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# Swords and Ploughshares

# Introduction

by JEREMIAH SULLIVAN

Welcome to *Swords and Ploughshares*, the new bulletin of the Program in Arms Control, Disarmament, and International Security (ACDIS) of the University of Illinois at Urbana-Champaign. *Swords and Ploughshares* will be published three times this academic year and twice each semester thereafter.

The ACDIS Program, academic in nature and in existence since 1978, has as its goals enhancing education, research, and public discussion in the following areas:

- political and technological issues related to international security
- efforts to control and reduce nuclear and conventional weapons
- historical and contemporary factors which lead to war
- means of achieving and enhancing peace
- economic, cultural, and ethical dimensions of war and peace

In its work, ACDIS involves scholars from disciplines as diverse as political science, physics, history, Asian studies, law, philosophy, and anthropology. In addition to participating in activities sponsored by the program as a whole, students and faculty members interact through special interest sections:

- The Ethical Studies Group
- The South Asian Regional Security Project
- The Science and Technology Group
- The War in History Unit
- The Project on European Arms Control and Security
- The Unit for Curriculum Development

The purpose and activities of each of these ACDIS sections are described further at the end of this bulletin. Participation in ACDIS is open to interested faculty and students from all sectors and disciplines of the campus.

**About This Issue . . .**

The first article in this issue is a memorial to a remarkable individual, the late Arthur B. Chilton, a graduate of Annapolis, a career officer in the U.S. Navy, a professor of nuclear and civil engineering at Illinois, and a co-founder of ACDIS.

The two articles which follow are devoted to the complex and contentious issue of ending all nuclear test explosions. This subject is once again moving to the forefront of the arms control agenda, and so it is a fitting theme for the première of *Swords and Ploughshares.*

"Nuclear Test Bans: the Verification Issues" discusses scientific methods of monitoring underground nuclear explosions and discriminating them from natural seismic activity. "Nuclear Test Bans: the Policy Issues" discusses national policy issues which are raised by efforts to limit or ban nuclear weapons tests.

The final article of this issue, "Did the Bishops Ban the Bomb?", reviews and evaluates the conclusions of the recent reports of the American Catholic and Methodist Bishops on the moral and ethical dimensions of nuclear weapons.

# Short Takes

*"Seeking to achieve the discontinuance of all test explosions of nuclear weapons for all time, determined to continue negotiations to this end, and desiring to put an end to the contamination of man's environment by radioactive substances . . ."*

Preamble to the 1963 Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space, and Under Water

*"Arms control should be pursued because the peoples of the world expect it of their leaders. That is a reason of special importance in a democracy."*

Report of the President's Commission on Strategic Forces, March 21, 1984

*There have been over 1,630 nuclear tests since 1945—an average of about one every nine days.*

*Nuclear Weapons Databook*, working paper, 86-2

*The United States has carried out over 20 nuclear tests since the Soviet Union declared a moratorium and suspended underground testing on August 6, 1985.*

*Nuclear Weapons Databook*, working paper, 86-2

*"I've looked carefully at the evidence and have concluded, as President Reagan did, that there is significant evidence the Soviets have violated the 150 kiloton threshold."*

Richard Perle, Assistant Secretary of Defense

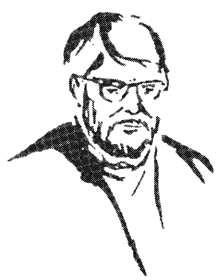
*"There is no evidence that the Soviets have tested over 150 kilotons, none whatsoever."*

Dr. Charles Archambeau, Seismologist, University of Colorado

*"We believe that the moral case for nuclear deterrence, even as an interim ethic, has been undermined by unrelenting arms escalation."*

United Methodist Council of Bishops, May, 1986

# Articles



## Arthur B. Chilton — 1918-1986: an ACDIS Pioneer

**A** few among us, seemingly driven by a special energy and intellect, reach across cultural divides, and, in doing so, enrich their fellow beings in special measure. Arthur B. Chilton was that kind of person.

