Nuclear programs in India and Pakistan

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Abstract. India and Pakistan launched their respective nuclear programs in the 1940s and 1950s with considerable foreign technical support, especially from the United States Atoms for Peace Program. The technology and training that was acquired served as the platform for later nuclear weapon development efforts that included nuclear weapon testing in 1974 and in 1998 by India, and also in 1998 by Pakistan – which had illicitly acquired uranium enrichment technology especially from Europe and received assistance from China. As of 2013, both India and Pakistan were continuing to produce fissile material for weapons, in the case of India also for nuclear naval fuel, and were developing a diverse array of ballistic and cruise missiles. International efforts to restrain the South Asian nuclear build-up have been largely set aside over the past decade as Pakistani support became central for the U.S. war in Afghanistan and as U.S. geopolitical and economic interests in supporting the rise of India, in part as a counter to China, led to India being exempted both from U.S non-proliferation laws and international nuclear trade guidelines. In the absence of determined international action and with Pakistan blocking the start of talks on a fissile material cutoff treaty, nuclear weapon programs in South Asia are likely to keep growing for the foreseeable future.

INTRODUCTION

This article looks at the origin and evolution of nuclear programs in India [1] and in Pakistan [2], highlighting a certain degree of ambivalence in the politics and status of these nuclear programs in their early years, with both India and Pakistan claiming peaceful use but sensitive to the option of one day wanting to develop nuclear weapons. The United States played an important role in the initial years through the provision of technical training for would be nuclear scientists and engineers, and the transfer of technology. United States support for the nuclear programs in both these countries was seen as necessary alliance building in the context of the Cold War confrontation with the Soviet Union. This included U.S. efforts to recruit India as an ally to balance the emergence of Communist China, a dynamic that has resurfaced recently as China has come to be seen as a possible peer competitor for the United States.

India has militarized its nuclear program, with nuclear testing in 1974 and 1998, the accumulation of a stockpile of fissile material and the development of nuclear weapons delivery systems, including short and long range ballistic missiles. The search for a triad of delivery systems, including ballistic missile submarines, and multiple warhead missiles suggests India is following in the footsteps of the United States, Russia, Britain, France and China. India is also seeking missile defense and anti-satellite military capabilities. Taken together these developments suggest India is seeking strategic capabilities to put it at least on a par with China and more broadly establish it as a major power. The United States has committed to assist in supporting the rise of India as its long-term strategic partner.

Pakistan has developed its nuclear weapons as part of its search to balance India's much larger conventional military, economic and political power. To achieve strategic parity with India, Pakistan has relied on an illicit nuclear technology procurement network and extensive direct assistance from China. It is seen as now having the fastest growing nuclear weapon arsenal of any state. As part of this effort, Pakistan is moving to greater reliance on lighter and more compact plutonium-based weapons and from aircraft-delivered nuclear bombs to nuclear-armed ballistic and cruise missiles. To ensure that its nuclear buildup can continue, Pakistan has been blocking talks on an international treaty to ban the production of fissile material for nuclear weapons. A longer-term concern now driving Pakistan's nuclear program is the prospect of a much stronger US strategic relationship with India driven by the United States' policy of seeking India as an ally to counter the rise of China as a potential great power competitor.

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INDIA'S NUCLEAR PROGRAM

India became independent from the British Empire in 1947. One of the first acts of the new state was to establish in 1948 the Indian Atomic Energy Commission. In introducing the legislation, Prime Minister Jawaharlal Nehru explained what he saw as the role of nuclear energy: "I think we must develop it for peaceful purposes… Of course, if we are compelled as a nation to use it for other purposes, possibly no pious sentiments of any of us will stop the nation from using it that way." [3] With the U.S. atomic bombing of Hiroshima and Nagasaki in 1945 still fresh in the minds of many people, it is hard to imagine Nehru's suggestion of using nuclear energy for "other purposes" being a reference to anything other than India one day choosing to develop nuclear weapons.

