Test Ban Compliance: Is Seismology Enough?

A debate over verification has stalled ratification of two treaties and is hindering negotiation of a more restrictive pact

GEOPHYSICIST Gregory E. van der Vink, director of a nuclear test ban verification study being conducted by the congressional Office of Technology Assessment, uses an apt wintery analogy to illustrate the trade-offs being juggled in the current debate over nuclear test limitations.

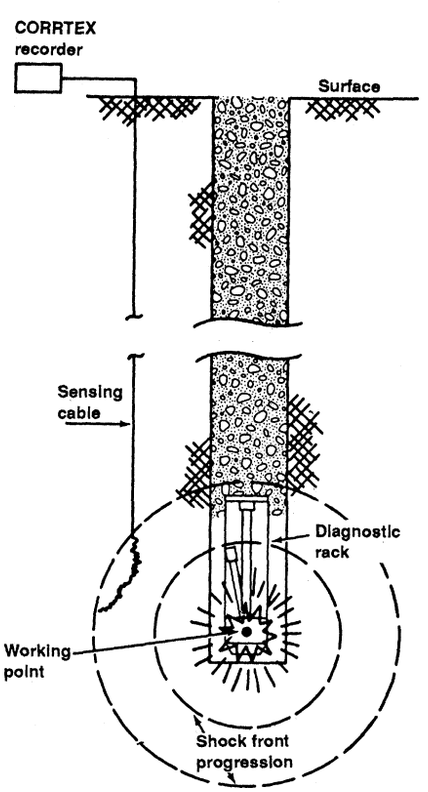
A country embarking on an arms agreement is like a traveler confronted by a frozen river, he suggests. The thickness of the ice covering the river symbolizes the degree to which compliance with that agreement can be verified. "Obviously, if the water is very deep and the ice is thin and there's not something you're interested in on the other side, you're not going to want to cross," says van der Vink. "But if there's something greatly worthwhile on the other side, then the ice has to be very thin to deter you from crossing."

Imbued with a profound skepticism about Soviet good faith and traditional arms control, the Reagan Administration contends that the United States is skating on thin ice, indeed, in verifying Soviet compliance with nuclear testing treaties. The consequent heated debate over whether and how to cross this particular arms control river—which has divided not only Congress but also the intelligence and technical communities—has become snarled in a knot of technical and procedural complexities of the sort all too typical of the arcane world of arms control.

The treaties now under debate were signed more than a decade ago: the Threshold Test Ban Treaty (TTBT) by President Nixon in 1974 and the Peaceful Nuclear Explosions Treaty (PNET) by President Ford in 1976. Between them, they prohibit all underground nuclear blasts with an explosive yield greater than 150 kilotons, the equivalent of 150,000 tons of TNT. Preoccupied with negotiating a more sweeping agreement banning all nuclear tests, the Carter Administration never asked the full Senate for a ratification vote on the two accords, although they were approved by the Senate Foreign Relations Committee in 1977. Nevertheless, the United States and the Soviet Union have pledged to abide by the treaties' strictures.

When negotiated, verification of the testing agreements was entrusted to seismology. Much as earthquakes are monitored, underground nuclear blasts can be detected and their magnitude gauged by measuring the vibrations they send rippling through the earth. But "the remote seismic techniques we must rely on today to monitor Soviet nuclear tests," the State Department reiterated in a policy paper last August, "do not provide yield estimates with the accuracy required for effective verification of compliance."

Administration charges that the Soviets have consistently exceeded the 150-kiloton limit have been undermined by a series of official recalculations of the "bias," or correction factor, used in converting seismic measurements of Soviet tests into yield estimates (*Science*, 31 May 1985, p. 1072). "The Soviets appear to be observing a yield limit . . . consistent with TTBT compliance," Milo D. Nordyke, head of the Lawrence Livermore National Laboratory's Treaty Verification Program, told Congress last January. But, he cautioned, "you cannot rule out the possibility that a few Soviet tests may have exceeded the limit." Because the TTBT contains a so-called "whoops clause" stating that "one or two slight unintended breaches per year would not be considered a violation of the treaty," however, even that possibility offers shaky ground for noncompliance charges.