Arthur joined the faculty of the University of Illinois in 1962, and, after 21 years of distinguished service as a scientist, engineer, and educator, retired in 1984 as a professor of civil and nuclear engineering. He left his mark in many places—one very special mark is ACDIS.

Arthur believed that this university had to be engaged in the great issues of the day to meet its obligations to students, state, and country. As a scientist and engineer, he understood the workings of the atom and the positive benefits which nuclear knowledge and energy offered mankind. He also understood the darker side of this technology — nuclear weapons. Convinced that all thoughtful citizens needed an understanding of the threat that mankind faced from an uncontrolled arms race, Arthur set about to use his knowledge as a scientist and engineer and his skills as a teacher.

In 1978, he joined with two Illinois colleagues from the social sciences and founded what was then called the Office of Arms Control, Disarmament, and International Security. The early years were lean ones, but, in 1980, ACDIS became a program with space and a staff of its own, and Arthur's dream became a reality.

Arthur contributed much in the early days of ACDIS besides initiative and technical knowledge. His standards of academic rigor and of open and non-partisan inquiry became standards of ACDIS. His recognition that problems of war and peace went beyond policy and technology to philosophical, moral, and historical issues saw expression in the interdisciplinary structure of ACDIS.

Arthur Chilton was born in Montgomery, Alabama in 1918. Upon completing high school, he won an appointment to the United States Naval Academy and was commissioned upon graduation in 1939. The navy sent him to Rensselaer Polytechnic Institute where he earned bachelor's and master's degrees in civil engineering in 1942 and 1943. He spent the remainder of World War II in the Pacific with the Naval Construction Battalions.

After the war, Arthur served as public works officer at the Philadelphia Naval Yard before being accepted into a new navy program in radiation protection. He earned master's and Ph.D. degrees in physics from the Ohio State University in 1951 and 1952 and afterward continued his naval career in the Civil Engineering Corps as a research scientist and engineer. In 1962, he retired with the rank of captain and began a second career as an academic at the University of Illinois.

Over the years, Arthur became an internationally recognized authority on radiation shielding. He served on many professional committees, including the Board of Directors of the American Nuclear Society. He also won many awards, including the society's Arthur Holly Compton Award in 1984. In 1969, the Department of Defense awarded him a Distinguished Service Citation.

On September 3, 1986, Arthur Chilton died. He is buried in Arlington National Cemetery.

Arthur gave much to his nation, to his professions, and to his fellow human beings. To this university he gave ACDIS. Thank you, Arthur.

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# Nuclear Test Bans: the Verification Issues

*by* FREDERICK K. LAMB

For three decades, it was official U.S. policy to seek a complete ban on testing of nuclear weapons. However, in July, 1982, President Reagan ended U.S. participation in international efforts to ban nuclear tests. In particular, he declined to resume negotiations on a comprehensive test ban with the Soviet Union, negotiations that had made substantial progress during the period 1977-80.

President Reagan partly justified his reversal of long-standing U.S. policy by expressing his desire to attempt development of new nuclear weapons, such as the proposed X-ray laser, and by the claim that continued testing is needed to check the reliability of old ones. But he also claimed that a total test ban would, in any case, be impossible to verify.

In halting further negotiations on a comprehensive test ban, the Reagan Administration has charged that the Soviet Union has repeatedly violated the Threshold Test Ban Treaty which limits underground tests to 150 kilotons (kt) or less. However, numerous distinguished scientists who have long been involved in monitoring test bans for the U.S. government say the Administration is basing its charges on a misinterpretation of the data.

During the last year, these test ban issues have once again come to the forefront of the arms control debate. This is due largely to increased public and congressional interest in a complete ban on nuclear testing, spurred in part by the unilateral Soviet halt in nuclear testing and new Soviet flexibility on test ban verification. There are also indications that substantial improvements in our ability to detect underground nuclear explosions in the Soviet Union are possible. Thus it seems appropriate to review the current situation.

