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Countdown on the Comprehensive Test Ban

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Fact Sheet on Nuclear Testing

1. What states have conducted nuclear tests? When did they begin testing?

United States	1945	France	1960
Soviet Union	1949	China	1964
United Kingdom	1952	India	1974

Note: In September, 1979, a U.S. Vela satellite detected what may have been a nuclear test of a 2-4 KT bomb in the south Atlantic Ocean between South Africa and Antarctica. It has not been determined that in fact it was a nuclear test and no state has claimed responsibility for it.

2. What states have nuclear weapons?

<u>Admitted</u>	<u>Close but not admitted</u>
United States	Israel
Soviet Union	South Africa
United Kingdom	India
France	Pakistan
China	

3. Where are nuclear tests conducted?

<u>Nation</u>	<u>Location</u>
United States —	Nevada
Soviet Union —	Semipalatinsk and Novaya Zemlya
United Kingdom —	Nevada (under U.S. auspices)
France —	Mururoa, South Pacific
China —	Xinjiang, Western China
India —	Rajasthan Desert

Note: The United States, Soviet Union, United Kingdom, and India have all signed the Limited Test Ban Treaty (LTBT) and all their tests since 1963 have been conducted underground. Neither France nor China have signed the LTBT; France now tests underground and China recently announced that it would conduct no more atmospheric tests.

4. How many tests have been conducted (1945-1986)?

United States	803	France	142
Soviet Union	604	China	30
United Kingdom	39	India	1

Note: All figures are approximations as not all tests are announced.

5. Why and how are tests conducted?

In the United States, nuclear tests are conducted:

- A) to test new designs for nuclear weapons
 - frequency = app. 10-15 per year
 - cost = app. \$6 to \$20 million per test
 - mode = in vertical shaft, 600 to 3600 feet deep
- B) to test effects of nuclear weapons
 - frequency = app. twice a year
 - cost = app. \$70 million per test
 - mode = in horizontal tunnels, app. 1000 feet deep
- C) to insure that weapons have not atrophied ("proof testing")
 - frequency = less than once a year
 - cost = app. \$6 to \$20 million per test
 - mode = in vertical shaft, 600 to 3600 feet deep

6. Who conducts tests and designs weapons?

In the United States, the Department of Energy conducts all tests at the Nevada Test Site. All weapons are designed either at the Lawrence Livermore National Laboratory in California or the Los Alamos National Laboratory in New Mexico, both of which are managed by the University of California. Sandia National Laboratory, also in New Mexico, designs some of the non-nuclear components for the nuclear weapons.

7. What treaties have been signed on testing?

- A) The Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water. Also referred to as the Limited Test Ban Treaty (LTBT) or the Partial Test Ban Treaty (PTBT). Signed since 1963 by over 100 countries including the United States, the Soviet Union, and the United Kingdom, it prohibits testing anywhere but underground.

- B)** The Treaty on the Nonproliferation of Nuclear Weapons (NPT). Opened for signing in 1968, now includes 127 signatories, among which are the United States, the Soviet Union, and the United Kingdom. Non-signers include, among others, Israel, South Africa, India, and Pakistan. Recalls in its preambular language the commitment in the LTBT to stop nuclear testing completely.
- C)** Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Underground Nuclear Weapon Tests. Also referred to as the Threshold Test Ban Treaty (TTBT), it prohibits any test underground from exceeding an upper limit of 150 kilotons. Bilateral treaty signed only by the United States and the Soviet Union. Not yet ratified.
- D)** Treaty Between the United States of America and the Union of Soviet Socialist Republics on Underground Nuclear Explosions for Peaceful Purposes. Also referred to as the Peaceful Nuclear Explosions Treaty (PNET), it sets conditions under which explosions for peaceful purposes can occur, prohibiting any single explosion from exceeding 150 kilotons and establishing inspection of group explosions when the aggregate yield is greater than 150 KT. Bilateral treaty signed only by the United States and the Soviet Union. Not yet ratified.

A History of Test Ban Negotiations

The First Years

Support for a comprehensive test ban can be dated even from before the first nuclear test was conducted. Scientists on the Manhattan Project had worked on splitting the atom in the fear that Nazi Germany would do so first. When the war against Germany ended, some felt that there was no need to continue the project. Such views were definitely a minority opinion, however, and the first nuclear test, code-named *Trinity*, was successfully conducted on July 16, 1945.

President Truman then introduced the idea of international control of the atom but a number of issues associated with the outbreak of the Cold War prevented agreement. Convinced that any international control agency would be dominated by the U.S., would be a front for U.S. espionage activities and would only serve to guarantee the U.S. monopoly on atomic energy, the Soviets insisted that before a control body could be established, the use and production of nuclear weapons would have to be outlawed. The U.S. stuck to its position that an inspection and control system would have to precede a treaty. There the debate bogged down, focused more on the weapons themselves than on testing.

With the explosion in 1954 of *Bravo*, the largest thermonuclear test to that date, opposition in the U.S. to nuclear testing became more general and vocal. The fallout from that test killed a Japanese fisherman and alarmed the world over the burgeoning destructive power of the atom. President Eisenhower was sensitive to the dangers of unbridled nuclear testing and by the middle of his second term was prepared to accept some form of control over weapon testing.

The Geneva Negotiations

A critical problem in any test ban would be the issue of verification. A conference of experts was convened in the summer of 1958. Based on evidence from a U.S. test code-named *Raintier*, the experts concluded that seismic events could be verified down to a 4.75 magnitude, thought to be equal to a 5 KT explosion (through later testing it was found to be closer to 19-20 KT). With that evidence in hand, the U.S. and the

U.S.S.R. prepared for the Conference on the Discontinuance of Nuclear Weapon Tests. On August 22, 1958, Eisenhower announced that the U.S. would halt testing unless the Soviets tested first. The moratorium would be for a period of one year beginning on October 31, 1958, the day the conference was to begin in Geneva, and was intended to help the atmosphere of the negotiations. Premier Khrushchev responded that the Soviets would do the same so long as the Western powers refrained from testing.

The talks made little headway but in 1959 Eisenhower extended the moratorium through December 31, 1959. Before the end of the year, he announced that the U.S. was relieved of the obligation to continue the moratorium, but that the U.S. would honor it for the time being. No test would be conducted without prior notice. On February 13, 1960, the French tested their first atomic bomb and with the U-2 incident in May of the same year, the talks broke down.

Upon assuming the Presidency, John F. Kennedy continued the Eisenhower policy but on September 1, 1961, citing French testing, the Soviets broke out of the moratorium. They launched a series of 30 tests in 60 days. Kennedy later remarked that it was clear that the Soviet program, "had been secretly under way for many months." The U.S. response was delayed as preparations to resume testing had not been made. When the response came, it was thunderous. In 1962 alone, the U.S. conducted close to 100 tests, almost one-third the total U.S. tests in the 17 years since *Trinity*.

The end of 1962 was marked by the Cuban Missile Crisis. Despite his misgivings about the Soviet test program which followed the moratorium, Kennedy came away from the Cuba crisis sobered by how close the world had come to nuclear war. In 1963 he sent a personal letter to Khrushchev proposing that senior representatives meet to try once more to work out a treaty. Khrushchev agreed and the U.S. sent Averill Harriman to Moscow to seek a CTB. When the Soviets argued for only a partial ban, which had initially been proposed under Eisenhower, the U.S. accepted. Within 10 days, an agreement was reached and the Limited Test Ban Treaty was signed.

The Nonproliferation Treaty

After the signing of the Limited Test Ban Treaty in 1963, attention in the arms control community as well as in Moscow and Washington shifted to other arms limitation measures. The LTBT had effectively quieted public concern about atmospheric radioactive fallout and with the massive involvement of the United States in the Vietnam War some two years later, popular attention within the United States, which had been a strong factor in U. S. decisions regarding testing, shifted to that issue. At the same time, the explosion of an atomic bomb in October 1964 made China the fifth member of the nuclear weapons club. Attention then shifted to the proliferation of nuclear weapons to new states; efforts in Washington, Moscow and London were then concentrated on formulating a nuclear nonproliferation treaty.

From the point of view of some states not possessing nuclear weapons, the opening of the NPT for signatures in 1968 was somewhat hypocritical. The Treaty discriminated against nuclear "have-not" states by disallowing them the nuclear weapons that were so clearly a significant element for security in the nuclear "have" states. In effect, the NPT suggested that the addition of a single nuclear bomb in the hands of a new state was more important than the addition of another 100 in the hands of the United States or the Soviet Union.

