessary procedures and conditions delineated in the Treaty itself. Instead of fully leaving the NPT, a non-nuclear country may declare that it no longer views it as valid because the decision to extend it is invalid. Naturally, such games surrounding the NPT will be opposed by the international community and international organizations. However, it must be admitted that the political motivations of this "disturbance" would be recognized by many non-nuclear states.

In life and in politics it is often simpler not to take an obligation than to give it up later. The CTBT is one such case, or at the very least, it looks that way right now.

Conclusion: The Possibility of Cooperation by Russia, the US and China

The CTBT does not work the way the supporters of nuclear disarmament expected it to work. Russia, the United States and China do not interpret the CTBT to completely rule out the improvement of nuclear weapons. On the contrary, all three countries plan to modernize their arsenals.

With time, problems related to lack of tests may grow. An argument will be voiced more insistently, that nuclear tests must be resumed. A sophisticated argument may develop that at the very least tests are needed to prove that they are not necessary. Another potentially important argument may be that experts who have no experience with field tests are not qualified to service and modernize nuclear arsenals.

If the issue is put rigidly -- military-nuclear potential cannot be maintained without tests -- military and political leaders in Russia, the United States and China, may accept the arguments of those who support resumption of tests. Once again, they did not view a ban on field tests as the beginning of a movement towards abolition of nuclear weapons.

Criticism of the CTBT and unilateral moratoriums on nuclear tests can result in the withdrawal of one of the leading nuclear powers from the CTBT. Or, Russia, the United States and China could begin a peculiar arms race and compete to maintain a nuclear arsenal without tests. Both scenarios would have severe negative results. In the first, another very important treaty could be jeopardized, the NPT. In the second, the spirit of nuclear competition could seriously damage relations among the three countries.

It would be wise to look into cooperation for maintaining the safety and reliability of nuclear arsenals in a test-free environment. None of the three countries -- Russia, the United States or China -- is interested in jeopardizing the regime of non-proliferation of nuclear weapons, or giving new excuses for attacks on the NPT. At the same time, none would be willing to sacrifice its military-nuclear potential to solve the problem of non-proliferation. Consultations among experts, scientists and politicians from Russia, the United States and China on the question of maintaining the safety and security of nuclear arsenals allow the three countries to coordinate their views on the ban of testing and avoid the demise of the NPT, or the transition to a new nuclear rivalry.

Russia, the United States and China should not be interested in the cynical use of each other's nuclear problems. It is not in the interest of any major nuclear power if its "nuclear neighbors" feel vulnerable in military-political issues or face problems in nuclear safety. Trilateral discussions of the safety and reliability of nuclear arsenals must support this common interest of the major three nuclear powers.

APPENDIX 1

CTBT and Status of Countries who's Ratification is required for Entry into Force: (As of April 2006)

Did not Sign	Signed	Ratified
	Australia (1996)	Australia (1998)
	Austria (1996)	Austria (1998)
	Algiers (1996)	Algiers (2003)
	Argentina (1996)	Argentina (1998)
	Bangladesh (1996)	Bangladesh (2000)
	Belgium (1996)	Belgium (1999)
	Bulgaria (1996)	Bulgaria (1999)
	Brazil (1996)	Brazil (1998)
	Great Britain (1996)	Great Britain (1998)
	Hungary (1996)	Hungary (1999)
	Vietnam (1996)	Vietnam (2006)
	Germany (1996)	Germany (1998)
	Democratic Republic of the Congo (former Zaire) (2004)	Democratic Republic of the Congo (former Zaire) (2004)
	Egypt (1996)	
	Israel (1996)	
	Spain (1996)	Spain (1998)
India		
	Indonesia (1996)	
	Iran (1996)	
	Italy (1996)	Italy (1999)
	Canada (1996)	Canada (1998)
	China (1996)	
Democratic People's Republic of Korea		
	Columbia (1996)	
	Mexico (1996)	Mexico (1999)
	The Netherlands (1996)	The Netherlands (1999)
	Norway (1996)	Norway (1999)
Pakistan		
	Peru (1996)	Peru (1997)
	Poland (1996)	Poland (1999)
	Russia (1996)	Russia (2000)
	Romania (1996)	Romania (1999)
	Slovakia (1996)	Slovakia (1998)
	United States (1996)	
	Turkey (1996)	Turkey (2000)
	Ukraine (1996)	Ukraine (2001)
	Finland (1996)	Finland (1999)

	France (1996)	France (1998)
	Chile (1996)	Chile (2000)
	Sweden (1996)	Sweden (1998)
	Switzerland (1996)	Switzerland (1999)
	South Africa (1996)	South Africa (1999)
	South Korea (1996)	South Korea (1999)
	Japan (1996)	Japan (1997)

APPENDIX 2

Warheads in the Arsenals of Nuclear Countries (January 2006)[22]

Country	Suspected Strategic Nuclear Warheads	Suspected Non-Strategic Nuclear Warheads	Suspected Total Number of Warheads
China	~130	?[23]	**~130**
France	348	-	**348**
India	-	-	**~50**[24]
Israel	-	-	**100-200**
Pakistan	-	-	**~60**
Russia	3,352	2,330	**5,682**[25]
United Kingdom	185[26]	-	**185**
United States	5,021	500	**5,521**[27]
North Korea[28]	~10	-	**~10**

[22] *Stockholm International Peace Research Institute: SIPRI Yearbook 2006*, Oxford University Press 2006, p. 640 Information taken from SIPRI for countries from China through United States.
[23] The existence of operational Chinese non-strategic warheads is uncertain.
[24] The stockpiles of India, Pakistan and Israel are thought to be only partially deployed.
[25] The total Russian stockpile contains roughly 16,000 warheads, of which about 10,100 are in storage and/or awaiting dismantlement.
[26] Some warheads on British strategic submarines have sub-strategic missions.
[27] The total U.S. stockpile, including reserves, contains about 10,000 warheads. In addition, 5,000 plutonium cores (pits) are in storage as a strategic reserve, while another 7,000 pits make up most of 34 tons of weapon-grade plutonium declared in excess of military needs.
[28] Country not included in the *SIPRI Yearbook 2006*. North Korea claimed in 2005 that it had developed nuclear weapons, although there is no public information to verify this claim. "…Pyongyang could have as few as five weapons or as many as fifteen. Ten weapons seems to be a reasonable estimate, with the addition of about one weapon per year." From *Global Nuclear Stockpiles, 1945-2006*; Bulletin of the Atomic Scientists [on-line]; available from http://www.thebulletin.org/article_nn.php?art_ofn=ja06norris; accessed 29 August 2006.

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