What are our present test ban verification capabilities? What is the current status of the controversy over Soviet compliance? Could a comprehensive test ban be verified?

**Current Capabilities**

U.S. verification of Soviet compliance with any arms control agreement is a two-step process: collection and interpretation of data on Soviet activities (monitoring), followed by a decision by the President as to whether Soviet activities are in compliance with the agreement. Although the President's decision is inherently political rather than technical, in order to make a wise decision the President must receive accurate information.

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Currently, the United States and the Soviet Union have agreed not to carry out nuclear tests in the atmosphere, in outer space, or underwater, and not to test weapons with yields larger than 150 kt. In order to monitor Soviet compliance with these agreements, the United States relies on a variety of measures, some unilateral and some cooperative.

Unilateral measures include networks of sensors to detect the sound waves produced by explosions underwater, satellites carrying detectors sensitive to the electromagnetic radiation produced by nuclear explosions in the atmosphere or in space, and a radioactivity program to detect the radioactive debris produced by nuclear explosions in the atmosphere. The United States presumably also makes use of other information such as that gathered by interception of Soviet communications and by spies.

The Soviet Union has agreed to a variety of cooperative arrangements to assist U.S. verification of the Threshold Test Ban Treaty (TTBT) and the Peaceful Nuclear Explosions Treaty (PNET). The PNET, for example, grants U.S. verification personnel the right to set up monitoring and inspection equipment on-site, provides them with various privileges and immunities, and protects U.S. ownership of the data gathered by the inspection team when a series of explosions with an aggregate yield of greater than 150 kt is planned. Before the United States broke off negotiations, substantial progress had been made in agreeing on monitoring and inspection procedures to verify a comprehensive test ban.

Underground nuclear tests may be detected by observing test preparations with photographic and communications satellites, by looking for the crater that sometimes forms above the explosion site, or by picking up radioactivity in the atmosphere from gases escaping from the explosion. However, the main technique for monitoring underground nuclear tests is to use seismometers to detect and measure the ground motion produced by such explosions.

The United States maintains a worldwide network of seismic stations to monitor Soviet underground testing. The usual method is to measure the amplitudes of 0.05 Hz waves that propagate around the surface of the earth and 1 Hz sound waves that propagate through the mantle. Underground explosions can be distinguished from earthquakes by a variety of methods, including the depth of the event, the relative amplitudes of the two waves, and their spectra.

The current capabilities of the U.S. network are impressive. The array in Norway, for example, can detect 25-ton explosions at the Soviet test site near Semipalatinsk, 4,000 km away, and routinely detects 10-ton chemical explosions in quarries in the western Soviet Union. Underground explosions anywhere in the Soviet Union with yields near the 150 kt maximum permitted by the TTBT are easily detected by the existing seismic stations outside the USSR.

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### Verification of the Threshold Test Ban

In order to monitor Soviet compliance with the TTBT, the United States must not only be able to detect any explosion near the 150 kt limit but also be able to estimate its yield with some precision. This requires knowledge of how much of the explosive energy ends up in seismic waves. Over the years U.S. scientists have carefully determined the conversion factor at the Nevada Test Site (NTS). However, the geologies of the Soviet test sites are different from the geology at NTS and therefore require different conversion factors. The appropriate factors can be estimated by various procedures but have not so far been measured directly by Western scientists.

Until recently, the U.S. government used a procedure that gave most likely yields above 150 kt for numerous Soviet tests. This was the basis for the Reagan Administration's charge that the Soviets have violated the TTBT. However, many distinguished seismologists involved in test ban monitoring had long criticized the government's procedure on scientific grounds, claiming that it systematically overestimated the yields of Soviet tests.

Criticism of the government's procedure reached a peak late last year. First a panel of scientists selected by the Defense Advanced Research Projects Agency (DARPA) reported that the government's procedure was based on faulty assumptions and recommended a change that would lower estimated yields. Then a separate study initiated by the Air Force Technical Applications Center, which operates seismic stations to monitor Soviet tests, issued a report agreeing with the DARPA panel. Finally, the Joint Atomic Energy Intelligence Committee recommended that the CIA adopt the scientists' advice.