The genesis of the test ban-related sections of the treaty is worth recalling. When the United States and the Soviet Union introduced the draft treaty, it contained no test-related language. The non-nuclear states proposed including language within the treaty calling on the signators to end all nuclear testing. Both the U.S. and the U.S.S.R. rejected that proposal and countered with an offer to include Article VI. The non-nuclear states accepted that compromise so long as language concerning a test ban was included in the preamble. Thus it came about that the preamble included a recollection of

the determination expressed 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 that end.

Article VI of the Treaty explicitly called on signators

... 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.

It should be added that when it came time for states to decide whether or not to ratify the NPT, the U.S. argued that each state should independently decide whether or not it was in its own interest to do so. With almost 130 nations now having signed the treaty, it has become apparent that notwithstanding its inherent discrimination, the NPT has been accepted by most states as a worthwhile bargain.

In the minds of many, however, Article VI established a quid pro quo: non-nuclear signators agreed not to proliferate but the nuclear states agreed to negotiate an end to testing and nuclear disarmament. In keeping with that agreement, the U.S. and the U.S.S.R. focused their energies in the early 1970s on strategic arms limitations and anti-ballistic missile system limitations. Agreement was reached in 1972 that quantitative limits would be placed on their strategic weapons and that neither side would emplace more than two ABM systems.

The Threshold Test Ban

In 1974, the U.S. and the U.S.S.R. took a further step with the signing of the bilateral Threshold Test Ban Treaty. The TTBT was in some senses a corollary to the Limited Test Ban Treaty. Just as the LTBT had represented a willingness to achieve the possible, so too did the TTBT achieve the possible, though it still fell short of ending tests. It set a limit for testing nuclear weapons at 150 kilotons; although the explanation for why a figure of 150 KT was chosen remains part of the classified literature, it was not chosen purely for ease of verification. The problem of verification lay in uncertainty in yield measurement; it was concluded that the uncertainty associated with a threshold of 150 KT could be tolerated.

An issue that would later contribute to Reagan Administration opposition to the TTBT was the "factor of two." At the time of the signing, it was believed that a factor of two uncertainty in yield determination would apply to any tests. What this meant was that a test measured at 150 KT might in fact have been as low as one-half that yield (75 KT) or as high as twice that yield (300 KT). This is due to statistical uncertainty associated with test monitoring as well as the uncertainty in converting seismic magnitude measurements (when a test yield is unknown) into yield estimates.

Another element of the TTBT is called the "whoops" factor. This is contained in an understanding appended to the TTBT which was not included as part of the original TTBT negotiations. It appears technically unsophisticated and may have been added to satisfy political misgivings both about what the treaty would and would not allow and about what could or could not be detected. It allowed for one or two slight, unintended breaches of the 150 KT threshold per year; such breaches would not be considered cause for withdrawing from the treaty but would be "cause for concern."

One other problem was left unresolved as well. The Soviets still wanted to test peaceful nuclear explosions which might exceed 150 kilotons. The U.S. had conducted a PNE program in the 1950s and 1960s but had concluded that it was not a fruitful engineering or research avenue. The U.S. was also opposed to PNEs since there is no essential distinction between the technology of nuclear explosions intended for peaceful purposes as opposed to weapon purposes. The two sides agreed to defer the issue to another set of negotiations.

The timing of the acceptance of the TTBT is important from the point of view of American domestic politics. It was signed almost exactly one month before Richard Nixon resigned from his Presidency, a time when he was clinging to the symbols and vestiges of power, still hoping that they would suffice to keep him in the Oval Office. His first administration had culminated in the signing of the SALT and ABM agreements, but his second had been bedeviled by obstacles to strategic accord as well as the mushrooming effects of the 1972 break-in at the Democratic National Committee headquarters. Frustration both with the failure to make headway on strategic arms limits and the tightening noose of the Watergate scandal encouraged him to assign his negotiators the task of negotiating what was, in effect, a modification of the TTBT. Within five weeks, the negotiators reached an agreement and on July 3, 1974 Nixon and General Secretary Brezhnev signed the treaty.

The Peaceful Nuclear Explosions Treaty

The separate negotiations on peaceful nuclear explosions (PNEs) began in October 1974 and ended in April 1976. The negotiations were very difficult and the protocol appended to the PNET exceeded the length of the treaty by a good margin. It allowed for on-site inspections of group explosions where the aggregate yield exceeded 150 KT. During such inspections, the

inspectors would be allowed access to the explosion site, use of monitoring equipment, ease of travel, photography, communication, certain privileges and immunities, and housing facilities.

Again, as with the TTBT, these provisions were only to take effect when the treaty was ratified. Both treaties were in fact submitted to the Senate for ratification by President Ford in 1976. But with a fight on his hands for the Republican nomination against Ronald Reagan, Ford found himself in no position to push the Senate for action. They languished until the election process could run its course in the Fall of 1976.

The Comprehensive Test Ban Negotiations

When Jimmy Carter became President in January, 1977, he moved quickly to begin negotiations on a CTB. Efforts to ratify the TTBT and PNET might have turned into a premature debate on CTB so Carter made no effort to push for ratification. A CTB would have made moot certain aspects of the TTBT and the PNET anyway. The Carter arms control policy began on an inauspicious note, however, when the Soviet Union rejected his initial deep cuts proposal on strategic arms limitations, tendered in Moscow in March 1977. The Soviets did agree to begin talks on a CTB which began between the U.S., the Soviet Union, and Great Britain in the fall of 1977.

The U.S. expected that PNEs would be a problem in these talks. But on November 2, 1977, Brezhnev announced that the Soviet Union would honor a moratorium on PNEs for the duration of a CTB. But although that issue was resolved, the steam went out of the CTB engine fairly early. Some participants argue that it was Carter's lack of leadership that impeded progress while others suggest that the bureaucracy greatly complicated the problem. In any event, it is clear that the Joint Chiefs of Staff, the Department of Energy, and the leaders of the nuclear weapons laboratories at Livermore and Los Alamos were opposed to a CTB.

Although the Joint Chiefs did not initially oppose a treaty, by the middle of 1978 they were working against it. Speaking for Secretary of Energy James Schlesinger in August 1978, Assistant Secretary of Energy for Defense Programs Donald Kerr (later appointed Director of the Los Alamos National Laboratory) suggested at a Committee on Armed Services hearing on the

effects of a CTB that a shorter CTB would be better and

a treaty that had zero-length . . . would certainly minimize the risks from our weapons development point of view.

Though other participants discount his influence, the Director of LANL at the time, Harold Agnew, later commented that,

I met with President Carter for almost two hours on the (Comprehensive) Test Ban Treaty . . . together with Livermore's Roger Batzel. We influenced Carter with facts so that he did not introduce the CTB, which we subsequently learned he had planned to do. There's no question in my mind that Roger and I turned Carter around because we incurred so many enemies from the other side!

The basis for opposing the CTB was a conviction that the reliability of U.S. strategic weapons would deteriorate and thus erode U.S. national security, as well as a lack of confidence in seismic verification of such a treaty. In any case, this internal opposition had the effect of shifting Administration emphasis from a CTB of infinite duration to a treaty of 5, and then 3 years time. Although these changes were proposed in order to placate domestic critics of the treaty, they were never coupled to actual support for a treaty. The critics effectively undercut the process without being forced to commit themselves to support a treaty once the offer of a shorter duration was made.

The CTB was clearly part of Carter's arms control program but the flagship of that program was SALT II. As those negotiations ran into problems related to fractionation, definitions of launchers, and conventional vs. strategic weapons (e.g., the Soviet Backfire bomber and U.S. cruise missiles), it became clear that CTB would take a back seat to these larger SALT issues. Thus even before the Soviets invaded Afghanistan in December 1979, CTB was slowing down. Significant progress had been made, in particular the Soviet and American agreement to accept 10 in-country seismic stations and the provisions for challenge on-site inspections. But the capture of the American embassy in Teheran and the invasion of Afghanistan made further progress totally impossible.