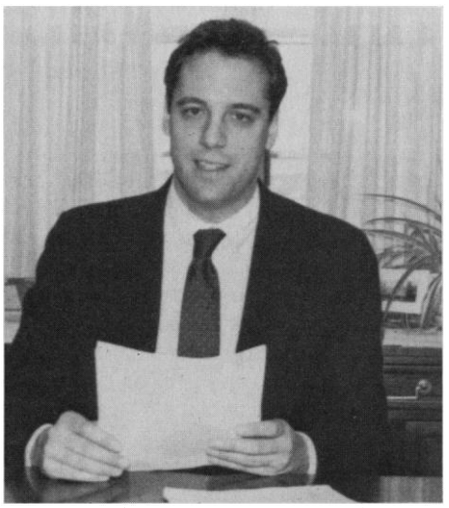
The Administration's favorite technique. *The CORRTEX system involves running a cable down a borehole about 50 feet from the shaft containing the explosive device. The shock wave crushes the cable and sends a signal to the surface recorder.*

Nonetheless, having largely rejected seismology, the White House had to cast around for another verification approach. The most accurate, radiochemical analysis of the exploded bomb's residue reveals too much about the weapon's design and purpose to be used for verification. The alternative seized upon, therefore, was hydrodynamics.

Unlike seismographs, which can gather data from thousands of miles away, hydrodynamic sampling requires on-site measurements of yield. The U.S. technique is called CORRTEX, a mercifully terse acronym for Continuous Reflectometry for Radius versus Time Experiments. A cable connected to a suitcase-sized electrical unit and a microcomputer is buried in a deep "satellite" hole roughly 50 feet away from the "emplacement" hole holding the nuclear device. The rate at which the CORRTEX cable is crushed and short-circuited by the shock wave generated by the exploding device provides the yield estimate. More than 100 tests have been carried out with the CORRTEX cable run down the emplacement hole. Only a handful have been conducted using a satellite hole.

Repeated invitations to the Soviets to visit the Nevada Test Site to observe CORRTEX-monitored nuclear tests have been just as repeatedly rebuffed. Twice, most recently last February, the State Department told Soviet seismologists slated to install monitoring equipment near the Nevada proving grounds as part of a cooperative monitoring experiment with the private Natural Resources Defense Council that they could do so only if their itinerary included watching a CORRTEX test. The Soviets, who contend that seismic means of verification are sufficient, stayed home both times.

Nor has CORRTEX proved universally popular within official U.S. circles. A classified Central Intelligence Agency (CIA) memorandum last December complained of



Gregory van der Vink: *Heading OTA study on test ban verification*

"inconsistencies, contradictions, and incomplete work" in the Administration's verification plan. "Frankly," its author wrote, "if the Soviets had said 'yes' to our initial proposals, we would be in trouble." The U.S. insistence on CORRTEX measurements of all Soviet explosions greater than 75 kilotons was flawed, in this analyst's view, because the Soviets could not be trusted to give advance notice of the tests that would qualify. The CIA favors inspection of Soviet nuclear test sites to ascertain their geological makeup, but would prefer to rely on an array of seismic stations in and around the Soviet Union rather than on CORRTEX.

A more public debate centers on whether the accuracy claimed for CORRTEX is significantly greater than that achievable seismically. According to the Los Alamos National Laboratory, CORRTEX tests at the Nevada Test Site have shown that Soviet tests could be measured with an uncertainty factor of 1.3 at the 95% confidence level. Stripped of the statistician's jargon, that simply means that there would be a 1-in-40 chance that a Soviet test gauged by CORRTEX to have a yield of 150 kilotons was actually 195 kilotons. The Administration contends that the most that can be hoped for from seismic means is an uncertainty factor of 2, meaning that there is a 1-in-40 chance that a test thought to be 150 kilotons was actually 300 kilotons. "The difference between 100% over the actual yield and 30% . . . is significant," asserted a U.S. official involved in the verification effort.

