DOI: 10.2968/065005008

Bulletin of the Atomic Scientists

Nuclear Notebook: Pakistani nuclear forces, 2009

Pakistan is enhancing its nuclear weapon capabilities across the board by developing and deploying new nuclear-capable missiles and expanding its capacity to produce fissile materials for use in weapons.

BY ROBERT S. NORRIS & HANS KRISTENSEN

Pakistan has an estimated arsenal of about 70–90 nuclear weapons and is busily enhancing its capabilities across the board. A new nuclear-capable ballistic missile is being readied for deployment, and two nuclear-capable cruise missiles are under development. Two new plutonium production reactors and a second chemical separation facility also are under construction.

It is exceedingly difficult to estimate precisely how many nuclear weapons Pakistan has produced, how many are deployed, and of what types. It is equally troublesome to guess what its future plans might be. In 1999, the U.S. Defense Intelligence Agency estimated that Pakistan had between 25 and 35 nuclear warheads and projected that it would have between 60 and 80 by 2020.[1] Yet Rolf Mowatt-Larssen, formerly the CIA's top official on weapons of mass destruction and the Energy Department's director of intelligence and counterintelligence during the Bush administration, recently noted a more accelerated pace: "It took them roughly 10 years to double the number of nuclear weapons from roughly 50 to 100."[2]

Although Pakistan's arsenal is clearly increasing, several factors suggest that it may not have reached 100 warheads quite yet. First, Pakistan is thought to have produced approximately 2,000 kilograms of highly enriched uranium (HEU) and 90 kilograms of separated military plutonium by early 2008.[3] While these amounts are sufficient for between 80 and 130 implosion-type warheads, assuming 15–25 kilograms of HEU are used for each warhead's solid core, it is unlikely that all of this material has been turned into weapons. Second, Pakistan does not have enough delivery vehicles to accommodate that many weapons. Furthermore, since all of its missile and aircraft types are dual-capable, only a portion of them may have a

IT IS 5 MINUTES TO MIDNIGHT
www.thebulletin.org

nuclear mission. Third, beyond the fissile material it has committed to weapons that are deployed or await deployment, Pakistan probably keeps stocks for future use.

The precise amount of plutonium or uranium needed for a bomb depends on two variables: the technical capabilities of the scientists and engineers and the desired yield. The better the technical capability, the less material is needed for a given yield, while higher yields require more material. While we do not know the skill level of Pakistani bomb designers, medium technical capabilities certainly seem plausible, which would require approximately 20 kilograms of HEU and 3 kilograms of plutonium for a warhead designed to have a yield of 10 kilotons.[4] Pakistan's weapons have been estimated to have yields of between 5 and 10 kilotons, judging by its few nuclear tests. Pakistan claimed it conducted six tests on May 28 and 30, 1998, yet most experts concluded based on seismic signals that there were only two tests. With warhead production probably well underway, if not already completed, for the Shaheen II medium-range ballistic missile, and deployment of the Babur cruise missile anticipated within the next few years, we estimate a current Pakistani nuclear stockpile of about 70–90 warheads.

Following the example of other nations that have developed nuclear weapons, Pakistan is improving its weapon designs, moving beyond its first-generation nuclear weapons that relied on HEU. For at least a decade, Pakistan has been pursuing plutonium-based designs. Central to that effort is the 40–50-megawatt heavy water Khushab plutonium production reactor, which was completed in 1998 and is located at Joharabad in the Khushab district of Punjab. Six surface-to-air missile batteries surround the site to protect against air strikes. As a sign of its confidence in its plutonium designs, Pakistan is building two additional heavy water reactors at the Khushab site, which will more than triple the country's plutonium production.[5]

In anticipation of this increased plutonium production capacity, Pakistan also is expanding its capabilities to reprocess it. The Pakistan Institute of Nuclear Science and Technology near Rawalpindi was Pakistan's original pilot chemical separation facility where plutonium from the first Khushab reactor was separated. Satellite images show a second under-construction separation facility adjacent to the original that could handle the plutonium produced in the two new Khushab reactors. Work also may have resumed on a partially built separation plant that dates from the 1970s. This plant is located at Chasma, where Pakistan operates a 300-megawatt commercial reactor (CHASNUPP-1) and plans to build three more, one of which is under construction. Additionally, Pakistan is expanding its facilities at Dera Ghazi Khan, in southern Punjab, where uranium hexafluoride and uranium metal are produced.[6]