Reagan Withdraws from CTB

Candidate Reagan had opposed SALT II as a fatally flawed document. His team of arms control advisors included Paul Nitze and Eugene Rostow, who were prominent among

SALT's domestic opponents as members of the Committee on the Present Danger. The CTB was considered to be equally objectionable and in July, 1982, it was formally tabled. Administration spokesmen argued that, "At present we cannot effectively verify the TTBT and the PNET." If verification of explosions as high as 150 KT was questionable, verification of a total ban would be impossible. The U.S. claimed that the Soviets had exceeded the 150 KT threshold perhaps as many as 11 times since 1978. The Reagan Administration therefore concentrated on trying to convince the Soviets that improved verification measures would have to be adopted before the TTBT and PNET could be ratified. A CTB remained in the long-term interest of U.S. foreign policy but would have to await resolution of the verification issue.

Rapid changes in the Soviet leadership in the first years of Reagan's Administration (Brezhnev died in 1982, Andropov in 1984, and Chernenko in 1985) had complicated any sustained Soviet arms control efforts. But with Mikhail Gorbachev came younger and presumably hardier leadership. Within his first 6 months in power, he announced a unilateral cessation of Soviet nuclear testing from August 6, 1985 through December 31, 1985. This moratorium was subsequently extended through March 31, 1986 and then again indefinitely unless the U.S. tested first. The U.S. did indeed test on March 23, 8 days before the moratorium was scheduled to expire but after the offer of an indefinite moratorium. This did not count against Gorbachev's final extension, however, which only came into effect after March 31. Thus, in Gorbachev's words, the U.S. would have "another chance." Reagan still declined to join a moratorium; the U.S. tested again on April 10, prompting the Soviets to announce that although they remained prepared to negotiate a CTB, they would end the moratorium.

On May 14, Gorbachev announced that the moratorium would continue through August 6, 1986 and again called on Reagan to join it.

Verification Issues

Verification of a comprehensive nuclear test ban is perhaps the most contentious issue involved in both the decision to enter into negotiations as well as the negotiating process itself. The U.S. has consistently feared that without adequate verification, the Soviets will be free to cheat; on the other side, the Soviets have consistently feared that the U.S. wishes to verify in order to conduct espionage. Verification can be done with national technical means (NTM), principally space-based photo-reconnaissance satellites and seismic stations outside the other's territory; with seismic monitoring stations within the other's territory; and with on-site inspections (OSI).

National Technical Means (NTM)

It had been understood in all U.S. — U.S.S.R. negotiations that NTM would be allowed and accepted as part of verifying compliance with treaties. National technical means include reconnaissance satellite photography and seismic monitoring. Satellite photography is helpful for both the TTBT and PNET in that one could observe preparations on the ground for a test. Large pieces of equipment usually would have to be moved into place, substantial digging would be done, and for many tests a subsidence crater would be formed after a weapon was exploded. Subsidence craters may be formed when the explosion vaporizes and compacts subterranean matter, in effect leaving a hole that is then filled in by the earth collapsing from above. In addition to satellite photography, seismic stations set up in third countries or on one's own territory are also important national technical means of verification. But seismic verification of a TTBT differs from seismic verification of a CTB.

Seismic monitoring and the TTBT

Seismic monitoring stations used to monitor Soviet tests are designed to determine the yield of an explosion from the magnitude of the explosion. They are calibrated from numerous explosions at the Nevada Test Site (NTS) as well as from earthquakes around the world. Although the stations are designed to monitor Soviet testing, a problem arises when the U.S.

extrapolates from this body of data to the Soviet case. The problem arises from the fact that Nevada is geologically younger and more seismically active than is Semipalatinsk, where the Soviet Union conducts its nuclear tests. Since Semipalatinsk is older and more stable, seismic waves generated by an explosion there propagate with less attenuation than in Nevada. In geologists' terms, the explosion is tightly coupled to the underlying rock formation. A given yield at Semipalatinsk at large distances will transmit a larger seismic signal than would the same shot at NTS. Therefore, U.S. seismic monitoring stations are off by a certain margin (estimated at 20%) and produce data that translate into a higher test yield than what actually was detonated.

Seismic monitoring and a CTB

Seismic monitoring of a comprehensive test ban would be complicated by the possibility that nuclear tests could be conducted and yet go undetected. It has been argued that a nuclear test could be hidden in two ways.

What was once called the big hole theory argues for the detonation of a nuclear weapon inside a large hole or underground cavern. By thus separating, or decoupling, the explosion from the underlying rock, a nearby seismic monitoring device would read the seismic event as an earthquake rather than a nuclear test. The chances for success in this effort could be enhanced by locating the hole so that the waves from the explosion would follow a path to the monitoring device through a region that absorbs seismic energy. Decoupling can reduce the seismic magnitude by about a factor of 100 over a coupled shot.

Critics of this argument find it implausible for two reasons. First, in order to conduct such a clandestine test in a natural cavern, it would be necessary to ensure that the cavern did not collapse as a result of the test and did not have any fissures to the surface that would vent radioactive material after the test. In addition, the technicians and equipment that would gather to conduct the test would have to be disguised to prevent identification by spaced-based reconnaissance satellites.

The second objection is that if such a test were to be conducted in a man-made hole, it

would not only be necessary to disguise the technicians and equipment, it would also be necessary to hide the vast amounts of dirt that would have to be dug out to make the hole. This problem could be avoided if the would-be cheater were to excavate a salt area. Then the salt would merely have to be dissolved with water and the brine eliminated. Such salt caverns have been excavated by the U.S. in Louisiana for the Strategic Petroleum Reserve. These cavities tend to be irregular and they are therefore not optimal for testing. Again, hiding technicians and equipment that would gather for a test from satellite photography would remain a problem.

A second suggested means to hide an explosion would be to conduct the test against a background of noise, such as an earthquake, that would inhibit the seismic monitoring station from getting a true reading of the event. This could be done in two ways. The cheater could wait for a very large earthquake that would knock the seismic monitors out of commission for a short period of time, and then promptly conduct the test. Alternately, he could pre-emplace a decoupled test weapon in a seismically active area, wait for a smaller earthquake and explode against the background of that noise.

Again, critics are unpersuaded by this scenario. It would call for establishing a seismic array that would identify an earthquake in the right location and of the right size to allow firing a device that had been implanted and waiting. Although perhaps technologically feasible, this has never been tested and would call for extraordinary luck and evasiveness.

Seismic Monitoring Stations

Seismic monitoring stations inside the other state were included on the agenda of the 1958 Geneva negotiations. At those talks, the Soviets agreed to establishing manned stations to monitor compliance with a test ban. The U.S. initially wanted 21 such stations but later dropped the number to 19. The Soviets were prepared to accept 15. After the negotiations broke down, the question shifted from manned to unmanned stations. Kennedy proposed installing 7 such "black boxes" while Khrushchev held out for only 3. The logical compromise of 5 was never struck.

This issue of seismic stations within the other's territory did not surface again until the CTB negotiations under Jimmy Carter. The TTBT and PNET did not require such in-country

stations. During the negotiations in the late 1970s, however, the U.S. suggested as an additional verification means that each side accept 10 unmanned seismic stations within its territory. The U.S. and the U.S.S.R. accepted this but the British refused, arguing that there should be only one on the British Isles. Given that Britain had conducted fewer than 20 tests since the LTBT had been signed in 1963 (all in Nevada) and given the gross disparity in the sizes of the states, London appeared to be taken aback by Soviet insistence that each state must take 10 and by the locations selected. Among the 10 sites specified were Pitcairn Island, which has no harbor and practically would have necessitated wading ashore to emplace the box; the Falklands Islands, whose ownership was in dispute; and Hong Kong, which no doubt would have perplexed and outraged the Chinese. This issue, as well as specifics regarding what kind of data could be gathered, how it would be transmitted, and where the boxes were to be manufactured, was left unresolved when the negotiators were recalled in 1980.

One possible solution to the problem of verification raised by the Reagan Administration may lie in these unmanned seismic stations within the other's territory. Jack Evernden and Lynn Sykes have proposed focusing on the surface waves that are propagated by earthquakes and nuclear tests, rather than the P waves that go through the earth's body and that are usually used for monitoring compliance. They argue that nuclear explosions emit far higher frequencies than do earthquakes and therefore provide a better discriminant between the two, regardless of magnitude and yield. But detecting these higher frequencies depends on regional seismic monitoring as they do not travel great distances. In order to be confident of identifying decoupled as well as coupled shots, it might be necessary to emplace up to 25 black boxes in the Soviet Union; more conservative estimates suggest the figure may be closer to 30. Requiring the Soviets to accept that many stations might guarantee that future CTB negotiations would be stillborn.