Other seismologists, however, contend that the Administration gives short shrift to their science. In a study of yield estimates for nuclear explosions at the Nevada Test Site published in a February 1986 issue of the *Journal of Geophysical Research*, Saint Louis University geophysicist Otto W. Nuttli found that analysis of Lg waves—seismic tremors that propagate in the earth's crust, as opposed to the more shallow surface waves and the deeper body waves upon which seismologists have traditionally focused—afforded yield measurements accurate to within a factor of 1.3, similar to that claimed for CORRTEX. "It's quite clear that the use of these Lg waves is proving remarkably accurate," said Paul G. Richards of Columbia University's Lamont-Doherty Geological Observatory, who has testified to Congress that seismic uncertainty factors of 1.5 were achievable.

"I think that with the three different seismic methods [surface, body, and Lg waves], we could do at least as good as 1.5," said Lynn R. Sykes, another Lamont-Doherty seismologist who has been immersed in the test verification debate for almost two decades. "And it may be that we can do 1.3." With an uncertainty factor of 1.5, a seismically miscalculated yield could actually be 225 kilotons, compared to the upper yield range of 195 kilotons claimed for CORRTEX. "It's a distinction without a difference," asserted a Senate Democratic aide. CORRTEX "adds something to our knowledge, but is it important to verifying the treaties? We would say no, it's not."

Hydrodynamic yield measurements, performed by an earlier technique called SLIFER, were always envisioned as the verification tool for some underground nuclear explosions conducted under the PNET. But so-called peaceful nuclear explosions, detonated for engineering purposes, would not involve militarily sensitive bomb designs. Application of CORRTEX to verification of the TTBT, however, raises a plethora of operational security issues.

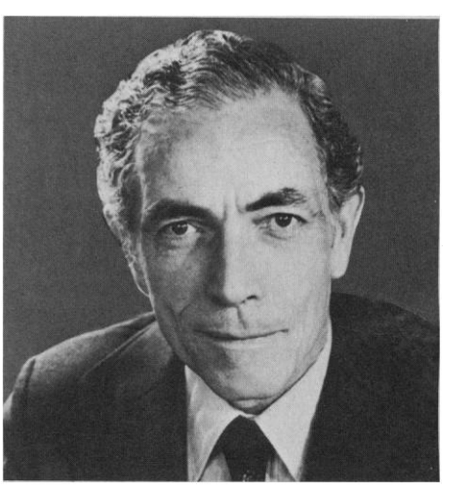
Because CORRTEX's accuracy could be affected by the configuration of the various diagnostic devices emplaced in the test hole with the nuclear device and by the relation of the satellite hole to the emplacement hole, Soviet technicians would have to be on the Nevada Test Site for weeks before a nuclear test shot. "What we're really talking about is a cooperative test program, with people on the site all the time and doing exploratory drilling," said Frederick K. Lamb, a physicist at the University of Illinois at Urbana-Champaign who is a consultant to the Departments of Energy and Defense and has written technical papers on CORRTEX. "It would be a significant change."

These security concerns, Livermore lab director Roger E. Batzel told Congress last January, "could be handled at some increase in cost," although trials of nuclear-powered beam weapons such as the x-ray laser would pose a unique challenge. "Inspection of the canisters of these tests to verify that treaty restrictions are being followed could reveal sensitive design information unless special procedures are followed," Batzel cautioned. In a 23 March response to questions about CORRTEX raised by Representative Edward J. Markey (D–MA), Admiral Sylvester R. Foley, Jr., the Assistant Secretary of Energy for Defense Programs, termed the security situation "manageable" provided additional guard stations are installed, escorts are assigned, and "shrouds" are draped around sensitive equipment. Nevertheless, CORRTEX-driven limitations on the size of test canisters and other test parameters, Foley admitted, "will cause some interference with the U.S. nuclear testing program."