As a result of these recommendations, last January the CIA finally revised the procedure it uses to estimate the yields of Soviet tests. Applying the new procedure retroactively leaves only three or four of about 200 Soviet tests over the last twelve years with most likely yields large enough to be of concern. Thus, there is now general agreement in the scientific and intelligence communities that Soviet test yields probably have not exceeded the 150 kt limit. Interestingly, ten months later the Administration still has not changed its official position that the Soviets have systematically violated this limit.

### Verification of a Comprehensive Ban

What about verification of a low-threshold or comprehensive test ban? Strictly speaking, any monitoring program can only detect tests larger than some threshold at a specified level of confidence. However, if this threshold can be made small enough, there are strong political incentives for establishing a complete ban (see "Nuclear Test Bans: The Policy Issues"). Furthermore, the question of compliance or noncompliance then becomes simpler, since the monitoring program only has to detect militarily significant nuclear explosions without having to provide an accurate estimate of yields.

If it could be assumed that no efforts would be made to muffle the seismic signals, a network of detectors outside the Soviet Union would be able to detect any nuclear test with a yield of 1 kt or more. However, the seismic signals produced by underground explosions can be muffled by setting off the explosion in a large underground cavity (a procedure called *cavity decoupling*) or in a thick deposit of soft, dry soil.

If a nuclear charge is exploded in a large enough cavity, in theory the amplitude of the 1 Hz sound wave can be reduced by as much as a factor of 100. However, existing cavities are small in number, and their locations are generally known. Creation of new cavities large enough to fully decouple a 10 kt explosion would be all but impossible without being observed, but covert excavation of smaller cavities that would cause partial decoupling might be possible.

If a nuclear charge is exploded deep in soft, dry soil the amplitude of 1 Hz sound waves can be reduced by a factor of 10. There is disagreement over the availability of layers of soft, dry soil in the Soviet Union deep enough to fully contain explosions larger than a few kilotons (if the explosion is not fully contained, a crater will form above the test site revealing the test to surveillance satellites). Another evasion ploy would be to conduct small nuclear tests during earthquakes. Although the usefulness of a test program constrained in this way is doubtful, some seismologists believe that traditional methods would have difficulty in detecting such explosions.

**▶ Last year, for example, the Defense Department spent 1,000 times as much on military intelligence programs alone ($16 billion) as for research on test ban verification.**

For these reasons, there is disagreement among seismologists about the kind of seismic network that would be required to detect fully-decoupled 1 kt explosions anywhere in the Soviet Union with high confidence. Some scientists believe this would be possible with 25 single seismic detectors in the USSR. Others believe that as many as 30 seismic arrays of 25 detectors each would be required (the Soviet Union has for many years accepted the need for in-country seismic stations to monitor a comprehensive test ban).

Recent progress in understanding the differences between earthquakes and explosions and new recognition of the possible usefulness of sound waves with frequencies in the range of 5-20 Hz may make it possible to detect small explosions during earthquakes and to completely eliminate decoupling as an issue. First, there is strong evidence that explosions during earthquakes can be picked out much more easily above 5 Hz. Second, U.S. nuclear tests have shown that the amplitudes of 10-50 Hz sound waves are only reduced a factor of 10 by decoupling.

The scientific question not yet fully resolved is whether these high-frequency waves can be picked up at the required distances. This question can be settled soon by more research. It is worth noting that the United States currently invests only a very small fraction of its defense budget on such research. Last year, for example, the Defense Department spent 1,000 times as much on military intelligence programs alone ($16 billion) as for research on test ban verification. (The Arms Control and Disarmament Agency has a total research budget of less than $1 million per year!) Given the importance of this question, adequate support of research to determine the answer should be a high priority.