On-site Inspections

On-site inspection has proven to be the thorniest verification problem in U.S. — U.S.S.R. negotiations. Early in the 1958 talks, the United States introduced a draft treaty that would have included an average of 20 on-site inspections per year; the Soviets countered with an offer of 3. After the talks broke down and

then resumed, the Soviets first withdrew, and then reiterated their offer of 2-3 visits. The U.S. in turn reduced its number, first to between 12 and 20, and then to 7. There was also a problem at this time over when such visits could take place. The U.S. argued for inspections by a neutral administrator whenever an ambiguous event took place. The Soviets favored a three-member council, one of whom would be a Soviet, and which would work on the basis of consensus. Such a system would have allowed the Soviets a veto, which the U.S. would not accept.

When negotiations for a comprehensive treaty finally broke down and Kennedy accepted only a partial test ban, on-site inspections ceased to be a problem. OSIs were unnecessary to detect atmospheric, under water, or space tests. Similarly, the TTBT posed no problems that required OSIs. A 150 KT threshold was considered verifiable without recourse to inspections.

The high-water mark for OSI verification came with the PNET in 1976. During the negotiations, the Soviets were adamant about including provisions for group explosions that would exceed the TTBT limit of 150 KT. From the U.S. point of view, it would be extremely difficult to ascertain in such group explosions whether any one of them exceeded 150 KT. The Soviets finally asked whether the U.S. would accept group explosions if there were a way to verify that no individual explosion exceeded 150 KT. The U.S. agreed and the Soviets proceeded to explain how instruments to measure ground motion could be located at the test sites. When questioned as to how the U.S. could have confidence in such measurements, the Soviets replied that U.S. personnel could be present to make the measurements. Thus were the provisions for on-site inspections of group explosions established. Designated personnel (the Soviets objected to the implications of the term "inspector") were therefore to be allowed to monitor group explosions, but not single tests. The activities of these designated personnel were carefully circumscribed in the protocol, down to specifying that field glasses *would* be allowed but that photographs would have to be taken by host country personnel, albeit at the direction of the visiting country representative.

The equipment that the Soviets proposed for determining the yield was found by the U.S. to be inadequate; the U.S. proposed instead that an electrical cable be inserted in the test hole. One end of the cable would be near the explosive and the other would be connected to electronic equipment at the surface. The force of the

explosion would crush the buried end while the other end would receive a signal from which the yield could be determined. This process was called the hydrodynamical determination of yield.

OSIs were next considered in the context of the Carter CTB negotiations. Attention then was focused on an on-site inspection scheme that had been promoted by Swedish delegates to the Committee on Disarmament. It suggested that inspections be conducted on a voluntary, or challenge, basis whenever a suspicious seismic event was detected. When presented in the 1960s, the proposal had received support within the UN Committee on Disarmament but had been rejected by the Soviets and the Americans. The U.S. had argued for mandatory inspections, while the Soviets said none at all were needed.

By 1975, the Soviets had swung around to acceptance of the voluntary system and in the CTB discussions they argued that if a suspicious event occurred, the inquiring state could request an inspection. The challenge would have to be supported with data; if the data was insufficient, an inspection could then be demanded. The U.S. finally accepted this argument too, reasoning that the deterrent effect on cheating would be the same under either a mandatory or voluntary system. If the challenged party ultimately refused the inspection, the other side could be strengthened in its conviction that misbehavior had taken place. This refusal could also constitute sufficient grounds for withdrawing from the treaty. The only difficulty in this arrangement was that it placed the burden of proof to some extent on the side presenting the evidence. If the evidence was in any way marginal, it might appear that the challenging side was only looking for an excuse to get out of the treaty.

More recently, President Reagan has introduced a modification of the voluntary system. In a speech to the United Nations in September 1984, he proposed that the Soviet Union send observers to monitor a U.S. nuclear test. Although that invitation was declined, in a private letter to Reagan on December 5, 1985 Mikhail Gorbachev indicated that he was prepared to accept "certain measures of on-site verification to remove the possible doubts about compliance with . . . a moratorium." Reagan continued to refuse to commit the U.S. to a moratorium and repeated his invitation for an on-site inspection. On March 14, 1986 he tried to make the invitation more attractive by proposing the use of a "new" on-site monitoring device called CORRTEX (for Continuous Reflectometry for Radius versus Time Experiment). This has

been in use for some time and is effectively the same kind of device that was proposed for use in PNET inspections. Again Gorbachev demurred, no doubt wary of committing the Soviets by way of example to a reciprocal inspection.

The Reagan offer varies from the PNET on-site inspection provisions since they applied to peaceful explosions while this offer is to inspect an actual weapon test. For the Soviets, CORRTX is meaningless since it is useful for monitoring tests and what they seek is a ban on all tests.

The Political Dimension of Verification

Verification of the TTBT is clearly a different matter from verification of a CTB. But the implication of the Reagan Administration position has been that until the U.S. is confident of verification of the TTBT, there can be no forward movement on a CTB. But as challenges to Reagan's claims about Soviet compliance have increased, Administration representatives have begun to suggest that something more than verification lies behind opposition to the CTB. Arms Control and Disarmament Agency Director Kenneth Adelman commented in October 1985 that even if verification of the TTBT and PNET were possible, "verification is not the only stumbling block to an agreement." In addition, Richard Perle, the influential deputy to Defense Secretary Caspar Weinberger added recently: "I'm opposed to a comprehensive test ban even if it were verifiable."

Reagan himself has tried to upgrade what verification means by calling for "effective," as opposed to "adequate," verification. President Nixon defined what he meant by "adequate" verification when the SALT negotiations began:

. . . whether we can identify attempted evasion if it occurs on a large enough scale to pose a significant risk, and whether we can do it in time to mount a sufficient response . . . is what I mean by the term "adequate" verification.

This definition had been accepted until Reagan took office. Reagan has not clarified the difference between the two terms but what was acceptable before is no longer acceptable.

Both the vagueness of Nixon's definition and Reagan's inability to sharpen the distinction in definitions serve as reminders that 100% verification will be impossible. Small explosions at or below one KT may be conducted and may go undetected regardless of the monitoring equipment. Inertial confinement fusion research on the peaceful applications of thermonuclear energy can be conducted within laboratories at very low yields. Such tests clearly

cannot be monitored. At the same time, it is conceivable that larger explosions could be hidden as described above. What is clear is that there will always be an irreducible minimum of risk involved in any decision to stop nuclear testing. Seismologists will not guarantee that if ever the Soviets detonate a bomb, it will be detected. The decision on whether to go ahead with a CTB therefore cannot be made purely on verification grounds. It is a political decision based on political calculations of national security and international stability. A CTB thus can go forward only when it is decided by politically responsible persons that the possible arms control benefits of a CTB (calculated in terms of nonproliferation and arms race avoidance) outweigh the probable security risks of doing so (calculated in terms of Soviet evasion and a freeze on modernizing weapons).

It is important finally to consider the following point. If a CTB is signed, it will be very difficult for the Soviets to evade its terms; they will have to go to extreme lengths to do so successfully. U.S. monitoring is now very good and will get much better. If it is the Soviet wish to continue testing, why then do they not simply accept President Reagan's reasoning, go along with the postponement of the negotiations, and test whatever weapons they choose under the limits of the TTBT?

Compliance Issues

A Background of Suspicion

Soviet sincerity with respect to international agreements has been questioned within the United States at least since the end of World War II. This general mistrust was fueled in 1961 when the 1958-1961 nuclear test moratorium was terminated by the Soviet Union. From the U.S. point of view, it was incredible for the Soviet Union to use French testing as a reason for arguing that the Soviet Union was not the first to break the moratorium. From the Soviet point of view, it may have been felt that the French test program allowed the West to gain certain security advantages unilaterally. The scale of Soviet testing and the size of the weapons tested immediately after the end of the moratorium in 1961 is convincing proof for many that the Soviet Union had been ready to break it for some time. What should be remembered, however, is that although the Soviets did break the moratorium, the U.S. test program between the end of the moratorium and the LTBT exceeded the Soviet program, measured in total number of tests. In any case, Soviet behavior at that time chastened a number of those who would have given the Soviets the benefit of the doubt, while it reinforced the disinclination to trust the Soviets of those who saw in their behavior a constant threat to American interests.

