96-631 F
July 17, 1996

Indian and Pakistani Nuclear Tests? Potential Test Ban Risks and Technical Benefits

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Summary

During the negotiations on the Comprehensive Test Ban Treaty (CTBT), India blocked the draft treaty from becoming an official Conference on Disarmament document; subsequently, India and Pakistan have refused to sign the treaty. Nonetheless, entry into force requires ratification by 44 specified nations with nuclear know-how; the list includes India and Pakistan. India holds that the CTBT must be a step toward disarmament, and insists that a treaty include a commitment by the five nuclear states to eliminate their nuclear weapons by a set time. Pakistan has declined to join the treaty unless India does, although this position was under review in mid-1998 This impasse could doom the treaty.

By not signing the CTBT, India and Pakistan preserved their option to conduct nuclear weapon tests. While they incurred diplomatic costs by testing, a test program would appear to offer India in particular large *technical* benefits, the pursuit of which might help explain its nuclear weapons-related efforts and diplomatic strategy. These potential Indian technical benefits may also help explain Pakistan's unwillingness to sign the treaty unless India does and Pakistan's unwillingness to test first. This report discusses what appears to be the technical logic of both nations' nuclear programs. To introduce key terms, it describes how a nuclear weapon works. It describes each side's weapons programs and explores possible links of Indian and Pakistani strategic goals to those programs. Finally, it examines potential technical gains from testing and concludes that India may feel the stronger compulsion to test.

Nuclear Weapon Operation

In simple nuclear weapons of the type Pakistan is thought to be working on, a layer of chemical explosive surrounds a hollow "pit" containing fissile uranium-235 or plutonium-239. Detonating the explosive creates an implosion wave that compresses the

pit, making it go critical and causing a nuclear explosion.[1] Thermonuclear weapons, which India may be pursuing, have two stages. The primary stage is a simple nuclear weapon but with hydrogen isotopes (deuterium and tritium) inside the pit. The heat of the fission reaction makes them undergo fusion, releasing neutrons that enhance the fission reaction and "boost" explosive yield sharply. The secondary stage, containing lithium-6 deuteride and uranium, adds most of the yield.[2] X-rays from the primary explosion flow through a metal radiation case to the secondary. They transfer energy to compress and ignite the secondary, causing fusion of tritium (generated from lithium-6) and deuterium, and fission of uranium.

Indian and Pakistani Strategic Goals and Weapons Programs

India and Pakistan have differing strategic goals that shape their nuclear weapon programs. Pakistan primarily feels the need to deter India. This goal could arguably be met with a modest number of simple nuclear weapons on bombers or short-range missiles, as some major Indian cities are near the border. (New Delhi is about 350 km away; Bombay is roughly 600 km away.) Partly because of its limited resources and small science and technology base, Pakistan's program is thought to be focused on a simple fission bomb using uranium-235, a bulkier design than one using plutonium-239.[3] The program is becoming more sophisticated, however; China is said to be "helping Pakistan build a nuclear reactor suited for making plutonium for use in more powerful and compact nuclear weapons."[4]

Both for reasons of deterrence and perceived international status, India has long felt a need to acquire a nuclear delivery capability against China as well as Pakistan. Deterring China would be a formidable task. The long distance from India to many major Chinese cities would give China's large air force and air defenses a few hours in which to intercept bombers, rendering them of uncertain deterrent value. Long-range ballistic missiles are more credible, and India's large space program provides a technical infrastructure of use in developing them. Missile accuracy, however, tends to decrease as range increases. Missile inaccuracy and the characteristically low yield of fission warheads raise questions about the utility of this combination for destroying distant Chinese targets. The range requirement also places a premium on lightweight, high-yield warheads. The U.S. Department of Defense reports India's Agni missile, currently under

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[1] An even simpler weapon, in which two subcritical masses of uranium-235 are assembled explosively, is rarely used.