A dramatic new development occurred last May when the Soviet Union agreed to allow U.S. scientists to set up three seismic stations surrounding the principal Soviet nuclear test site at Semipalatinsk. With this agreement, the Soviet Union demonstrated its willingness to accept in-country monitoring while the United States stands to gain valuable information about this Soviet test site. Even if the Soviets conduct no nuclear tests during the experiment, the seismometers will detect earthquakes and quarry explosions in the Soviet Union and nuclear weapon explosions in the United States, providing Western scientists with the first direct measurements of the geologic structure near this test site. At the Reykjavik Summit, the Soviet Union reportedly accepted a phasing-in of further restrictions on nuclear testing and additional verification measures as part of the proposed arms control package.

**Conclusion**

We have seen that the United States already has impressive capabilities for monitoring test bans and that important improvements in this capability appear possible. Even in the absence of improvements, there is broad agreement within the scientific community that 25-30 seismic stations in the Soviet Union, plus stations outside, would be sufficient to detect all unmuffled explosions larger than 100 tons and fully-decoupled explosions larger than 1 kt. The current strong Soviet interest in a comprehensive test ban presents a special opportunity for concluding an agreement that would meet U.S. verification concerns. Will this chance be missed? Or will nuclear weapon testing at last be ended?

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*The author, professor of physics and astronomy at the University of Illinois at Urbana-Champaign and a member of the University's Program in Arms Control, Disarmament, and International Security, is a consultant to the U.S. government on national security and arms control issues. He has just returned from a year as a Fellow at Stanford University's Center for International Security and Arms Control.*

# Nuclear Test Bans: The Policy Issues

*by* JEREMIAH SULLIVAN

The United States, Soviet Union, and other signatories of the 1963 Limited Test Ban Treaty (LTBT) agreed for an unlimited period of time not to conduct nuclear explosions of any type in the atmosphere, in outer space, or underwater. In the preamble to this treaty, signatories proclaimed as a goal the permanent end of nuclear weapon test explosions and pledged their determination to continue negotiations to this end. These commitments were reaffirmed in the preamble of the 1968 Non-Proliferation Treaty (NPT), another multilateral accord binding upon the superpowers.

In spite of these pledges, efforts to reach agreements to restrict underground nuclear explosions have produced limited results. The bilateral Threshold Test Ban Treaty (TTBT) of 1974 and the companion Peaceful Nuclear Explosions Treaty (PNET) of 1976, are the only visible products to date. Together, these treaties restrict underground nuclear explosions for any purpose to individual device yields not to exceed 150 kilotons.

▶ **A third major factor standing in the way of progress on underground nuclear test limitations is the lack of consensus in the United States that partial or complete bans on underground testing are desirable.**

### Arguments Pro and Con

Several major factors are behind the limited progress made towards a comprehensive test ban (CTBT) since 1963. Foremost of these is the adversarial relationship between the United States and Soviet Union which often causes unrelated issues to become coupled to nuclear weapon agreements even when this is contrary to the best interests of both countries.

The second major factor is verification. The 1963 talks started with a comprehensive ban as a declared goal, bogged down over verification, and were rescued only when the subject of underground testing was put aside. As discussed earlier, enormous progress has been made in understanding and advancing seismic monitoring capabilities since the signing of the LTBT (see "Nuclear Test Bans: the Verification Issues"). Unfortunately, this progress is often unappreciated or ignored in the public debate. In order to focus on the other issues of the CTBT, the discussion below assumes that adequate verification is feasible.

A third major factor standing in the way of progress on underground nuclear test limitations is the lack of consensus in the United States that partial or complete bans on underground testing are desirable. One can only speculate about the analogous situation in the Soviet Union. Powerful constituencies within and without the U.S. government feel strongly that nuclear weapon testing must continue. The main arguments are: the need to assure stockpile reliability, requirements of nuclear force modernization, the necessity of keeping a body of expert nuclear weapon scientists and engineers intact, the need to conduct nuclear weapon effects tests, and the need to develop new generations of nuclear weapons. Taken together, these seem to be a powerful set of arguments against restrictions on nuclear testing. However, when these arguments are carefully evaluated in the broad context of U.S. security interests and actual experiences of over 40 years of the nuclear arms race, they are far less compelling.