Lacking domestic capabilities and seeking to build a nuclear infrastructure, India acquired in 1954 its first research reactor, Apsara, from Britain. It also sought training in nuclear science and engineering. The U.S. Atoms for Peace Program provided a platform. Between 1955 and 1974, over 1100 Indian nuclear scientists trained in the United States.[4].

India acquired the CIRUS heavy-water moderated natural uranium fueled research reactor from Canada. It was modeled on the Canadian NRX reactor that had been used to make plutonium for the Manhattan Project. The heavy water for CIRUS was supplied by the United States. The reactor and heavy water were supplied strictly for peaceful purposes. It went critical in 1960. Plutonium was separated from CIRUS spent fuel at the Trombay reprocessing plant, which India acquired in 1964. The plant was based on blueprints supplied by a U.S. company. With these facilities, India had acquired a latent nuclear weapons capability. Prime Minister Jawaharlal Nehru chose not to exercise this nuclear option, however.

India could conceivably have acquired nuclear weapons through another route. The successful Communist revolution in 1949 in China posed a major problem for the United States in its Cold War contest with the Soviet Union. The United States looked to newly independent India as the only potential regional power able to compete with Communist China in Southeastern Asia.[5] In 1964, concerned about China getting nuclear weapons, the United States considered helping India by providing India nuclear weapons under U.S. custody, modifying Indian aircraft and training air crews for nuclear use, and even considered sharing a nuclear device to test in India.[6] The U.S. eventually decided against such nuclear sharing, and Jawaharlal Nehru in any case was expected to reject such an offer.

While India chose not to develop nuclear weapons in the 1960s, despite having the capability to do so, it was also unwilling to forgo the right to do so. The nuclear Non-proliferation Treaty was opened for signature in 1968 and came into force in 1970. The treaty defines a nuclear weapon states as one that had tested a nuclear explosive before 1 January 1967. These states are United States, Russia, Britain, France and China. All other states are by definition non-nuclear-weapon states under the Treaty. India has refused to sign the treaty since it can do so only as a non-weapon state.

India eventually militarized its nuclear program, carrying out its first nuclear explosion in 1974. The test was of a Nagasaki-type plutonium implosion bomb. The plutonium was produced in CIRUS and separated at Trombay. As a result, the United States banned nuclear trade with India and led the effort to set up the international Nuclear Suppliers Group of countries to agree guidelines to prevent future diversion to weapons use of nuclear facilities and materials supplied for peaceful purposes. Among other restraints, these guidelines banned nuclear trade with countries that were not signatories to the NPT, which included India, Pakistan and Israel.

India did not carry out another test for over 20 years. Until, in 1998, it conducted a series of five nuclear test explosions, including of a two-stage fission-fusion thermonuclear weapon and a device that used reactor-grade plutonium. There is a dispute over the yields of the test in 1974 and those in 1998, with independent estimates from seismologists suggesting a significantly lower yield than claimed by Indian officials.[7] There also has been a debate in India over the success of the thermonuclear weapon test, with nuclear program insiders making public that the yield of the thermonuclear device "was much lower than what was claimed."[8] This has been used by Indian advocates of further nuclear testing as an argument for why India should not sign the Comprehensive Test Ban Treaty. India has however maintained a unilateral moratorium on nuclear testing since 1998.

India has been building up a stockpile of separated plutonium and highly enriched uranium (HEU). The International Panel on Fissile Materials (IPFM) estimates that as of 2013, India has a stockpile of about 550 kg of weapon plutonium, with an uncertainty of ± 30%.[9] Most of this weapon plutonium was produced at the CIRUS and Dhruva reactors at the Bhabha Atomic Research Center, near Mumbai. CIRUS was shut down at the end of

2010 but a new larger production reactor is planned to replace it. The 100 MW Dhruva reactor, which was commissioned in 1985 continues to operate.

