Did Test Ban Watchdog Fail to Bark?

Critics fault the seismic detection system for missing one announced Indian blast and are trying to cut its budget, but seismologists believe the test didn't match India's claims

Seismologists who watch for tremors caused by nuclear tests are puzzling over a problem like one that intrigued Sherlock Holmes: the dog that didn't bark in the night. In their case, the watchdog is a sprawling web of sensors that encircles the globe, programmed to monitor compliance with the Comprehensive Test Ban Treaty (CTBT). It sounded an alarm on 11 May, when India set off a cluster of underground bomb tests. But on 13 May, the same system remained strangely silent at a time when the Indian government claimed to have detonated another set of nuclear explosions equal to 800 tons of TNT. The sensors saw and reported nothing.

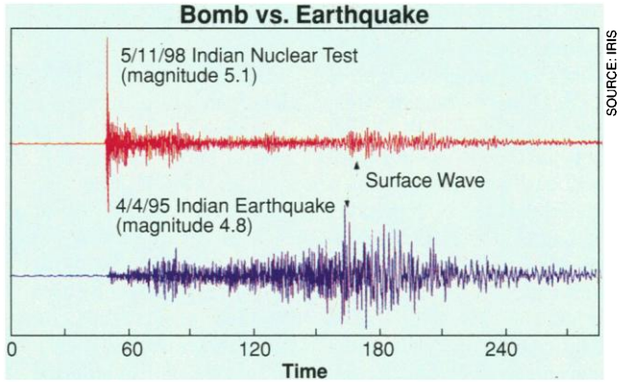
The network's apparent failure to detect all of India's explosions has given ammunition to those in Congress who oppose the treaty and led critics to argue that the seismic network can't be trusted to detect small tests. For example, the Center for Security Policy in Washington, D.C., headed by CTBT critic Frank Gaffney, said on 19 May: "It has now been established that if India (or other nations) wish[es] to conduct nuclear tests in the future—even after pledging not to do so—they can be reasonably sure of getting away with it."

But a strong consensus has emerged among U.S. seismologists that the system in fact worked well. It immediately and convincingly detected the 11 May Indian blasts and those set off by Pakistan on 28 and 30 May. And, based on that performance, a dozen specialists consulted by *Science*—from both government and private labs—say that even though the system's design limit is 1000 tons, it should easily have detected the claimed 800-ton blast on 13 May. Indeed, most believe a blast as small as 100 to 200 tons would have been picked up. Says geophysicist Hans Hartse of the Los Alamos National Laboratory in New Mexico, "[India's] claim of 800 tons would have been visible all over the world."

This has led some experts to suggest that the 13 May tests may have been at most small subcritical blasts fueled by chemical explosives—"hydrodynamic" experiments of the type detonated frequently by U.S. and Russian weapons engineers and not considered a bomb test under the CTBT. India has released few details, other than to say these were "low-yield" nuclear explosions.

The controversy is likely to play a role in the continuing debate over whether the United States should ratify the CTBT. Although President Clinton signed the treaty in September 1996, the Senate has not approved it. Several powerful senators, including Foreign Relations Committee chair Jesse Helms (R–NC), oppose the measure, arguing that it would hamstring U.S. weapons designers while permitting nonsignatories—which include India and Pakistan—to go on testing. Critics like Gaffney also argue that if the monitoring system can't detect small explosions, even a nation that has signed the treaty could get away with clandestine testing. Republican Majority Leader Trent Lott (R–MS) calls the treaty "unverifiable" and has delayed putting it on the Senate's schedule.

The performance of the monitoring system could also affect how it fares in the face of a more immediate threat. Last week, the House Appropriations Committee voted to delete $25 million from the Administration's 1999 funding request to support the International Data Center (IDC), which monitors the seismic network that helps enforce adherence to the treaty. Not cut in the House bill are funds for industry and peer-reviewed university research on monitoring. According to an appropriations subcommittee report: "The recent nuclear tests in South Asia raise serious concerns about the [Defense] Department's ability to support a robust operational nuclear test monitoring program." IDC backers will be trying to persuade Congress in the next few weeks to restore funding.



Seismic signatures. Signals from the 11 May Indian test (red) and a similar sized earthquake (blue) recorded by a seismometer at Nilore, Pakistan.

The nerve center

At ground zero in this debate is a global web of 35 primary seismic monitoring stations called the International Monitoring System (IMS), supported by 58 auxiliary stations that can be queried for data as needed. The United Nations, which oversees the system, plans to expand it in a few years to a 50-station main network supported by 119 auxiliary stations. Complementary systems will be added over the next 4 years to provide different kinds of data to back up the seismic information. These include 80 sensors that monitor radionuclides in the atmosphere (15 are now running), 11 hydroacoustic devices to pick up blasts at sea, and a group of 60 infrasound microphones to detect airborne low-frequency waves from distant blasts—including large chemical explosions. The radionuclide system is already generating reports on minor leaks from commercial reactors and radio pharmaceutical plants.