Questions from the Reagan Administration

The question of Soviet compliance with the TTBT had been raised under the Carter Administration but it was given greater prominence when Reagan became President. The concern was that the Soviets had exceeded the TTBT limit of 150 KT. In a February 1982 column on the American decision to withdraw from negotiations on a CTB, Jack Anderson, citing leaked Administration sources, "revealed" that at least 11 Soviet tests had exceeded the 150 KT threshold. The State Department later issued a report alleging that

Soviet nuclear testing activities for a number of tests constitute a likely violation of legal obligations under the Threshold Test Ban Treaty of 1974.

The Administration therefore decided to seek changes in the TTBT and PNET based on the argument that their verification provisions were inadequate.

The Reagan Administration thought it was making headway in arms control by proposing action on these two unratified treaties. Instead, a storm burst over the basis for the request. Was the Soviet Union complying or not?

Technical Answers

Most scientists felt that the Reagan argument was weak. Eugene Herrin, chairman of the advisory panel on yield estimates to the Defense Advanced Research Projects Agency, argued that

... from a scientific, technical point of view, the evidence is insufficient to assert that the Soviets have been cheating — certainly in no more than a very, very few cases — and even then not with a high degree of confidence.

Donald Springer, deputy manager of Livermore's seismic monitoring program noted that

... most people in my laboratory believe that the evidence is equivocal. The military and the Administration just want to believe the worst.

Warren Heckrotte, an advisor at both the TTBT and PNET negotiations, summarized the conclusions of a study of seismic data of Soviet high yield tests between March 31, 1976 and December 31, 1981 as follows:

... the distribution of seismically measured yields of Soviet weapons tests is not inconsistent with Soviet observance of the 150 limit. However, the distribution is also not inconsistent with a distribution of actual yields in which there are some events above 150. This reflects the statistical nature of the problem.

The evidence was ambiguous and provided little support for the Reagan decision.

The Soviet Response

For their part, the Soviets responded with a report noting that if the two treaties had been ratified, the exchange of data called for in their protocols would have taken place and American uncertainties would have been dispelled. What was the solution? Ratify the treaties, exchange the data on test site geology, exchange sample

test data to calibrate accurately the national seismic devices, and therefore verify that the Soviets were complying. If after calibration there were any doubts, they could be raised within the normal forum for such disputes.

Those who suspected the Soviets, however, countered that the data exchanged would itself be questionable: how would the U.S. know that the Soviets weren't doctoring the data? The response is twofold. Regarding the geological data, the U.S. clearly knows enough through its own means to determine whether the Soviet data was bad; the sample yield issue was not so clear. The sample test data selected by the Soviets could be completely accurate but atypical. It could reflect tests that did not lie close to the least-squared line that one would draw to characterize an array of nuclear tests. Choosing higher magnitude tests that exceeded that line would give an erroneous norm for actual Soviet yields.

The Adjustment Factor

The compliance dispute continued at a meeting of the American Geophysical Union in 1983. Lynn Sykes and Ines Cifuentes, of Columbia University's Lamont-Doherty Geological Observatory, argued that the estimations of Soviet testing by the Reagan Administration were systematically overstated, as they included too small an adjustment for the hard rock through which the seismic waves from the Soviet tests propagated. The main Soviet test site at Semipalatinsk is geologically older and harder than the U.S. Nevada test site, the only other available location for calibrating American seismic instrumentation. Ralph Alewine and Thomas Bache, speaking for the Administration as members of DARPA, argued that the kind of adjustment called for by Sykes and Cifuentes would be, "inconsistent with the best available geophysical evidence." They defended the conclusion that Soviet tests had exceeded the 150 KT limit. Sykes responded in a letter written with Jack Evernden, a member of the U.S. Geological Survey (USGS). They argued that the Alewine/Bache argument was based on uncorrected data taken from preliminary estimates of magnitudes from USGS; such an approach, they contended, was scientifically unacceptable.

Despite the legitimate question about the Soviet data, the debate on how much to adjust in order to get a more accurate seismic reading would be better informed with the ratification of the TTBT. The Administration was unimpressed and reiterated its point in a report in February

1985 arguing that, "a likely violation of legal obligations" under the TTBT had taken place.

In an apparent departure from this Administration conclusion, the CIA announced one year later in March 1986 that it was changing the way it measured Soviet tests in order to build in a larger adjustment than previously used. The prior, presumably erroneous measure would have overestimated Soviet yields by about 20%. Although this CIA decision has not closed the debate, it adds one more argument against the Reagan Administration case for Soviet noncompliance with the Threshold Test Ban Treaty.

Reliability of Stockpile

Early Concerns

The argument that a comprehensive test ban would seriously restrain U.S. weapons development was raised as early as 1954 with President Eisenhower as a reason not to halt testing. The reliability of the nuclear stockpile became an issue, however, only after the 1958-1961 moratorium between the United States and the Soviet Union. Once the moratorium was over, it was possible to resume testing and therefore to explore the designs that had been introduced, without benefit of testing, into certain of the weapons. Before the moratorium began, Edward Teller, Director of the Lawrence Livermore Laboratory had noted that

we . . . hope to be able to make some advances which are essential and which at the same time are so cautiously planned that in case of continued moratorium the corresponding weapons can be put into stockpile without testing.

In fact, certain new designs proved to be inadequate and had the moratorium continued, questionable weapons might have been added to the stockpile.

Donald Kerr and Roger Batzel, former Directors of the Los Alamos and Lawrence Livermore National Laboratories, later argued that in the case of the W45 warhead, it was discovered after 1961 that in fact the designs introduced were inadequate, as the weapon detonated at only half its rated yield. This issue did not serve as a deterrent to the subsequent negotiations on the Limited Test Ban Treaty, the Threshold Test Ban Treaty, or the Peaceful Nuclear Explosions Treaty since none of those treaties had the effect or the intent of preventing either side from conducting nuclear weapons tests.

The Issue Today

The issue re-emerged, however, under the Carter Administration when formal negotiations took place with the objective of ending all testing. Hearings were held before the House of Representatives Committee on Armed Services on "Effects of a Comprehensive Test Ban Treaty on United States National Security Interests." Then Assistant Secretary of Energy for Defense Programs Donald Kerr suggested six basic

merits to testing as it related to the nuclear weapons' design. Testing was important, he argued, to: 1) improve yield-to-weight ratios; 2) reduce warhead cost and special nuclear material usage; 3) enhance warhead safety; 4) increase weapon control to prevent unauthorized use; 5) tailor weapon outputs to specific military needs; and 6) understand long-term chemical and structural stability.

Points 1, 2 and 5 relate to the continued employment of nuclear weapons in other than purely deterrent roles, which a comprehensive test ban would seek to avoid.

Currently, the yield to weight ratio is very efficient. Testing has allowed the U.S. to develop a 200 KT warhead that weighs 270 pounds; early 20 KT warheads weighed as much as 4,000 pounds.

If there are to be no new additions to the nuclear stockpile, then the cost of future weapons becomes a moot point. But without new weapons, old ones would have to be fitted onto new delivery vehicles which is not cost-efficient.

Finally, there would be no need to tailor nuclear weapons to specific military needs if the U.S. chose not to rely on nuclear weapons for military ends. In effect, a CTB would force the U.S. and the Soviet Union to rely on nuclear weapons exclusively for deterring their use by the other side, rather than for waging war against each other.

Point 3 is an important consideration. Although the weapons in the stockpile are designed not to go off by accident and are considered to be very safe, it is still possible that an accident could cause plutonium to spread. On the other hand, the experience of the crash of a U.S. plane carrying nuclear weapons in Spain, of their not detonating, and of their subsequently being recovered without major contamination is not one that should be repeated. But it is a reminder that warhead safety is already robust.

Point 4 is certainly a significant concern. Given the threat of terrorism against the United States, it is imperative that no unauthorized persons be allowed access to nuclear weapons. The permissive action links which now prevent unauthorized use are not built into the design of the weapon, however, and therefore tests need

Effects of a Comprehensive Test Ban

On Humans

We may be unaware of certain long term consequences of the nuclear testing conducted prior to the 1963 limited test ban, but since 1963 underground nuclear testing has not physically affected humans to any great degree. As the Soviet Union, the United States, and the United Kingdom were the only states conducting extensive testing at the time, once their tests moved underground, atmospheric fallout was virtually eliminated.