PAKISTANI NUCLEAR FORCES, 2009

We estimate that Pakistan has produced 70-90 nuclear warheads that can be deployed on the following delivery vehicles:

TYPE	RANGE [1] (kilometers)	PAYLOAD (kilograms)
Aircraft		
F-16A/B	1,600	1 bomb (4,500)
Mirage V	2,100	1 bomb (4,000)
Ballistic missiles		
Ghaznavi (Hatf-3)	~400	Conventional or nuclear (500)
Shaheen-1 (Hatf-4)	450+	Conventional or nuclear (1,000)
Shaheen-2 (Hatf-6)*	2,000+	Conventional or nuclear (1,000)
Ghauri (Hatf-5)	1,200+	Conventional or nuclear (1,000)
Cruise missiles		
Babur (Hatf-7)*	320+	Conventional or nuclear (n/a)
Ra'ad (Hatf-8)*	320+	Conventional or nuclear (n/a)

[1]Missile payloads may have to be reduced to achieve maximum range. Aircraft range is for illustrative purposes only; actual mission range will vary according to flight profile and weapon loading.

*Under development.

All of these efforts suggest that Pakistan is preparing to increase and enhance its nuclear forces. In particular, the new facilities provide the Pakistani military with several options: fabricating weapons that use plutonium cores; mixing plutonium with HEU to make composite cores; and/or using tritium to "boost" warheads' yield (loading the reactors' targets with lithium 6 will produce tritium). Absent a successful full-scale thermonuclear test, it is premature to suggest that Pakistan is producing two-stage thermonuclear weapons, but the types of facilities under construction suggest that Pakistan has decided to supplement and perhaps replace its heavy uranium-based weapons with smaller, lighter plutonium-based designs that could be delivered further by ballistic missiles than its current warheads and that could be used in cruise missiles. Pakistan has repeatedly stated that it won't break the testing moratorium that has been in place in South Asia since 1998, yet if its neighbor India tested a weapon, Pakistan would likely follow suit for political and technical reasons.

Despite the apparent investment in Pakistan's nuclear infrastructure, President Asif Ali Zardari denied that his country was preparing to add to its nuclear stockpile during a May visit to the United States. "We're not adding to our stockpile as such. Why do we need more?" He told MSNBC reporter David Gregory. When pressed further, Zardari hedged. "So you're not adding to your nuclear arsenal at

all?" Gregory asked. "I don't think so, no," Zardari said. "You don't—do you know?" Gregory asked. "Even if I did, I wasn't going to tell you," Zardari replied. Precisely what Zardari knows is unclear, but sources suggest that an upward trend is underway. We estimate that Pakistan's nuclear weapons stockpile may reach between 100 and 120 warheads within the next decade, or even sooner.

Nuclear command and control. Concern about the physical security of Pakistan's nuclear weapons has increased in the past few years, particularly in light of the insurgent uprisings in the northern parts of the country. In February 2008, Lt. Gen. Khalid Kidwai, the director general of Pakistan's Strategic Plans Division (SPD), who is in charge of all aspects of Pakistan's nuclear weapons except field operations, acknowledged that at nuclear facilities the "state of alertness had gone up." "We have institutionalized the structures [overseeing the nuclear arsenal] and introduced modern technology so there are sufficient firewalls, safety, and security built into the chain of command, as well as into the weapons and weapon producing facilities."[7] Then-President Pervez Musharraf later added that the SPD and the Army Strategic Force Command has "a strength of between 12,000 and 15,000 people."[8]

U.S. officials have said there is no reason to believe that Pakistan's arsenal faces an imminent threat. Yet their knowledge of the arsenal is limited, as the Pakistani government has deflected U.S. requests for more information about the location and security of the sites, perhaps fearful that U.S. commandos might seize them if the nation tumbles into chaos. We do not know the status of a U.S. security-assistance program intended to upgrade the physical protection of some Pakistani facilities and train guards, but it is apparently behind schedule. "We are largely relying on assurances, the same assurances we have been hearing for years," one senior official told the *New York Times*. "The worse things get, the more strongly they hew to the line, 'Don't worry, we've got it under control.'"[9]

We do not know what kinds of "use-control" features Pakistan employs on its nuclear weapons. Lieutenant General Kidwai reportedly said in 2006, "Pakistani nuclear controls include some functional equivalent to the two-man rule and permissive action links" used by other nuclear weapons states.[10] Furthermore, the weapons are believed to be stored unassembled with the nuclear cores separate from the rest of the weapon, and the weapon storage areas are some distance from the delivery vehicles, under normal circumstances.