What are the arguments against continued underground nuclear testing? There are two major ones: a discontinuance of nuclear weapon testing would restrain and temper the nuclear arms race between the United States and Soviet Union which has gone on since the 1950s and led to a dangerous world; and an end to testing by nuclear weapon states, especially the U.S. and USSR, would dissuade non-nuclear weapon states from acquiring nuclear weapons. Although these two arguments deal with issues of fundamental and long-term importance, because they are necessarily stated in broad policy terms, they are often taken less seriously than arguments for continued testing, especially when the latter are viewed in a narrow context as is so often the case.

### A Critique of Continued Testing

Consider now the arguments presented above against test bans, beginning with the issue of stockpile reliability. Although actual numbers are classified, it is generally agreed that very few of the 20-30 nuclear test explosions the U.S. conducts each year are for stockpile verification. If reliability were a major concern in an era of limited or no testing, weapon designs could be chosen with this in mind. Currently there is no incentive to do this. In addition, a great deal of reliability testing can be done without generating an actual nuclear yield. And if non-nuclear tests or careful inspection shows that weapon components are deteriorating with time, these components could be remanufactured to original design standards.

Another factor to keep in mind is that deterrence is the stated purpose of U.S. nuclear weapons. It is difficult to believe that a slight decrease in stockpile reliability, should it occur, would have a discernable effect on deterrence, given the latter is intrinsically non-quantifiable, and the nuclear arsenals on both side are so large. The consequences of test ban restrictions are felt by both sides. A mutual decrease in stockpile reliability would lessen fear, without significantly affecting retaliatory capabilities. This would be a stabilizing factor.

▸ **To assume that new nuclear weapons contribute automatically to a safer world or give some practical military advantage is a fallacy.**

▸ **The X-ray laser does not seem to offer a compelling reason to continue nuclear testing.**

Next consider the argument that testing must continue because nuclear forces must be modernized. To assume that new nuclear weapons contribute automatically to a safer world or give some practical military advantage is a fallacy. Two separate, parallel developments need to be distinguished: one in delivery systems and the other in warhead design. The ability to manufacture smaller, more compact nuclear weapons has made it possible to reduce dramatically the size and cost of delivery systems in comparison to the 1950s and early 1960s. At the same time, improvements in accuracy have enabled destructive capabilities to be retained at lower yield values. As components of delivery systems have gotten smaller, warhead numbers have increased dramatically, and arms control measures have become more difficult. In recent years, research and testing has led to increases in the yields of weapons on delivery systems already in the field. A continuation of this trend is undesirable. Especially troubling for arms control are dual-purpose delivery systems such as cruise missiles, which have the same external appearances, whether nuclear or conventionally armed. Of course, an end to testing would not mean an end to the offensive arms race. Even in a CTBT regime modernization programs for delivery systems could still be carried out if existing warhead designs were used.

Keeping a body of nuclear experts intact is a complex issue of motivation and incentives. New accords on underground testing—even a CTBT—would not suddenly throw employees of the weapons laboratories and their supporting contractors out of work. Nuclear weapons would still be with us, and many technical questions would arise. Present trends of using increasingly sophisticated computer simulations for design would probably be accelerated in many areas which now rely upon testing as a matter of tradition, convenience, or economy. The tremendous advantage that the U.S. has over the USSR in computer technology is particularly notable. Finally, it must be remembered that the U.S. has over forty years of nuclear testing experience, and, even if there were a Soviet breakout from a test ban, a new group of technical experts could be rapidly assembled. We are a country where unmatched technological and organizational capabilities can be summoned when real needs exist.

Nuclear weapon effects are difficult to simulate by non-nuclear means and to calculate from first principles because of the special physical regimes involved. However, much more could be done than at present via non-nuclear test simulation if appropriate support were available. And, as already mentioned, computer calculations are destined to play an increased role in nuclear weapon studies anyway, and this is especially true in the effects area. Even today, computer simulations are the only way to study the performance of large components or entire systems which are too big or too expensive to subject to radiation from an underground nuclear test explosion.