[2] "The secondary is the stage that produces high yields for modern U.S. strategic weapons -- typically hundreds of kilotons." U.S. Department of Energy. Office of Arms Control and Nonproliferation (NN-40). The National Ignition Facility (NIF) and the Issue of Nonproliferation. Final study, Dec. 19, 1995, p. 13.

[3] Pakistan's first choice was reportedly not the uranium route. "During the 1970s, Pakistan attempted to acquire from France a reprocessing plant that would have allowed it to extract weapons-usable plutonium from spent nuclear fuel. However, when Paris canceled the sale in mid-decade, Islamabad redirected its attention to the more promising route of highly enriched uranium." Mitchell Reiss, "Safeguarding the Nuclear Peace in South Asia," Asian Survey, Dec. 1993, p. 1109-1110.

[4] R. Jeffrey Smith, "U.S. Aides See Troubling Trend in China-Pakistan Nuclear Ties," Washington Post, April 1, 1996: 14.

development, has an intended range of 2,000 kilometers, a few hundred kilometers short of the range required to reach Beijing, Shanghai, and much of China's populous eastern coast.[5] Reducing the weight of a warhead for Agni would extend its range.

To deter China, which has dozens of missiles that can reach Indian targets,[6] India might want some tens of thermonuclear warheads and the missiles to deliver them. But building this force would be costly. Would India invest large sums in a nuclear deterrent without the assurance a test provides that the warheads would work? By the same token, while India's "peaceful" nuclear test of 1974 and its conventional force superiority may suffice to deter Pakistan, it is less clear if an upgraded Indian deterrent would be credible to China without one or more nuclear tests demonstrating that its weapons work.

India has taken steps that advance the development of modern thermonuclear weapons. William Webster, Director of Central Intelligence, testified in 1989 before the Senate Governmental Affairs Committee that certain indicators "tell us that India is interested in thermonuclear weapons capability." He said that India's research on lithium separation of stable isotopes "is just another indicator of interest leading toward capability." He noted India was producing plutonium in reactors not subject to international safeguards.[7] Other reported details of India's weapons program include production of tritium and uranium, and an "inertial confinement fusion (ICF) program at BARC [Bhabha Atomic Research Center]. An ICF facility would be useful in the study of phenomena associated with a hydrogen blast."[8]

How Testing May Help Indian and Pakistani Weapons Development

From a technical perspective, it appears that India and Pakistan could both learn much by testing. Testing confirms that a design works. This is more important for a sophisticated weapon, such as India may be pursuing, than for a simpler one such as Pakistan may be developing. Testing also provides information on explosive yield. A proliferant could not extrapolate from the behavior of materials during a conventional explosion to the behavior of materials during a nuclear explosion because temperatures and pressures in the latter case are so much greater. As a result, yield calculations would be unreliable without testing. Confirming the yield is probably more important for India, where yield has greater strategic significance and is less predictable given the type of

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[5] U.S. Department of Defense. Office of the Secretary of Defense. Proliferation: Threat and Response, p. 41. Other sources report Agni's range at 2500 km. See Leonard S. Spector et al., Tracking Nuclear Proliferation: A Guide in Maps and Charts, 1995. Washington, Carnegie Endowment for International Peace, 1995, p. 89.

[6] As of June 1994, China's strategic missile forces reportedly had 14 intercontinental ballistic missiles, at least 60 intermediate-range ballistic missiles, and one submarine carrying 12 submarine-launched ballistic missiles. International Institute of Strategic Studies, The Military Balance, 1994-1995. London, Brassey's, 1994, p. 170.

[7] U.S. Congress. Senate. Committee on Governmental Affairs. Nuclear and Missile Proliferation. Senate Hearing 101-562, held May 18, 1989. Washington, U.S. Govt. Print. Off., 1989, p. 16-17.

[8] David Albright, "India and Pakistan's Nuclear Arms Race: Out of the Closet but Not in the Street," Arms Control Today, June 1993: 13-14. Note that the United States, Germany, Japan, Russia, and some other nations have much larger ICF programs.

weapon design, than for Pakistan. In addition, a primary must have a minimum yield (and other characteristics) to drive a specific type of secondary.