This issue also impinges on the accuracies claimed for CORRTEX. According to Princeton University physicist Frank von Hippel, who recently conducted a seminar on CORRTEX in Moscow, the Soviets did not argue with the U.S. assertion that yields could be measured with an accuracy of 1.3, "but they were skeptical that without greater intrusiveness than the weapons establishment would permit that you could achieve that in an adversary situation."

Because the satellite hole must be dug impossibly close to the emplacement hole for tests smaller than 50 kilotons, CORRTEX's final and perhaps fatal drawback in the view of many legislators is that it is inapplicable to a low-yield test ban. Bills pending in both the House and the Senate would terminate the funding for all tests over 1 kiloton, provided that the Soviet Union follows suit and also allows in-country monitoring. The House bill, appended to the fiscal year 1987 supplemental appropriations bill, is expected to come up for a vote in late April or early May.

House passage of just such a measure last year set in train an unusual series of political



Senator Claiborne Pell: *The Administration has not twisted arms to get treaties ratified.*

maneuvers around the two 1970s testing treaties. In a deal hammered out on the eve of the Reykjavik summit meeting last October, designed to free a legislative logjam over a package of restrictive arms control amendments being pressed by the House, President Reagan promised to ask for ratification of the TTBT and the PNET early in the 1987 legislative year. Appended to the treaties, it was agreed, would be a "reservation" that they would not take effect until "effectively verifiable."

The reservation language submitted by the Administration to the Senate Foreign Relations Committee on 13 January, however, called for two ratification votes, one on the treaties themselves and another to approve any verification protocols subsequently negotiated. This two-vote formula met with stiff opposition from senators, who felt that the first vote would be but a meaningless formality and feared that the unusual procedure could establish an unwanted precedent for multistaged legislative action on future treaties.

Particularly outspoken was Senate Armed Services Committee chairman Sam Nunn (D–GA). If the White House insisted upon the second ratification vote, an irate Nunn told Senate Majority Leader Robert C. Byrd (D–WV) in a 6 February letter, it would "scuttle a prudent and sensible approach to achieving further limitations on nuclear testing" and "be buying a bucketful of trouble in both the House and the Senate as we deliberate on arms control amendments this year."

Under the gun from Byrd, who was anxious to wield expeditious action on the treaties as a symbol of Democratic commitment to arms control and tough verification, Foreign Relations Committee chairman Claiborne Pell (D–RI) crafted new language calling for only one vote to ratify the treaties, leaving it up to the President to settle the details on verification.

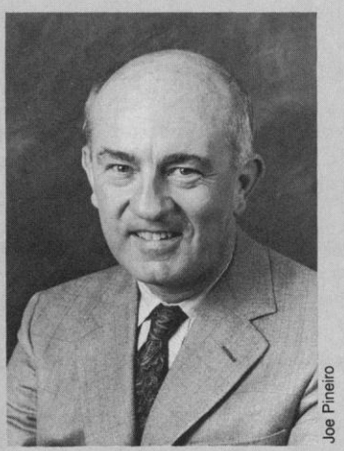
But the Pell formula was, in turn, opposed by committee Republicans wary of signing a possible blank check for Reagan's successor, who might be softer on verification, and loath to abdicate Senate treaty-making prerogatives. "Senator Byrd was very much pressing Senator Pell," said committee member Nancy L. Kassebaum (R–KS), "and the whole thing seemed to snowball without careful thought given to what the meaning of [it] would be." With Senator Daniel J. Evans (R–WA), she proposed a substitute resolution whereby the treaties would be tabled until the verification issue was resolved with the Soviets. After a lengthy debate, the committee decided to punt, voting out both resolutions for consideration by the full Senate.