All these data will be fed into the IDC analytical group, now staffing its headquarters in Vienna, Austria. A prototype IDC is currently operating in Arlington, Virginia, and U.S. and other Western governments are providing most of the technical support to get the network and data center running.

Even though the network is far from complete, experts who support the IMS and IDC say the system had no trouble spotting the 11 May blast. "All of our beepers went off about an hour after the detonation," says Richard Gustafson, a U.S. Defense official involved in developing the IMS. Like other members of this technical support group, Gustafson carries a phone beeper that is triggered when computers see a large seismic signal from a location targeted for observation.

Skeptics of the IDC's performance on 11 May have pointed out that the system's initial alert placed the Indian seismic signal as originating from 57 kilometers below the surface—not consistent with a bomb test. Gustafson responds that automatic event reports like the one from India on 11 May are not expected to give precise locations. They're meant to alert staffers to the need for more thorough analysis, he says. The IDC issued a more precise bulletin later, but by then, India had informed the world.

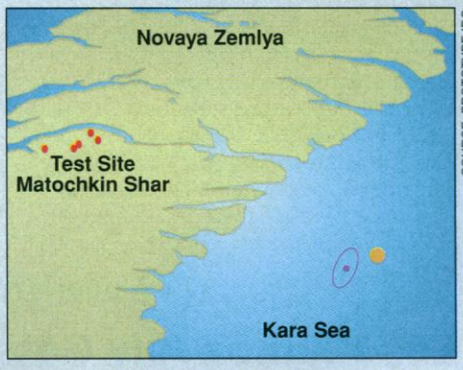
A State Department arms control official,

Novaya Zemlya: The Quake That Roared

When distant tremors arrive from an area near a nuclear test site, scientific interpretations don't always square with political views of the event. This summer, seismologists are challenging India's official version of two bomb tests announced in May (see main text). Last summer, they differed with the U.S. Central Intelligence Agency (CIA) and other agencies over claims that Russia had detonated a nuclear blast at a test site on the Arctic island of Novaya Zemlya. In the Russian case, the CIA later retreated, without openly conceding an error. Researchers involved in the episode argue that the events illustrate the benefits of open scientific analysis of suspect signals.

The Novaya Zemlya incident began on 16 August 1997 when a seismic wiggle (below 4 in Richter magnitude) appeared on northern European sensors. The signal was traced to an Arctic region that isn't usually seismically active, making it look suspicious. However, a computerized grid of sensors called the International Monitoring System (IMS), launched in 1995 to support the nuclear Comprehensive Test Ban Treaty, quickly came up with a preliminary location. Within an hour, this largely automated network placed the source at a point off Novaya Zemlya's eastern coast—in the Kara Sea. Staff analysts at the IMS's prototype International Data Center in Arlington, Virginia, issued a more thorough bulletin within a few hours, placing the source 130 kilometers at sea, suggesting an earthquake (see map). Geophysicists using data from an academic consortium run by the Incorporated Research Institutions for Seismology (IRIS), in Washington, D.C., also reached this conclusion within hours.

U.S. intelligence agencies, however, relying on a narrow data set from "secure" sensors and satellite imagery, had a different interpretation. They concluded that the Russians had conducted a small nuclear blast, apparently breaking a test moratorium. On the advice of the intelligence experts, the U.S. secretary of state summoned the Russian ambassador to the State Department on 20 August 1997 to complain about the alleged bomb test. The Russians responded that they had not conducted a test; they said the signal had come from a small offshore quake.



False charge. The United States accused Russia of nuclear testing, but international seismic monitors traced tremors to an offshore quake. (Estimated location 1 hour after the event, *purple*, and final estimate, *orange*.)

As reported later in *The Washington Post*, U.S. intelligence analysts had based their conclusion in part on photos showing activity at the Russian test site—such as the laying of cables in a shaft—on 14 and 16 August, just before the small tremor. In retrospect, analysts have concluded, the Russians may have been working on a hydrodynamic test—a type of non-nuclear explosion run by U.S. and Russian weapon designers to test bomb materials.

U.S. seismologists say that intelligence analysis initially relied on seismic data from a few, similarly aligned stations, making it difficult to triangulate the event. Had they relied on information from other public sources, they might have determined immediately that the signals didn't come from the test site. "It now appears that the basic tenets of good science—consideration of all data, independent review, and open analysis—may also ... be the new basic tenets of good treaty monitoring," says Gregory van der Vink, director of planning for IRIS.