The French continued to test in the atmosphere until 1976, but conducted only 41 atmospheric explosions up to that time, fewer than the U.S. had conducted in 1958 alone. The Chinese continued to test in the atmosphere through the 1970s but recently stated that they would no longer test in the atmosphere. With only 30 tests conducted overall (21 in the atmosphere) since 1964, that program too has had a negligible effect on the world population (although we do not yet know if there have been harmful effects within China).

At the U.S. test site itself, however, there is a greater danger to humans. Officials at the Nevada Test Site report that 62 radiation accidents have occurred since the LTBT was signed (out of a total of approximately 400-450 tests in that time). Of these, 24 produced enough radiation for some to be carried off in the wind while 9 were actual ventings of radiation, defined by the government as a "massive release of radiation."

The most recent venting was on December 18, 1970, from a test code-named *Baneberry*; the radiation was tracked as far away as North Dakota. Two widows of workers unsuccessfully sued for wrongful death, alleging that their deceased husbands had contracted leukemia and died as a consequence of the *Baneberry* leak.

Although they have not been measured, the psychological effects of nuclear testing may be substantial. Senator Charles McC. Mathias, Jr. has argued that,

... a (CTB) would respond to the need of humanity for hope that the scourge of nuclear weapons may be banished from the Earth.

Recent attitudinal studies of school children have indicated a certain inchoate fear and psychic numbing connected with the threat of

nuclear war. Thus to the extent that a test ban is linked in the public mind with movement toward nuclear disarmament, it could relieve psychological stress associated with nuclear weapons.

Regardless of whether a test ban were signed, of course, the weapons would still be available for use and the threat of nuclear war would not disappear.

On Strategic Arms Talks

A CTB will not affect the Geneva arms negotiations primarily because the issue is not strong enough politically to carry START negotiations. It can even be argued that the political capital that one would need to push through a CTB would endanger other items on the arms control agenda. It is thus more likely that a CTB would follow along in the wake of strategic arms limitations. There is a belief within the Reagan Administration that a CTB puts the cart before the horse. So long as American security is built upon nuclear weapons, it makes no sense to forgo the opportunity, indeed the responsibility, to continue improving those weapons. Thus it is extremely unlikely under the current administration that an agreement on a comprehensive test ban would precede an agreement on strategic weapons.

In fact, this was Carter Administration policy as well. Under Jimmy Carter, SALT II and the CTB were negotiated simultaneously. But as problems arose with SALT, the CTB was not used to pave the way for SALT. Rather, the CTB negotiations were downgraded until SALT could get back on track. Once SALT foundered, the CTB negotiations were also allowed to fall apart.

If a CTB preceded strategic arms agreements, it would of course impose qualitative limits on further arms developments; similarly, it might help the atmosphere surrounding such negotiations. But this hypothetical condition has not been met in either this Republican Administration or the last Democratic Administration.

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On the Next Generation of Weapons

There can be no doubt that if a comprehensive test ban were signed, there would be no new generation of nuclear weapons. Testing is absolutely essential for the nuclear weapons laboratories to design a new weapon for the stockpile. In testimony before the House Armed Services Committee's Subcommittee on Arms Control and Disarmament, all witnesses agreed that "no new nuclear weapons should be fielded without testing." Thus depending on when it was signed, a CTB could undermine the development and deployment of the Navy's D-5/Trident II submarine launched ballistic missile as well as mobile intercontinental ballistic missiles. It has recently been estimated that a third generation of nuclear arms (beyond the atomic and thermonuclear generations) might require from 100 to 200 experiments. A number of experiments can be conducted from a single nuclear test. Robert Selden, head of theoretical and computational physics at the Los Alamos Laboratory, suggested

It will take at least that many (experiments). This is a very new thing. The physics processes we're looking at are far more complicated than anything we've looked at before.

John Hopkins, head of weapons technology at Los Alamos, added

The traditional nuclear weapons program is still going to go on as long as we depend on a nuclear deterrent . . . (but it is) very complicated, very long-range, and very speculative as to what (new) systems might be successful and what might not. It's going to go on for a long period of time, for decades.

A comprehensive test ban would clearly prevent such testing and long-range planning.

However, if it were clear that prospects were good for the signing of a CTB, it would be likely that the U.S. laboratories would be asked to produce a more robust design for nuclear warheads, a design that would be less subject to loss of confidence, that would be more easily repaired, perhaps that would degrade less quickly — in short, that might be less sophisticated. Former Los Alamos Director Donald Kerr recently estimated that such a design might take five years to complete.

On the Strategic Defense Initiative

One of the President's stated objectives for the Strategic Defense Initiative is that it be non-nuclear. If this objective can be achieved, then a CTB would have no effect on it. However, things

might not work out that way. Indeed, despite the President's stated wishes, some of the most notorious, if not the most promising, of the ideas currently being explored are based on nuclear explosives. The best known example is the X-ray laser device now being developed at Livermore. In addition, in the past nuclear warheads have also been contemplated for terminal intercepts and it is always possible that they may be considered again for that purpose. A CTB anytime soon would completely eliminate any possibility of proceeding with the X-ray laser and some other even more remote so-called "third generation weapons" as well.

On Anti-Satellite Development

A comprehensive nuclear test ban would not affect the ASAT programs now being developed in the Soviet Union and the U.S. Under President Carter, ASAT negotiations were conducted but, as with the CTB talks, they did not produce agreements and have not been resumed by the United States.

The Soviet ASAT weapon is launched from the ground by a 3-stage SS-9 booster. The weapon itself is about 20 feet long and weighs about 2 tons. It is put into an orbit next to its intended target; after orbiting next to the target, it crosses the target's path, detonates, and the resultant shrapnel destroys the target. It is a non-nuclear weapon whose development would not be hindered by a comprehensive nuclear test ban.

The United States in September 1985 successfully tested an anti-satellite weapon launched from the air by a high-altitude F-15 jet. A 2-stage, 18 foot booster was strapped under the F-15 and launched toward an orbiting satellite. The weapon did not go into orbit but rather was aimed directly at the target. Called a Miniature Homing Vehicle (MHV), it sought out the target using infrared telescopes, a laser gyroscope, and small jets which helped it maneuver. The 1 foot long, 35 pound MHV then slammed directly into the target and destroyed it. This too is a non-nuclear weapon whose development would not be affected by a comprehensive nuclear test ban.

In addition to MHVs, the X-ray laser may prove to be suitable for attacking Soviet satellites. A CTB would prevent the development of the X-ray laser, as the X-rays are pumped by a nuclear explosion in space.

On Nuclear Proliferation

The Issue

There can be no doubt that for many states, there is a clear connection between the Nuclear Nonproliferation Treaty and negotiations toward nuclear disarmament. But it is reasonable to ask whether such negotiations would bring about an end to nuclear proliferation. There are two issues involved: first, whether the nuclear armed signatories do negotiate toward nuclear disarmament and second, whether the nuclear armed signatories cease nuclear testing. As a practical matter, the latter issue has come to be viewed in the international community as a more possible first step; it is unlikely that the nuclear armed signatories will give up their arms, especially given that a number of states that have weapons or may have the capability to develop weapons have still failed to join the NPT (France, China, Israel, South Africa, India, and Pakistan). But an agreement to stop testing nuclear weapons presents fewer risks than would giving up their nuclear weapons. Thus a comprehensive test ban has become the litmus test for the sincerity of the nuclear armed signatories on the issue of stopping nuclear proliferation. It is also reasonable though to ask what effect a comprehensive test ban between the United States, the Soviet Union, and Great Britain would have on nuclear proliferation.

Testing and Proliferation

Two questions therefore must be considered. 1) If a CTB were signed, would France, China, and India also agree not to test? 2) Would a CTB make Israel, South Africa, India, Pakistan, and any other would-be proliferator refrain from continuing or beginning a nuclear weapons program?

If a CTB were signed, the burden of world opinion would be on any state that chose to test. The signing of the Limited Test Ban Treaty in 1963 did not cause France or China to limit themselves to underground testing. But after about ten years, the French did begin testing exclusively underground. Chinese testing is not extensive but it too has recently been confined to underground sites. The only other state to have tested a nuclear device, India, had signed the LTBT and thus conducted its single test in 1974 underground. Thus although France and China never formally committed themselves, they seem to have accepted the international norm of underground testing as codified in the

LTBT. A comprehensive test ban may well have a similar informal effect.