"Ideally, it seems to me that we shouldn't

Seismic Politics

In no other realm of public policy, perhaps, are science and politics as intimately intertwined as in that of weaponry and arms control. This reality can often prove an uncomfortable one for scientists, such as seismologists, who find themselves pulled out of a safe, dry, subterranean world of "anelastic attenuations" and "Rayleigh waves" and propelled into the chaotic maelstrom of a supercharged political debate.

"I recognize that this has to be decided as a political judgment," Columbia University seismologist Paul G. Richards took pains to stress recently during testimony to the Senate Armed Services Committee on the question of Soviet compliance with the 1974 Threshold Test Ban Treaty. "The way that the technical community can contribute is to give a best professional opinion on the relevant numbers." In a subsequent interview, Richards was no less insistent on carefully delineating the division he perceived between political and technical judgments.



Joe Pineiro

Lynn Sykes: *"You have to be willing to make some general conclusions from the data."*

"What I have found is that the notion that somehow you can be nonpolitical and just stick with the facts does not square with my history of the subject," said Columbia University's Higgins Professor of Geological Sciences, Lynn R. Sykes, who, after some 20 years toiling in the fields of test ban verification takes a more combative tack than his colleague Richards. "If you want to be effective in getting across the bigger picture that comes from the science and keep other people from distorting that, you have to be willing to make some general conclusions from the data."

As an example of how technical data can easily be distorted, Sykes complained about the practice by some Administration witnesses of throwing around high values for statistical uncertainty for seismic verification without making it clear that, at a 95% confidence level, there is only a 1-in-40 chance that the actual yield exceeds the estimated yield. "A lot of mischief is played that way," he asserted.

Another pitfall for seismologists who have plunged into the test ban verification debate is the danger of becoming pawns in the rhetorical chess games on Capitol Hill. "What can impose difficulties is if forces with a strong opinion, as they naturally will, try to make use of one's technical analysis in trying to push their argument," said University of Illinois (Urbana-Champaign) physicist Frederick K. Lamb, whose mildly critical analyses of CORRTEX have been used as ammunition by Administration critics in Congress. "That's fine, unless it becomes unbalanced or distorted and then one feels used," he added. "But that's something one has to learn to live with in an area where there's such strong feeling and political significance to the work one is trying to do."

Gregory E. van der Vink has succeeded in corralling about 50 seismologists and geophysicists—including Richards, Sykes, and Lamb—to participate in an Office of Technology Assessment study of yield verification he is heading up that will be completed in late summer. "The response has been resounding," said van der Vink. "And the only two people I've encountered who said, 'I'd rather not get involved,' were people who were involved actively about 20 years ago and are sick of it. These [seismologists] are people whose livelihood depends on the taxpayers and many of them see this as a way to contribute back to the public."

There is "important work to be done at that boundary between science and policy," admonished Sykes. "But scientists should not assume that there is going to be someone there as if by magic to take their scientific findings and turn them into policy." ■ **D.C.M.**

be doing this," admitted committee member Paul Simon (D–IL), "But the reality is that we can't get the votes without the reservation."

Because he has continued to be unable to harvest the votes needed to secure passage of the Democratic reservation language, however, Byrd has yet to steer the resolutions to the floor for a vote. And there the situation hangs, in legislative limbo.

During a 24 March hearing, a plaintive Pell took Arms Control and Disarmament Agency director Kenneth L. Adelman to task for the Administration's failure to twist arms on the Hill to get the two treaties ratified. "It seemed to me very strange," Adelman responded, "that the Senate would be interested in ratifying treaties when they did not see the whole language involved." The Reagan Administration "had been saying for 6 years we need better verification for these treaties," he reminded Pell, while "the Soviets have been saying 'nyet' for 6 years."

For a brief moment in early April it looked as though the treaties might gain a new lease on life when President Reagan greeted as "encouraging" a Soviet offer to discuss new verification measures on the TTBT and PNET at the same time that additional and more restrictive limitations on nuclear testing were negotiated. Within a few days, however, the Administration reaffirmed its earlier position that Soviet agreement to CORRTEX monitoring of the two older treaties was a precondition to opening up new talks on further restricting nuclear testing.