IPFM estimates that India also has a stockpile of 4.7 tons of separated plutonium from heavy water power-reactors as of 2013. This plutonium is unsafeguarded and weapon-useable. India has claimed that this plutonium is intended for use as fuel for its planned fleet of fast breeder reactors. The under construction 500 MWe Prototype Fast Breeder Reactor (PFBR), to be fueled by power-reactor plutonium, is planned to be commissioned in 2014. There are plans for 4 additional breeders.

While the fuel in the cores of these breeder reactors would be plutonium recovered from heavy water power reactor spent fuel, these breeder reactors would be able to produce weapon-grade plutonium in their blankets. It is estimated that at 75% efficiency the PFBR will be able to produce annually about 140 kg of weapon-grade plutonium per year, a major increase in India's existing rate of production of plutonium for weapons.[10]

India is also producing HEU. It is believed that this is mostly for naval fuel. IPFM estimates the HEU stockpile as of 2013 to be about 2.4 tons, with an uncertainty of ± 40%.[11] This is intended to fuel India's nuclear submarines, which may require an enrichment of 30% uranium-235, significantly below the 90% uranium-235 enrichment level associated with nuclear weapons. India may also be enriching to this higher level.

Uranium enrichment takes place at the Rattehalli Rare Materials Plant, near Mysore, that has been operating since 1990. The site is being expanded. Satellite imagery suggests new enrichment halls are being added at the Rattehalli site. Along with adding more machines, India is moving to new generations of more powerful centrifuges that have possibly 10 times the separative capacity of earlier designs. India also has announced plans for a second site, the Special Material Enrichment Facility, to be built at Chitradurga. The new facility may be used for enrichment of HEU for nuclear submarines and for weapon purposes in addition to production of low-enriched uranium for power reactors.

There will be growing demand for HEU from India's nuclear navy. The reactor in the first nuclear submarine INS Arihant went critical in August 2013 and the vessel is undergoing sea trials in 2014 prior to deployment. A second submarine, INS Aridaman, is under construction. Work on a third submarine is at an early stage. Plans call for Arihant submarines to carry 12 submarine launched ballistic missiles (SLBMs) with a range of 700 km, and in future even longer range SLBMs. These SLBMs are only part of diverse array of missiles that have been under development and some of which are deployed (see Table 1).[12] India also has bombs to be delivered by aircraft.

Table 1. Indian nuclear capable missiles

Missile	**Range**	**Status**
Prithvi (liquid-fueled)	150-350 km	deployed
Agni I	700 km	deployed
Agni II	2000 km	deployed
Agn III	3000 km	operational tests
Agni IV	4000 km	R&D
Agni V (3 warheads)	5000 km	R&D
Agni VI (10 warheads)	10,000 km	R&D
K-15 SLBM	700 km	(R&D)
Shourya (silo-based)	700 km	R&D)

Since 2006 India has been developing a missile defense capability by conducting missile interceptor tests. It now claims to have an intercept capability against 2000 km range ballistic missiles, which matches the reported capability of Pakistan's longest range ballistic missile (see below). The Defense Research and Development Organisation (DRDO) claimed in 2011 that "Our BMD programme has matured, and it is really ready now for integration into the air defence assets of the country."[13] More advanced military capabilities are also being sought. In 2012, the head of DRDO reported that "we have developed all the building blocks for an anti-satellite (ASAT) capability."[14] This is presented in India as an attempt to match the ASAT capability demonstrated by China.

PAKISTAN NUCLEAR PROGAM

Pakistan launched its nuclear program much later than India. The decision was announced in late 1954 and coincided with a meeting between Pakistan's prime minister and President Eisenhower at the White House, in

Washington DC. The announcement was a way for Pakistan to show its support for President Eisenhower's Atoms for Peace Program which he had made public in a speech at the United Nations in December 9153. Pakistan's initiative was part of its larger set of efforts to build close political, economic and security relations with the United States.[15] Earlier in 1954, Pakistan and the United States had signed a Mutual Defense Agreement and Pakistan had started receiving increased levels of U.S. military and economic aid.