It is arguable whether banning nuclear testing will persuade would-be nuclear states not to acquire their own nuclear weapons. Such states could move in two directions. First, they could choose to develop relatively unsophisticated fission weapons which they could more confidently deploy without testing. Alternatively, they could choose to develop thermonuclear weapons which would require testing. If they chose the fission route, a CTB would have had little effect in stopping nuclear proliferation. If they chose the fusion route, they would then face the opprobrium of a world that had foresworn nuclear testing.

In thinking about future proliferation, it may be useful to consider the incentives that drove the current nuclear powers to proliferate. It is clear that the United States, the Soviet Union, and China were driven by deep insecurities about the possible acquisition and use of nuclear weapons by their enemies. The United States was at war with Hitler's Germany and feared that Nazi development of nuclear weapons would bring about a German victory in World War II; the Soviet Union feared U.S. nuclear capability after that war and responded with its own weapons; China was threatened with American nuclear weapons in the Korean war and Soviet behavior in the late 1950s and responded with nuclear weapons of its own. In the British case, their initial nuclear program began under the same Nazi threat as the American program, although it was completed well after that threat had disappeared. Charles de Gaulle claimed to fear American indifference to an attack on France but was none the less inspired by visions of French *grandeur* that he deemed to be dependent on acquiring nuclear weapons. More recently, Israel's rumored capability apparently stemmed from what appeared to be U.S. indifference to Israeli security following the Suez crisis of 1956 and is couched in the context of Arab neighbors who, by and large, still do not acknowledge Israel's right to exist. The single strongest motivation then for nuclear weapon acquisition among these states appears to be insecurity.

Can we assume that the incentives for new nuclear states will strongly differ from the incentives evident in the known cases of nuclear proliferation? Until the insecurities of would-be nuclear states are eliminated or ameliorated, it cannot be assumed that an international norm of not testing would be sufficient to prevent would-be nuclear states from acquiring nuclear weapons.

On the same note, it has recently been argued by the Reagan Administration that one effect of a CTB would be to encourage nuclear proliferation. It is suggested that as confidence in the American stockpile declines, other states will feel less protected by the American nuclear umbrella and will develop their own nuclear weapons. Congressman Edward Markey argued in response that U.S. allies have long endorsed a ban on testing, as have a number of potential proliferators. In his view, a CTB would put "tremendous international pressure on the 'threshold' states to forgo the nuclear option."

Symbolism

A critical third question must also be considered: what will happen to the non-proliferation regime if a CTB is not signed? The NPT will be reviewed again in 1990 and comes up for renewal in 1995; without a CTB, will the NPT come to an end? The answer to that question will depend on the security perceptions of states at that time, just as past proliferation behavior has depended on questions of security. Thus although it is difficult to conclude that a CTB alone will stop nuclear proliferation, such a treaty would stand as a powerful symbol of the rejection of nuclear weapons as a legitimate means of assuring security.

The argument has been made that the nuclear arms race is the modern equivalent of slavery or colonialism. There was a time when both those institutions were commonplace, even accepted in many quarters as legitimate activities for states to pursue. Both were ultimately condemned and efforts to eliminate them were in the end successful. It is argued that the possession of nuclear arms should similarly be condemned as a crime against humanity. A CTB then, as a symbol of a turning away from nuclear weapons, could powerfully discourage proliferation in the future.

Alternate Approaches

As is the case for many arms control efforts, a CTB could be achieved either unilaterally, bilaterally, or multilaterally. At the same time, each of these modes of achieving a CTB could contain some, all or none of the aspects included in prior negotiations.

Unilateral

The recent Gorbachev proposal for a moratorium on all testing, which the Soviet Union proceeded to honor unilaterally, is the simplest and most direct means to achieve a CTB. The most obvious disadvantage of this was shown when the United States chose not to go along with it. It is impossible to establish a norm of not testing if only one of the major nuclear states restrains itself. Even if the U.S. had gone along with it, it would have left open the critical issues of verification and reliability. At a minimum, the moratorium might be seen as a way to set the right atmosphere for negotiations. But the connection between a moratorium and the "right atmosphere" is not at all clear. Although Eisenhower and Khrushchev agreed to a moratorium to help the atmosphere, no agreement was reached; in contrast, Carter did not begin a moratorium yet the talks proceeded smoothly.

In any case, Gorbachev stated "I do not see any insurmountable obstacle to this — political, technical, or any other." As is the case for any set of negotiations, it would remain to be seen at the negotiating table what was insurmountable from the Soviet side as opposed to what was insurmountable from the American side. Thus a mutual moratorium would by itself not be sufficient to stop testing unless the U.S. had full confidence that Soviet testing could be verified without seismic stations within Soviet territory. Few seismologists would argue that seismic detection is sophisticated enough to ensure such confidence.

The necessary next step even if a moratorium were established, therefore, would be the opening of formal negotiations. It has been the argument of a number of American administrations that the American experience of the Eisenhower/Kennedy moratorium weighed in favor of going directly to negotiations rather than beginning with a moratorium. The Soviet test series that followed the 1958-1961 moratorium

was so extensive that it was generally argued that the moratorium had only benefitted the Soviets, who used the hiatus to catch up to the United States. In fact, during the recent Soviet moratorium, Reagan Administration officials tried to paint the Gorbachev proposal as a repeat of the earlier episode. In mid-March, 1986, it was reported that satellite reconnaissance photographs indicated that the Soviets were digging tunnels and installing monitoring equipment in apparent readiness to resume testing.

Bilateral

The Carter Administration negotiations left a number of details unresolved but the critical problem from the point of view of getting a CTB accepted was the political response back in Washington. All the concerns now being expressed under the Reagan Administration were being raised when Carter was president and indicated that the problem of a CTB was finally much more political than technical. The question of how to go about achieving a CTB must therefore consider what is politically acceptable within the United States, more than what is technically negotiable with the Soviets. Many negotiating problems with the Soviets were resolved by the end of 1978; but the Soviet invasion of Afghanistan put into question how confident the U.S. could be of Soviet good faith and an American willingness to accept the residual uncertainties of stockpile reliability was ultimately lacking. How then can these political problems be resolved?

To an extent, the process we have seen since the Eisenhower era has been a salami approach to a CTB. Once it became clear that a CTB was not immediately attainable, it was approached instead slice by slice. First the LTBT moved testing underground. The immediate effect of that was to accelerate the total number of tests, but at least they were safer. The next slice was to limit the total yield of the tests to 150 KT in the Threshold Test Ban Treaty. A third slice was taken when PNEs were also limited to 150 KT each in 1976. Although the effort to complete the slicing process failed under Carter, it may be that the parties can return to a piecemeal approach. The political problems cited above remain but perhaps they can be met

by scaling the next slice so as not to confront them. If the U.S. concern is for reliability of weapons and verification, a number of things could be done.

First, it could be agreed that no test should exceed a lower threshold of perhaps 10 kilotons. There is relatively high confidence expressed in unclassified literature that detection is quite easy down to this threshold.

Second, it could be agreed that each side would be allowed only a specific number of tests per year that exceed this threshold. These could be the proof tests that many feel are vital for reliability. If the number of tests were small enough, they could not support the development of new weapons and thus would not undercut the key argument favoring a CTB. One problem with such a quota, however, is that more than one weapon can be put in a hole at a time. It is impossible to verify how many weapons are actually detonated. One could argue that the quota could be on detonations or events, rather than weapon tests; but such an approach arguably encourages contempt rather than respect for the treaty.

Third, the data exchange negotiated in the PNET could be adapted to continued testing, to allow each side access to and monitoring of the other's testing. Clearly this would be an even more difficult task than were the PNET negotiations. But if it were understood that negotiations should have the goals of reducing the risk of nuclear war and nuclear proliferation and of maintaining high confidence on both sides, it would be possible to allow at least some data gathering and exchange that would support the first goal and yet not compromise the second.

Fourth, a stop-start approach might be tried. A test ban could be put into place for a specified number of years, after which each side could conduct two or three proof tests. Another round of non-testing could ensue, to be followed by another round of proof testing, and so on.