Computer models ("codes") are the heart of a nuclear weapon design effort because they enable a weapon designer to examine and predict how a design might work. Codes are built from weapons physics equations, and integrate data from nuclear tests and nonnuclear experiments to model weapon behavior. Nuclear testing is the only source of much of the data needed to build codes.[9] For example, a test can provide such data on the progression of an explosion as the shape of the implosion wave and the flow and density of x-rays from primary to secondary. Code development and empirical understanding are iterative, with each supporting advances in the other.

India's ICF program at BARC might aid in developing codes for thermonuclear weapons. Ray Kidder, a retired Lawrence Livermore National Laboratory physicist with extensive experience in ICF and nuclear weapon physics, argues that "Weapons codes and ICF codes share much of the same physics, require similar mathematical, numerical and computer programming skills, and are sufficiently similar themselves that knowledge of one can be very useful in developing the other." He states further, "A consequence of these similarities is that an ICF implosion design group, comprised of physicists, numerical analysts, and computer programmers, constitutes a significant *de facto* nuclear weapons design capability. That is, such a group, regardless of its present intentions, could modify its computer programs for weapons use and adapt its skills and experience to the design of nuclear weapons on relatively short notice."[10] Similarly, the U.S. Department of Energy notes, "some of the computer codes that are used to predict behavior of an ICF target have much in common with codes used to design boosted primaries and secondaries."[11]

A key weapon characteristic is the yield-to-weight ratio (explosive yield per unit of warhead weight). Increasing this ratio increases the yield of a warhead of a given weight, or reduces the amount of weight to produce a given yield. Testing can help increase yield-to-weight. It can generate data for computer codes. It can confirm calculations on how design changes affect yield. Boosting enhances yield-to-weight; at least one test is probably needed to have confidence in a design. Testing can answer questions relevant to boosting, such as the maximum compression of fissile material under an implosion wave and the flow of neutrons through compressed fissile material. A thermonuclear design also increases yield-to-weight. Testing may be needed to develop such weapons, and is essential for having confidence in, and for refining, the design. Testing can provide data to help calculate the minimum primary yield needed to drive a secondary and can

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[9] There is an iteration between codes and tests. Codes help with weapons design, but code development requires test data. Conversely, weapons could be developed without codes, relying only on experimental data from testing, but that approach would be much more costly and time-consuming.

[10] Ray Kidder, "The International Inertial Confinement Fusion (ICF) Program and Its Relation to the Development and Proliferation of Nuclear Weapons," unpublished paper, Livermore, CA, May 5, 1995, p. 2.

[11] Department of Energy, The National Ignition Facility (NIF) and the Issue of Nonproliferation, p. 3.

examine the performance of the radiation case in transferring x-ray energy from the primary to the secondary.

If India is working toward the development of boosted primaries and thermonuclear weapons, testing could greatly increase confidence in its designs. Such designs could be expected to result in lighter, higher-yield warheads for missiles, whose carrying capacity over a given range is fixed and whose range can typically be extended by using a lighter warhead.[12]

For Pakistan, since simple fission weapons gain yield by using relatively large amounts of fissile material, modest improvement in yield-to-weight would enable a given amount of scarce fissile material to make more, or higher-yield, bombs. Testing could aid technical development in this area.

Few tests and little time may be needed to develop boosted primaries and thermonuclear weapons. According to Lewis and Xue, China conducted its first atomic bomb test in October 1964; a test of May 1966 proved the feasibility of a boosted fission weapon, a uranium device containing lithium-6; a test of December 1966 examined thermonuclear explosion fundamentals in a device using uranium and lithium; and in June 1967 China tested "a multistage thermonuclear bomb, a three-megaton device."[13] There are reasons to believe that India might be able to develop a thermonuclear weapon in less time (from a decision to proceed) than it took China: India's 1974 test, its work on weapons and on inertial confinement fusion, its extensive nuclear infrastructure,[14] and the tremendous advances in computing over the past three decades. It also appears that Pakistan could deploy a simple fission bomb without testing, but that a few tests could improve the performance of its weapons.