In a grudging clarification, the CIA issued a public comment on 4 November 1997. It noted that an outside panel of experts had "concurred in the CIA's assessment" that the Russians had conducted "nuclear weapons–related experiments" in August 1997. It added that "during the same time frame," a seismic event occurred "in the Kara Sea," stressing the uncontested fact that "experts cannot say with certainty whether the Kara Sea event was an explosion or an earthquake." **–E.M.**

speaking on background, said the IDC "detected and located with high accuracy the Indian and Pakistan events in a very timely manner; it was clearly a success for the emerging CTBT international monitoring system." And Terry Wallace of the University of Arizona, Tucson, says even the preliminary IDC bulletins generated "pretty darn good locations." But some of the best data, according to Wallace and other seismologists, came from a station at Nilore, Pakistan, which is part of an academic research consortium, the Incorporated Research Institutions for Seismology (IRIS) in Washington, D.C. As an IMS auxiliary station as well, Nilore has a dual role.

Located just 750 kilometers from the Indian test site, Nilore is an "open" research source—unlike many other IMS stations. This means that anyone can see its raw data, and academic researchers have been giving its seismic traces a thorough going-over. The director of planning for IRIS, Gregory van der Vink, says open stations have been instrumental in helping the IDC decipher the Indian and Pakistani tests. But he adds, "It's not clear yet whether the scientific community will be receiving a similar courtesy from the IMS." The U.S. Defense Department and other national agencies are pressuring the IDC not to release raw data on a rapid basis. So far, IDC has complied.

Missing kilotons?

Just how well the system performed in estimating the size of the Indian and Pakistani blasts is, however, more difficult to assess, because there are no onsite measurements to compare the seismic data against. Pakistan has not released technical information on its blasts, nor has it responded to a request for data from *Science*. The Indians have been far more forthcoming. Physicist Satindar K. Sikka, associate director of India's Bhabha Atomic Research Center in Mumbai, said in a faxed statement to *Science* last week that India detonated three devices "simultaneously" on 11 May: a 45-kiloton thermonuclear bomb (which included a 15-kiloton fission primary), a second 15-kiloton fission device, and a 0.2-kiloton device. Each was detonated in its own vertical shaft, the first two separated by "about a kilometer," Sikka says, and the third about 2 kilometers away. This total estimate of about 60 kilotons is slightly higher than India's initial claim of 55 kilotons.

Experts studying data from IMS and a consortium of IRIS and U.S. Geological Survey stations have concluded, however, that the combined yield from this set of tests was much smaller than 60 kilotons. "There's something really fishy going on," says geophysicist Jeffrey Park of Yale University.

Wallace has been comparing the "very well recorded" seismic traces of the 11 May blast with waves from India's 1974 test—estimated by the Indians at 12 kilotons. "We can do a really good relative yield estimate," says Wallace, and the seismic analyses are converging. He has concluded that the 11 May yield was a factor of 2.1 to 2.2 larger than the 1974 test, and, Wallace says, "most

people think the [1974] test was on the order of 6 to 8 kilotons." Expressing a widely held view, Wallace says that if shock waves from the recent Indian test were "well coupled" to surrounding rock, "you're going to be pushing 20 kilotons at most for the 11 May test."

Park agrees. He says that if the early readings available for the 11 May seismic signal—from 4.7 Richter magnitude on the IMS network to 5.1 for IRIS's Nilore station and 5.4 on the Geological Survey system—are scaled to the qualities of rock under India's test site, they "lead to an estimate of 20 to 25 kilotons, and really more like 20" for the 11 May explosion. Allowing for geological anomalies, many seismic experts consider the upper bound to be 30 kilotons or so. Others note that it's standard to assume a factor of 2 uncertainty in such calculations, leading to an upper bound of 40 kilotons.

Although Pakistan has published no official estimates, U.S. analysts conclude from seismic data that its first bomb test on 28 May was a bit smaller than India's first. And the final Pakistani blast on 30 May appears to have been a great deal smaller, according to Los Alamos's Hartse. He says it appears to have been in the range of 1 to 5 kilotons. Nilore, unfortunately, reported no data for these explosions because that station, based at Pakistan's nuclear research center, was presumably disconnected from the network 2 hours before Pakistan began testing. (It's now back on line.) India's nuclear experts, according to Sikka, calculated from their local seismic data that the first and second Pakistani explosions had yields of 5 to 10 kilotons and 2 to 4 kilotons, respectively.