Variants of these approaches, as well as others, have been raised in a number of places as possible next steps. To a large degree, they too depend on political will in Washington and Moscow. Lacking such will, no steps will be taken and the CTB will remain only a long-term goal without any corresponding policy to bring it about.

Given the opposition of the Reagan Administration, the U.S. Congress has responded to public pressure favoring a CTB. In a Senate amendment to the Department of Defense Appropriations bill in 1984 and via House Joint Resolution 3, approved in December 1985,

Congress has asked the president to support both the TTBT and the PNET and to begin negotiations on a CTB with the Soviet Union. Although it is possible for someone other than the president to introduce these treaties on the Senate floor for ratification, it is agreed in the Senate that without at least some Administration support, such an effort would be doomed. There is thus an inherent dilemma in that although these resolutions express certain sympathies on the part of the legislators, they have no weight in policy terms.

Multilateral

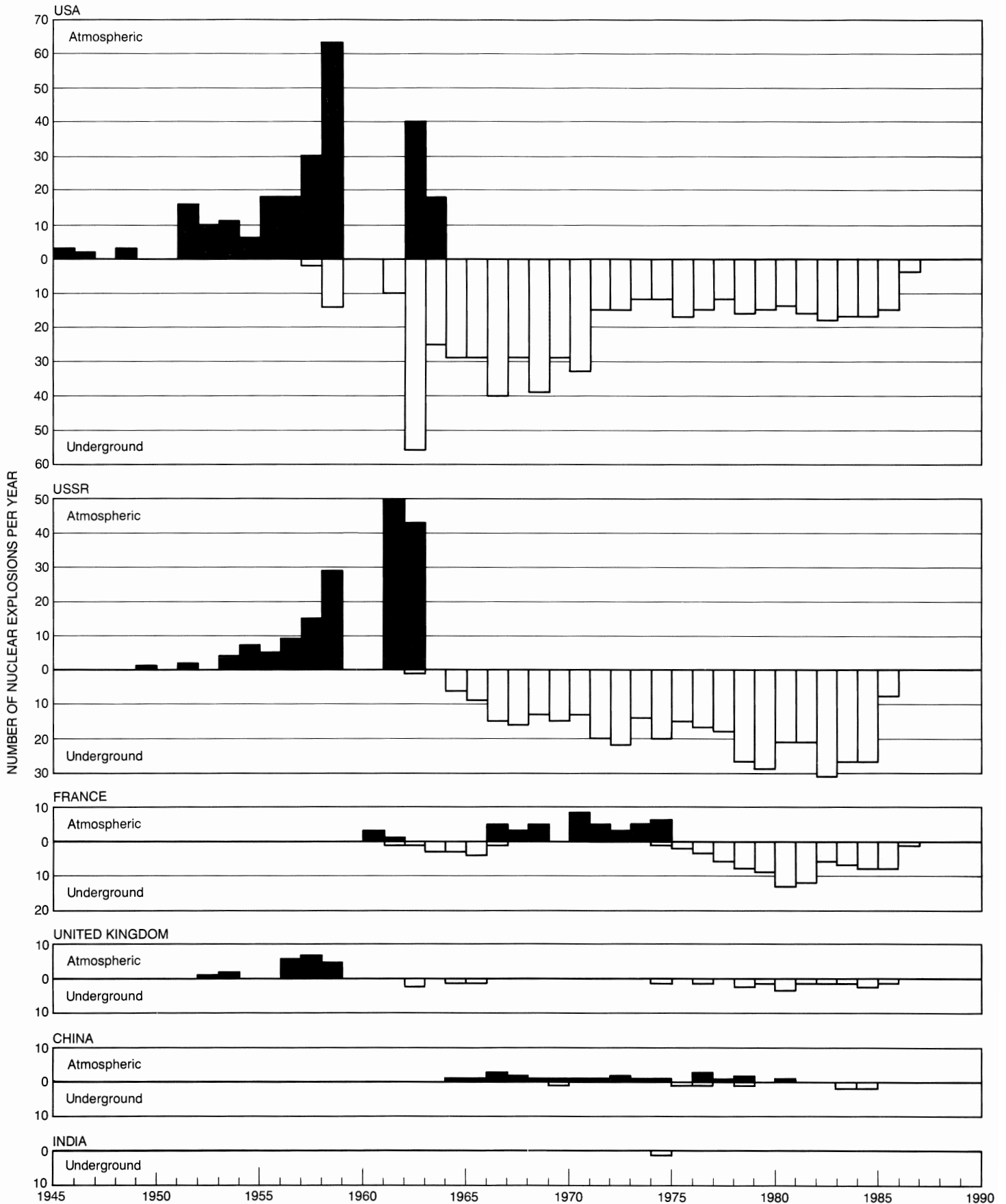
Although only the nuclear weapons testing states can reach an agreement not to test, pressure has been brought by the international community to resume such negotiations. In the Committee on Disarmament, the respective parties have regularly been called upon to conduct negotiations in accord with their commitments made in the NPT. A somewhat more forceful position has been taken in the Five Continents Peace Initiative, in which six states have offered to verify compliance with a nuclear moratorium. These six states — Sweden, Argentina, India, Mexico, Tanzania, and Greece — called on President Reagan and General Secretary Gorbachev on February 28, 1986, to stop testing at least until the next summit. Gorbachev has accepted third party verification of a test ban and of a moratorium. Reagan favors continuing testing with reciprocal on-site inspections.

Glossary

ABM	Anti-ballistic Missile
ASAT	Anti-satellite
CD	Committee on Disarmament
CORRTEX	Continuous Reflectometry for Radius versus Time Experiment
CTB	Comprehensive Test Ban
DARPA	Defense Advanced Research Projects Agency
DOE	Department of Energy
KT	Kiloton (equal to 1,000 tons of dynamite)
LANL	Los Alamos National Laboratory
LLNL	Lawrence Livermore National Laboratory
LTBT	Limited Test Ban Treaty
MHV	Miniature Homing Vehicle
MT	Megaton (equal to 1,000,000 tons of dynamite)
NPT	Non-proliferation Treaty
NSS	National Seismic Stations
NTM	National Technical Means
NTS	Nevada Test Site
OSI	On-site Inspections
PAL	Permissive Action Link
PNE	Peaceful Nuclear Explosion
PNET	Peaceful Nuclear Explosions Treaty
PTBT	Partial Test Ban Treaty
SALT	Strategic Arms Limitation Talks
SDI	Strategic Defense Initiative
START	Strategic Arms Reduction Talks
TTBT	Threshold Test Ban Treaty
USGS	United States Geological Survey

Atmospheric and Underground Testing

July 16, 1945 – April 30, 1986



Nuclear test explosions in the atmosphere and underwater are represented by solid bars, those underground by white bars.

Total Explosions 1945-1986*

	USA	USSR	UK	FRANCE	CHINA	INDIA
1945	3					
1946	2					
1947	0					
1948	3					
1949	0	1				
1950	0	0				
1951	16	2				
1952	10	0	1			
1953	11	4	2			
1954	6	7	0			
1955	18	5	0			
1956	18	9	6			
1957	32	15	7			
1958	77	29	5			
1959	0	0	0			
1960	0	0	0	3		
1961	10	50	0	2		
1962	96	44	2	1		
1963	43	0	0	3		
1964	29	6	1	3	1	
1965	29	9	1	4	1	
1966	40	15	0	6	3	
1967	29	16	0	3	2	
1968	39	13	0	5	1	
1969	29	15	0	0	2	
1970	33	13	0	8	1	
1971	15	20	0	5	1	
1972	15	22	0	3	2	
1973	12	14	0	5	1	
1974	12	20	1	7	1	1
1975	17	15	0	2	1	0
1976	15	17	1	4	4	0
1977	12	18	0	6	1	0
1978	16	27	2	8	3	0
1979	15	29	1	9	0	0
1980	14	21	3	13	1	0
1981	16	21	1	12	0	0
1982	18	31	1	6	0	0
1983	17	27	1	7	2	0
1984	17	27	2	8	2	0
1985	15	8	1	8	0	0
1986**	4	0	0	1	0	0
TOTAL	803	604***	39	142	30	1

*Source: National Resources Defense Council

**Through April 30

***The Stockholm International Peace Research Institute and the Swedish National Defense Research Institute report an additional 18 Soviet tests between 1956 and 1958; the French Ministry of Defense reports an additional 16 Soviet tests between 1963 and 1977.