U.S., Soviets Share Seismic Posts

With Pentagon monitors already in place at four Soviet cities, a joint network designed by geologists to collect earthquake and bomb test data wins public approval

WORKING IN DELIBERATE OBSCURITY, an unusual coalition of geologists, defense officials, and nuclear testing opponents has engineered the installation of a wide network of seismic listening posts in the Soviet Union, in what amounts to the first major, open U.S. intelligence-gathering effort in that country.

One purpose will be to collect scientific data from an area that has not been open to Western researchers before, but the network will also greatly improve the United States' capability to detect small Soviet nuclear tests.

Indeed, if the network proves as sensitive as researchers hope, and if the plans to double its size are carried out, it could make it possible to verify stringent testing limits, perhaps even a future ban on tests above 5 kilotons.

The Soviets have made achievement of a comprehensive test ban one of their highest foreign policy goals, and, under the terms of this cooperative research agreement, they will gather the same kind of verification data in the United States. But the Soviets are equally eager, according to U.S. scientists, to obtain assistance in predicting the magnitude and nature of future earthquakes within their country.

In the first round of hardware deployment last year, seismic monitors owned by the Defense Department were installed without publicity in four Soviet cities. Under the terms of an agreement approved in Washington and Moscow last month, more modern equipment will be installed at these locations and at three others next spring.

Scientists say the monitoring network will provide a unique opportunity to study the geology of the Eurasian continent. Geological data "are extremely limited in this area of the world and this program should help remedy that situation," says Jonathan Berger, a geophysicist at the Scripps Institution of Oceanography in La Jolla, California, who helped negotiate and secure funding for the arrangement. "By working in these areas and understanding the regional seismology and tectonics, both countries [also] will be in a better position to assess the effectiveness of seismic data in monitoring nuclear tests," he adds.

Berger and John Filson, a seismologist at the U.S. Geological Survey (USGS), are principal investigators for the academic consortium known as Incorporated Research Institutions for Seismology (IRIS), formed several years ago to install and maintain such sensors in more than 25 countries. Now that the political and financial barriers have been removed, IRIS will be able to extend coverage into a vast and relatively unexplored territory in the Soviet Union, which researchers find exciting.

Ears to the ground. *U.S. seismic monitors have been installed near four cities (Moscow, Sverdlovsk, Kislovodsk, and Garm). New stations are planned at Frunze, Garni, and Irkutsk.*

Thomas Jordan, chairman of the Massachusetts Institute of Technology Earth, Atmospheric, and Planetary Sciences Department, said he was "really enthusiastic about this project, and you'll find that most of the seismological community feels the same. It's a geologically interesting area, and we've had very little information" because the Soviets have historically treated seismic data as state secrets.

Because the project is politically sensitive, its leaders have shunned publicity until now. Their main concern was that it might be shot down by arms control skeptics within the U.S. government—officials who, in previous years, have opposed research that would make it easier to verify a test ban.

For example, a seismic monitoring program set up earlier by the Natural Resources Defense Council, a New York–based advocacy group, was attacked by hard-line Pentagon policy officials Richard Perle and Frank Gaffney as "mischievous," "counterproductive," and "scientifically unsound."

These officials have since left government, and S. Jacob Scherr, a senior attorney at NRDC, observes that "we've come a long way from those days." At five of the IRIS sites, the Pentagon's new seismic recorders are plugged into equipment installed by NRDC and later sold to the Soviets.

To avoid flak from the critics, Soviet and U.S. scientists said little about the negotiations until August, after the Administration and Congress smiled on the proposal. Tongues have been loosened by the Bush Administration's endorsement, which came after an interagency review this summer, and by the inclusion of special appropriations for the seismic monitors in the House and Senate versions of the pending fiscal year 1990 defense budget.

Berger and other project leaders sought funding from the Defense Advanced Research Projects Agency (DARPA) because it supports an existing network of U.S. seismic stations outside Soviet territory. Last year, DARPA paid about $5.7 million to the National Science Foundation, which passed a portion to the USGS, and the rest to IRIS. This year, the House and Senate have approved an additional $6.5 million to $8 million in funding, and the project won formal bureaucratic approval as part of an obscure U.S.–Soviet effort to study environmental protection.

The arrangement ensures that there is no direct contractual tie between the Pentagon and the program managers, a feature that may make it more palatable to the Soviets. However, military agencies regularly get copies of the sensor data from which they glean unspecified information about Soviet nuclear weapons.

In exchange, the Soviet Academy of Sciences will get seismic data from U.S. equip-

ment at five sites in the United States and has already received approval to set up its own seismic sensors alongside IRIS equipment at the Blacksburg campus of Virginia Polytechnic Institute and at Albuquerque, New Mexico, 500 miles east of the underground nuclear test site in Nevada, according to Berger.

Within the Soviet Union, one of the first new listening posts will be at Frunze, in Soviet Central Asia, 500 miles from Semipalatinsk, the main Soviet nuclear test site. It is also near what seismologists call a "collision zone" for the immense subterranean tectonic plates that comprise the Indian and Asian subcontinents. Berger says earthquakes in this region occur at unusual depths, complicating previous studies of the processes involved.

Another new post will be in Garni, Armenia, near the site of last December's ruinous earthquakes. U.S. experts believe that a better understanding of the regional seismology will allow the Soviets to construct buildings with improved earthquake resistance.