India's second round of tests, on 13 May, presents more of a puzzle. According to Sikka, India simultaneously detonated two "low-yield" devices of 0.3 and 0.5 kiloton in vertical shafts. He says that "only regional seismic recorders and closeup arrays have picked up this 13 May signal." He promised that the local seismic data "will soon be released."

International experts will be eager to see those data, because their instruments picked up no signals at all. Wallace, for example, says he searched through 6 hours of records on either side of the announced zero hour, and the blast "simply isn't there." Many experts believe that some signal ought to have appeared at Nilore, which was running and reporting small earth tremors at the time. Indeed, Hartse estimates that an explosion in the range of "tens of tons" would have been detected. Others, like Wallace and Park, allow a bigger margin of error, saying the maximum blast that might have escaped detection would have been about 100 tons.

Terry Hawkins, acting director of Los Alamos's nonproliferation and international security division, says he has examined photos of the 13 May test hole released by India. The small mound of sand over ground zero indicates a "very, very low yield," he says, suggestive of a hydrodynamic test powered by chemical explosives. Such tests can provide critical information on how bomb components may perform in a nuclear explosion, but they are not considered to be nuclear tests. Sikka responds that "without the knowledge of the depth of the blast, it is highly unscientific to come to such a conclusion."

Indian officials offer some theories for why seismic sensors might have missed the 13 May tests and made the earlier round of explosions look small. Sikka suggests that because several explosions took place simultaneously in both tests, the seismic waves may have interfered with one another, diminishing their apparent magnitude. He also suggests that unspecified geological irregularities could have interfered with signal transmission. And the second round of tests, Indian officials have said, took place in a "sand dune," which muffled the shock. Another Indian expert suggests that other techniques could have been used to diminish the signal. But Hartse says an 800-ton blast would certainly have been visible even in sand, and others say they can see no reason why India would have wanted to muffle the explosion.

The only way to resolve the debate about blast yields may be through independent studies of the bomb test sites. These might provide a clear indication of just how well the seismic watchdog performed. But at the moment, neither India nor Pakistan is ready to invite such inspections.

–Eliot Marshall

With reporting by Pallava Bagla in New Delhi.

CABINET APPOINTMENT

Los Alamos Ally Gets Top DOE Post

Ending months of speculation, President Bill Clinton last week said he would nominate U.S. United Nations Ambassador Bill Richardson to succeed Federico Peña as head of the Department of Energy (DOE). The move would put a former seven-term congressman whose district included DOE's oldest weapons lab at the helm of the $16.6 billion department. Richard Holbrooke, a former State Department official, was named to replace Richardson.

Richardson, 51, is expected to win easy—although not necessarily swift—confirmation by the Senate. "He's well respected on both sides of the aisle," says one Republican staffer.

DIANA WALKER / GAMMA LIAISON

Friendly boss. Richardson's New Mexico district included DOE weapons lab.

While a legislator, Richardson served as a self-appointed troubleshooter, negotiating with foreign leaders from hot spots around the globe—experience that served as a good apprenticeship for the U.N. job, which he took 18 months ago. "He's bright, he's very active, and I think he'll be very successful," says one senior DOE official familiar with the ambassador.

He is also popular at DOE's Los Alamos National Laboratory. "We love him," says lab spokesperson Jim Danneskiold. While in Congress, Richardson represented the New Mexico district that includes Los Alamos, the largest employer in the northern part of the state. "I'm truly delighted," adds Los Alamos director John Browne, who notes that Richardson has "superb insight" into the lab's science, energy, and nuclear weapons programs. Although he did not serve on defense or DOE oversight panels, Richardson worked closely with lab officials on economic development issues.

Richardson wasted no time in backing DOE's most prominent effort, the $4-billion-plus stockpile stewardship program. "The department's ability to maintain a safe and reliable stockpile" is the key to securing a Comprehensive Test Ban Treaty, he said at a White House ceremony on 18 June, adding that Los Alamos must play a leading role in cleaning up the nuclear waste from the Cold War. Clinton praised Richardson's "extensive, firsthand experience" on energy issues, adding that national security and economic growth "will require the greatest energy from our labs, from our scientists and technology, and from an Energy Department that can work clearly with the private sector."

If confirmed, Richardson would be the second Hispanic in a row to hold the post. Peña leaves office at the end of the month, and DOE Deputy Secretary Betsy Moler is expected to run the department until Richardson is confirmed, a process that could take months. Moler was in line for the top job before Peña, transportation secretary during Clinton's first term, was nominated in January 1997. She was also regarded as a leading contender after Peña announced in April that he would be stepping down.

–Andrew Lawler