Another possible route around the TTBT verification roadblock was charted during Secretary of State George P. Shultz's recent talks in Moscow, when the superpowers tentatively agreed to explode nuclear weapons at each other's test sites to permit precise calibration of their seismic instruments. But the details of this unusual swap have yet to be worked out and the United States is still insisting that CORRTEX is the key.

"It's not adequate, it's a first step," said outgoing assistant secretary of defense for international security policy Richard M. Perle, of the test exchange in a 19 April "Meet the Press" interview. "In order to get real verification of the present limit on nuclear testing, we need to be able to send teams to the Soviet Union, and they have to send teams to the United States, who will stand by and measure the yield of those tests when they take place. That's the American proposal," said Perle.

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Report Blasts Human Development Office

House committee sees grounds for researchers' complaints of politicization of grants process

THE House Committee on Government Operations has released a scorching report accusing the Office of Human Development Services (HDS) within the Department of Health and Human Services (HHS) of "mismanagement" and of funding questionable research projects in defiance of the recommendations of peer reviewers. The report also criticizes HDS officials for failure to allocate funds provided by law, improper delays in promulgating regulations, and "misrepresenting" their activities to Congress.

The HDS, which funds social welfare services and research on programs for children, the elderly, the developmentally disabled, and American Indians, has the sort of functions that the Reagan Administration has consistently sought to curtail. The fiscal year 1987 research budget was $41 million—less than half the FY 1980 level and $12 million more than the President requested. The HDS was run until recently by Dorcas Hardy, a longtime associate of President Reagan who resigned last year to become the commissioner of Social Security.

The report is based on an investigation by the subcommittee on human resources chaired by Representative Ted Weiss (D–NY), which was prompted by numerous complaints from researchers about politicization of the grants process. Dissatisfaction with the HDS modus operandi has been simmering for some years, as evidenced by criticisms voiced in two previous reports, in 1983 and 1984, by the HHS Inspector General and the General Accounting Office.

The House committee report focuses in particular on the conduct of the coordinated discretionary grants program which handles most of the research funding. The grant process is as follows: researchers submit "preapplications." Following peer review, some applicants are asked to submit full applications. The full applications are submitted either to "competitive review"—involving further peer review—or "administrative review," which is done in-house and is directed at projects deemed to be of "unique interest" or "exceptional merit."

The subcommittee expressed concern about "the inordinate number of grants that receive funding despite very low scores and ranking by the experts in the field. . . . " It seems that any proposal subjected to administrative review was virtually assured of funding, regardless of how it had been ranked in the preapplication process. Some were arbitrarily assigned a score of 99 (on a scale of 0–100) for the administrative review.

The highest ranked preapplications were often ignored—for example, in the FY 1984 child abuse grant category, 44% of those selected for administrative review and 22% of those selected for competitive review had not received high priority rankings and thus were selected "despite, not because of, the peer reviewers' recommendations."

The committee concluded that "apparently inferior programs that appeal to the HDS politically appointed administrators are funded." This is suggested by a listing of projects for FY 1985, which shows that 33% of the grants funded after competitive review were not among the highest ranked. The majority of these projects fell in areas of Administration concern, such as "management systems," and "strengthening families."

One of the outstanding examples of "out of order funding" was a grant to Childhelp USA, a California organization, for a study of why foster care placements fail. Despite low preapplication scores, it was assigned to competitive review and authorized to apply for $36,000 for 1 year. Childhelp instead applied for $300,000 over 3 years. The application was given scores of 13, 27, and 43 by the reviewers, who found it "very expensive" and not innovative. A second review was then conducted, with different reviewers, who accorded it scores in the 80s. The $300,000 proposal was funded. No written justification was given for the unusual handling of the grant. The committee notes that the project director was a former HDS administrator under President Ford, and that Mrs. Reagan is a friend of Childhelp's founders and honorary chairman of the organization.

In testimony at committee hearings last