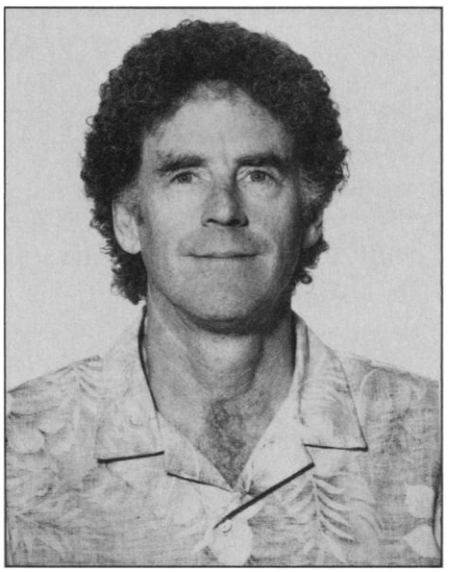
The third new station will be near Irkutsk, near the Mongolian border. Existing stations are located near Moscow, Sverdlovsk, Kislovodsk, and Garm.

Information from monitors at these remote sites may help bring an end to a longstanding dispute about the minimum technical capabilities required to enforce a test ban. A report last year by the Office of Technology Assessment estimated that 15 to 20 seismic listening posts should be installed in the Soviet Union to verify compliance with a ban on nuclear tests of greater than 5 kilotons. Although IRIS is beginning with only seven stations, Berger says that it eventually hopes to install at least twice that many.

Gregory van der Vink, a geophysicist and director of planning at IRIS, explains that debate on this issue "has been unresolved until now because we've been postulating a hypothetical [seismic] network. Now that we have an opportunity to go from modeling to actual experimentation, the uncertainties should diminish."

Milo Nordyke, director of an arms control group at Lawrence Livermore National Laboratory, agrees that the project will "provide a solid base for analyzing" major technical problems associated with future testing limitations. The United States has pledged to consider such limits after Moscow and Washington agree on new verification measures for a 1974 treaty limiting tests to 150 kilotons.

Negotiations on the new measures began in 1987 and the prospects for accord brightened recently when the Soviets agreed to allow on-site inspections of any test expected to exceed 75 kilotons. This meets the position taken by the United States when bilateral negotiations on the issue opened in 1987. Washington subsequently stiffened its demand, asking that all blasts above 50 kilotons be covered.



Seismic diplomat. *Scripps Institution geophysicist Berger helped with negotiations.*

The Soviets originally would allow no more than a few on-site inspections using the laborious U.S. method known as Corrtex, for Continuous Reflectometry for Radius versus Time Experiments. The method involves burying special electronic cables near Soviet nuclear weapons, and it cannot be used to verify compliance with a comprehensive nuclear test ban—a feature that some officials say is the reason Washington has been such a strong advocate of Corrtex.

The Soviets still have not accepted a U.S. demand for a minimum of two inspections each year, even when no high-yield blasts occur, and they are insisting on the right to install a seismic network of their own at the Nevada test site, an unresolved issue.

However, some congressional advocates of a comprehensive ban are encouraged. Senator Edward Kennedy (D–MA), who is pleased with the Pentagon's change of heart about the seismic stations, observes that "too often in the past, opportunities for U.S.–Soviet scientific cooperation to improve verification have been wrongly viewed as undermining short-term negotiating goals."

Advocates of the new Pentagon-funded network also portray it as consistent with the President's highly publicized proposal to conduct trial inspections of weapons that may be limited under a new arms treaty, a proposal the Soviets have informally said they will accept. ■ **R. Jeffrey Smith**

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Hipparcos: In the Low-Orbit Blues

The European Space Agency's (ESA's) new $300-million Hipparcos astronomy satellite has become a world-class exercise in frustration: after a perfect launch aboard an Ariane 4 rocket on 8 August, it is now functioning beautifully—in the wrong orbit.

The failure lay in the Apogee Boost Motor, a small solid-fueled rocket atop the Ariane that was to have lofted Hipparcos from the low Earth orbit where Ariane left it to the distant geostationary orbit where it was to operate. Although identical boosters have fired successfully on 26 previous missions, this one did nothing: at ESA's first command to ignite shortly after launch and at every urgent attempt thereafter, it has stayed silent.

At ESA's control center in Darmstadt, West Germany, the speculation is that the booster suffers from a short circuit. Whatever the reason, the drama is inexorably coming to a close. Although one last firing attempt was being considered as *Science* went to press, the spacecraft's battery power was running low. If that attempt fails, the controllers would be forced to extend Hipparcos' solar panels, which cannot be refolded. And this means that the booster could no longer be used, even if it did recover: the acceleration would rip the solar panels off and destroy the mission entirely.

Meanwhile, working under the assumption that Hipparcos will be stranded, the science team has been frantically improvising new plans to see what they can salvage of the spacecraft's original mission, which is to map the position of some 120,000 stars to an unprecedented degree of accuracy. Fortunately the picture is not completely bleak. Data-taking should be no problem, since Hipparcos itself is in excellent condition. And its orbit—a highly elliptical path ranging in altitude from 210 kilometers to 3600 kilometers—puts it in no immediate danger of reentering Earth's atmosphere. Indeed, the tentative plan is to raise the low point by several hundred kilometers by firing the spacecraft's tiny hydrazine thrusters, which were intended for keeping it stable. The Hipparcos scientists believe that the resulting orbit, although far from optimal, should allow them to recover a substantial fraction of the science they planned to acquire.

■ **M. Mitchell Waldrop**