Finally, consider the development of new generations of nuclear weapons. Although a number of possibilities have been discussed in the open literature, the X-ray laser is the most frequently mentioned. Under development at the Lawrence Livermore National Laboratory, the X-ray laser has been widely heralded as an effective anti-ballistic missile weapon and is an element of the SDI program funded by the Department of Energy. Even if this type of laser can someday be developed to the brightness levels required to destroy enemy ballistic missiles, countermeasures have already been identified which make the usefulness of the X-ray laser as an anti-ballistic missile weapon highly unlikely. Assuming that these and the many other obstacles facing the defense designer are somehow overcome, could the U.S. ever depend on a device which had never been tested in its operational environment? And, if not, would the U.S. want to abrogate the LTBT in order to conduct nuclear test explosions in space? The X-ray laser does not seem to offer a compelling reason to continue nuclear testing.

### Advantages of a CTBT

What about arguments in favor of test bans? They have been persuasive to all U.S. administrations up to the present. The first argument, cited above, that an end to nuclear testing by the superpowers would put restraints on the arms race, is supportable on both practical and symbolic grounds. Without the certain opportunity to develop and test new warheads to extract an extra few percent of yield out of the available volume or lift capability of a missile or airplane, strategic force planners are much more likely to accept present systems and limitations on the introduction of new types of delivery systems. When the offensive nuclear forces of the enemy are better known, worst-case analyses are restrained. Subsequent measures to reduce or limit offensive nuclear arms would be correspondingly enhanced.

**▶ A major national debate on underground testing appears to be in the offing and could be the springboard for a reversal in the nuclear arms race.**

The second main argument cited above in support of test bans, discouragement of nuclear proliferation, has been the cornerstone of U.S. policy since the NPT was signed in 1968. The Soviets have been especially cooperative in helping to prevent the spread of nuclear weapons to other countries. The non-nuclear signatories to the NPT have been uniformly critical of the nuclear weapon states for failing to live up to a pledge made in signing the treaty, namely that all nuclear weapon testing would be ended. Many nations have stated repeatedly that they feel continued testing threatens the future of the treaty. While it may be doubted that these claims can be supported by real security needs, continued testing by the U.S., USSR, and other weapon states provides a convenient excuse for holdout states to refuse to sign the NPT and for non-nuclear signatories to withdraw. The claim made by the Reagan administration in the past year that, if the U.S. discontinued testing, its non-nuclear allies would lose confidence in our nuclear deterrent and be forced to adopt nuclear weapons programs of their own, is totally unsupported by any statements from these allies.

### Conclusion

A policy decision to seek limitations on underground testing, especially a comprehensive ban, cannot be said to have no risk or uncertainty. However, in assessing the merits of test bans, the risks and uncertainties of the present course of the nuclear arms race must not be forgotten. Nuclear weapons have made this a more dangerous world, even if they have made certain forms of deterrence cheap. The present course is manifestly one of high risk. Measures to reduce and eventually eliminate underground testing can lessen these risks.

Recently the administration accepted the principle that nuclear weapons testing could someday be stopped but stated that this would be the case only after nuclear weapons themselves had been eliminated. It seems more likely that the opposite is true. Namely, a cessation of nuclear weapon testing is a necessary first step.

Many technical developments, especially in the field of seismology, indicate that substantial improvements in verification are possible, that much can be learned quickly from a well-supported research program, and that cooperative efforts with the Soviets can work (see "Nuclear Test Bans: the Verification Issues"). Although the jump to a comprehensive test ban treaty cannot be taken in one step, the time seems ripe to resume efforts in that direction. In October, the Reagan administration agreed to submit the TTBT and PNET, with certain qualifications about verification, to the Senate for ratification . A major national debate on underground testing appears to be in the offing and could be the springboard for a reversal in the nuclear arms race. Progress toward eliminating nuclear testing would be a magnificent statement heard around the world.

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