Under the Atoms for Peace Program, over 100 Pakistani scientists and engineers came to the United States for training. In the 1960s some of these returning scientists pressed without success for Pakistan to begin a nuclear weapons program. Among them was Munir Ahmad Khan, who trained at Argonne in the 1950s and later became the head of the Pakistan Atomic Energy Commission (PAEC).

Pakistan followed India in refusing to sign the NPT. In 1972, Zulifkar Ali Bhutto, a long term advocate of Pakistan having nuclear weapons assumed power as Pakistan's leader and ordered a nuclear weapons program. He was close to Munir Ahmad Khan and put him in charge of the weapons program.

Pakistan is believed to have acquired a basic nuclear weapons capability in the 1980s but did not carry out any explosive nuclear tests until 1998. The Indian nuclear weapon tests in early May 1998 provided an opportunity and within weeks Pakistan carried out six nuclear weapon tests. The weapons, according to Pakistani accounts, included a boosted design as well as low-yield devices.[16] As with the Indian tests, the officially claimed yields for these nuclear tests are disputed.[17]

The fissile material used in these weapons was HEU. Estimates of Pakistan's HEU production capacity are very uncertain. It is known that Pakistan uses centrifuges. Information on the total number of centrifuges and their enrichment capacity is poorly constrained, however. Pakistan has acquired designs for possibly four centrifuge generations, with separative work capacity ranging from 1-2 SWU for the first generation P-1 machine to 20 SWU for the advanced fourth generation P-4 machine. By the early 1980s the Kahuta enrichment plant was producing HEU for weapons. A second plant at Gadwal was set up later. IPFM estimates that as of 2013 Pakistan has a stockpile of about 3 tons of HEU, with an uncertainty of ± 40%.[18]

Pakistan had illicitly acquired its uranium enrichment centrifuge technology from Europe through Abdul Qadeer Khan who had worked for a Dutch company producing centrifuge components.[19] Khan went on to become the head of the Kahuta facility. According to A.Q. Khan, in the early years of Pakistan's uranium enrichment program, China supplied uranium hexafluoride (the gas used in centrifuges), weapon-grade HEU, design details for a nuclear weapon, and technical help. In 2004, Khan was arrested for running a black market network selling Pakistani centrifuge technology, and in some cases a weapon design, to Iran, North Korea and Libya and possibly other countries.

Pakistan also produces plutonium for weapons. The 40-50 MW Khushab-I heavy-water reactor was built, with Chinese assistance, in the 1980s and 1990s and began operating in 1998. Like India's CIRUS reactor, it is based on the Canadian NRX design. A second Khushab reactor started-up in 2009/2010 and two additional reactors are still under construction. They all appear to have similar capacities. IPFM estimates that as of 2013, Pakistan may have a weapon plutonium stockpile of about 150 kg, with an uncertainty of ± 30%.[20]

One reason for the large commitment of resources to plutonium production may be to build lighter and more compact warheads for use on the array of ballistic and cruise missiles that Pakistan has been developing (table 2).[21] Pakistan also has nuclear bombs delivered by aircraft.

Table 2. Pakistan's nuclear capable missiles

Missile	Range	Status
Ghaznavi	300 km	deployed
Shaheen I	600 km	deployed
Shaheen II	2500 km	R&D
Ghauri (liquid fueled)	1500 km	deployed
Babur ground-launched cruise missile	700 km	R&D
Raad air-launched cruise missile	350 km	R&D
Nasr	60 km	R&D

The Shaheen I missile is believed to be derived from the Chinese M-11 missile. The liquid-fueled Ghauri missile is believed to be derived from the North Korean No-Dong missile. The most recent delivery system to begin development was Nasr, a potential battlefield nuclear weapon. With a range of 60 km, it is intended for use against Indian armored forces. It was first tested in 2011, and an official account said "The missile has been developed to add deterrence value... at shorter ranges."[22]

To protect its investment in a rapidly expanding fissile material production complex Pakistan has been blocking the start of negotiations on a Fissile Material Cutoff Treaty, FM(C)T at the United Nations Conference on Disarmament in Geneva.[23] There is a strategic logic at work. Pakistan is aiming for a much larger arsenal than its current fissile material stockpile would allow. It is seeking a triad of delivery systems, and is moving to develop tactical weapons, which need be deployed in large numbers if they are to change the course of battle. Pakistan is also seeking a large arsenal as a way to overwhelm a possible Indian missile defense system.