A test program could contribute to Indian and Pakistani weapons program technology in narrower ways. It could help "weaponize" a design, i.e., turn it into a workable weapon with required military characteristics such as safety, weight, volume, ruggedness, yield, and compatibility with the bomber or missile carrying the weapon. Testing may be crucial for mating a weapon with its casing (i.e., missile re-entry vehicle or bomb case). Testing would provide data of use in improving diagnostic equipment (which provides data from a test) and in containing debris from an underground test, and would provide seismic data that could be used to help determine how to detect or hide future tests.

Conclusion

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[12] As an example of the relation between range and payload, India's Prithvi missile "is designed to be deployed with a payload of 1,000 kilograms to a range of 150 kilometers (or 250 kilometers with a 500-kilogram payload)." U.S. Department of Defense. Office of the Secretary of Defense. Proliferation: Threat and Response. Washington, April 1996, p. 38.

[13] John Wilson Lewis and Xue Litai, China Builds the Bomb, Stanford, CA, Stanford University Press, 1988, p. 197, 201.

[14] Spector et al., Tracking Nuclear Proliferation, p. 92-95.

In theory, India's two-track strategy, a diplomatic stance of linking a CTB to nuclear disarmament by a date certain while apparently continuing work on thermonuclear weapons, has a certain logic, but given the virtual impossibility of the disarmament condition being met, the Indian approach appears to many to be mainly designed to create a rationale for not signing the treaty or even effectively blocking it, and for protecting its option to test. Some observers believe that an advanced weapons development program would support India's regional power aspirations and underscore its adamant opposition to acquiescing in China's local nuclear monopoly. Whether India's strategy -- placing the CTB at risk, threatening to resume testing, and trying to deter China -- actually serves its best interests is another matter.

Pakistan's strategy of not testing unless India does also has a certain logic. Pakistan can have high confidence without testing that its simple weapons would work. If India tests, a much smaller Pakistani weapon development and testing program might suffice to deter India. Yet it appears that India's strong technical lead would enable it to test and deploy sophisticated weapons quickly. Pakistan would come out second in a race to develop nuclear warheads of increasing sophistication, so it has every incentive not to start one. A Pakistani "no-first-test" policy would deny India an easy excuse to test, might focus world attention on barring Indian testing, and would likely force India to bear the blame if it resumes testing.

George Perkovich, an American analyst of international affairs, argues for "non-weaponized deterrence" for India and Pakistan, in which "deterrence derives from the power of each to construct nuclear weapons quickly." For this to be effective, both nations "would have to undertake a rather demanding set of confidence-building measures to assure each other and the international community that they have not built weapons."[15] They would seek to verify that nuclear delivery systems were not deployed, to bar nuclear weapon preparations going beyond what both agree is permissible, and to promote crisis stability.

Verifying a ban on certain types of weapon preparations would be difficult at best. The preceding discussion implies that the conduct of nuclear testing may well offer a meaningful, clear, and readily verifiable dividing line between permissible and impermissible weapon preparations. While testing would help Pakistan's weapons program somewhat, that nation is unlikely to test first under present circumstances. Should India decide to pursue a thermonuclear force, testing would be a crucial technical step. India has in place various pieces needed to quickly design, assemble, and test thermonuclear devices, so that with a relatively modest test program it could arguably weaponize a thermonuclear force. Testing by India would likely lead Pakistan to test and could prompt China to increase its nuclear weapons efforts and its nuclear aid to Pakistan.

At issue, then, for both nations is whether the potential costs of conducting a nuclear test program as part of a nuclear arms race -- costs that include a heavy fiscal burden, economic sanctions, international opprobrium, and the risk of a nuclear war -- outweigh the technical advantages that testing offers.

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[15] George Perkovich, "A Nuclear Third Way in South Asia," Foreign Policy, Summer 1993: 86.