Pakistani officials also argue that India has much larger fissile material stocks and Pakistan will not accept a fissile material "gap." They point in particular at India's unsafeguarded stock of almost 5 tons of plutonium separated from power reactor spent fuel and its breeder reactor program. They also claim that the 2008 US-India nuclear deal and the subsequent exemption for India from NSG guidelines served to lift restrictions on nuclear trade with India (including uranium imports and technology transfer) and so privilege India unfairly and also allow India to divert more of its domestic uranium resources to its weapons program and rely on imports for its civilian nuclear energy program. Pakistan has conditioned the start of FM(C)T talks on a nuclear deal similar to the one granted to India and demanded that an FM(C)T should include an obligation for states with large fissile material stockpiles to reduce them so as to not leave states with small stockpiles at a disadvantage.

Pakistan has been successful at holding up the start of FM(C)T talks not by virtue of the force of its arguments or its power in the international system. It has few supporters at the United Nations Conference on Disarmament in Geneva and is very dependent on international economic aid and assistance. Rather Pakistan has prevailed because the international community has had higher priorities in its dealing with Pakistan than the FM(C)T and restraining the nuclear arms buildup in South Asia. Most notably, there has been no U.S. or other international pressure on Pakistan on this issue since 2001. The war against Al-Qaeda and the Taliban in Afghanistan has commanded greater priority in dealings with Pakistan.

The lack of concern about the nuclear arms race in South Asia is despite the fact that Pakistan and India fought three wars before they acquired nuclear weapons (in 1947, 1965 and 1971) and a fourth war (in 1999) after both had tested nuclear weapons. There have been in addition crises that have verged on war and during which nuclear threats were made. There is a growing body of research that suggests a South Asian nuclear war in which each state used only 50 weapons each, against cities, would have large-scale long term environmental effects including a collapse of agriculture across much of the northern hemisphere for as long as a decade.[24]

The current neglect of the nuclear danger in South Asia is in marked contrast to the reaction of the international community to the nuclear tests by India and Pakistan in May 1998. United Nations Security Council Resolution 1172, passed unanimously on 6 June 1998, calls upon India and Pakistan:

– immediately to stop their nuclear weapon development programmes,
– to refrain from weaponization or from the deployment of nuclear weapons,
– to cease development of ballistic missiles capable of delivering nuclear weapons
– and any further production of fissile material for nuclear weapons.

It also "encourages all States to prevent the export of equipment, materials or technology that could in any way assist programmes in India or Pakistan for nuclear weapons."[25]

Since it was passed, Resolution 1172 has been ignored by India and Pakistan but also by the broader international community. As a consequence, nuclear arsenals in South Asia have grown much larger and gone largely unchallenged. The large nuclear complexes that have emerged in India and Pakistan as a result and pattern of political acceptance that surrounds them will make disarmament much more difficult in South Asia.

SUMMARY TABLES

	India	Pakistan
Weapons Tests	1974, 1998 (Pu)	1998 (HEU)
Plutonium	0.6 t weapon-Pu, 4.7 t reactor-Pu Dhruva HW reactor operating Breeder reactor in construction	0.15 t weapon-Pu 2 Khushab HW reactors operating 2 reactors in construction
Uranium	2.4 t HEU naval fuel (30% ^{235}U) using centrifuges	3 t (90%) of HEU for weapons using centrifuges
Delivery systems and plans	Agni I–III mobile missiles Arihant SSBN with K–15 SLBM Shourya silo-based Agni-V and VI MIRVed missiles	Shaheen I–II mobile missiles Babur GLCM, Raad ALCM Naval cruise missile Nasr battlefield missile
Comments	Seeking BMD and ASAT capability	Blocks talks on FMCT

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