The precise location of the storage areas is extremely sensitive information, but U.S. officials recently provided a general picture of the situation. Secretary of State Hillary Clinton recently told Congress that Pakistan's nuclear weapons "are widely dispersed in the country—they are not at a central location," and senior U.S. officials

later said that most of the arsenal was south of Islamabad.[11]

Nuclear-capable aircraft. The Pakistani Air Force most likely assigns its U.S.-manufactured F-16s a nuclear mission, though it also could use French-manufactured Mirage Vs. The United States delivered 28 F-16A (single-seat) and 12 F-16B (two-seat) trainers to the Pakistani Air Force between 1983 and 1987. At least eight of these are no longer in service. Pakistan ordered 11 replacement F-16A/Bs in December 1988, but delivery of these aircraft—and a plan to acquire 60 more F-16s—was held up for nearly 16 years because of the Pressler Amendment, which forbids U.S. military aid to suspected nuclear weapon states. Pakistan's 1998 nuclear tests deepened U.S. opposition to delivering the aircraft, but attempts to enlist Pakistan as an ally against the Taliban in Afghanistan prompted former President George W. Bush to waive the Pressler Amendment on September 22, 2001, so that the aircraft could be delivered. On March 25, 2005, the Bush administration announced that it would resume sales of aircraft to Pakistan, and Pakistan quickly asked for 36 additional F-16C/D Block 50/52 aircraft as well as 60 F-16A/B Mid-Life Upgrade Kits to extend the life of the current aircraft. These aircraft and kits would "enhance Pakistan's conventional deterrent capability," according to the U.S. Defense Security Cooperation Agency.[12]

The Babur cruise missile is significantly slimmer than Pakistan's ballistic missiles, which suggests that Pakistani engineers have made progress in warhead miniaturization, perhaps based on a new and smaller plutonium warhead. A submarine-launched version of the Babur, which has been rumored to be in the work, has not materialized.

The Pakistani Air Force deploys its F-16s with Squadrons 9 and 11 at Sargodha Air Base, which is located 160 kilometers northwest of Lahore. The F-16 has a refueled range of more than 1,600 kilometers, and that range can be extended if the planes are equipped with drop tanks. The aircraft can carry up to 5,450 kilograms externally on one under-fuselage centerline pylon and six underwing stations. The F-16s with nuclear missions under NATO control can each carry up to two B61 nuclear bombs, but Pakistan's F-16s most likely carry a single bomb on the centerline pylon because the arsenal's uranium-based weapons likely are heavier than the 343-kilogram B61.

Sargodha's weapons storage area has igloos but lacks the extra security features that would suggest that the base stores nuclear weapons. The assembled nuclear bombs and/or bomb components assigned to the F-16s stationed at the base may be kept at the large Sargodha Weapons Storage Complex 10 kilometers south of Sargodha. Another alternative is that, fearing a first strike by India, Pakistan stores its weapons at operational or satellite bases west of Sargodha, where the F-16s could disperse to pick up their bombs.

The Mirage Vs that might also have nuclear-strike missions may

be deployed as part of the 8th (Haider) Squadron of the 32nd Fighter Wing at the Masroor Air Base, located about 8 kilometers west of Karachi. They also could be deployed as part of the 25th (Eagles) Squadron of the 33rd Fighter Wing at Kamra Air Base located 65 kilometers west of Islamabad. The air force could deploy the nuclear-capable Ra'ad (Hatf-8) cruise missile to Mirage V squadrons in the future.

Ballistic missiles. Pakistan has three types of operational ballistic missiles that are considered capable of delivering a nuclear warhead. These include the short-range ballistic missiles Ghaznavi (Hatf-3) and Shaheen-1 (Hatf-4) and the medium-range Ghauri (Hatf-5). A fourth missile, the Shaheen-2 (Hatf-6), may soon become operational.

The solid-fueled, single-stage Ghaznavi entered service in 2004 and can deliver a 500-kilogram payload approximately 400 kilometers. We don't know how many Ghaznavis Pakistan deploys or keeps in storage. The missile is believed to be derived from the Chinese M-11 missile, of which approximately 30 were delivered to Pakistan in the early 1990s. The Ghaznavi is launched from a four-axle, road-mobile transporter-erector-launcher; Pakistan deploys fewer than 50 such launchers. Some Ghaznavis might be deployed south of Sargodha at a large weapons storage facility that has 12 missile garages. Pakistan test-launched a Ghaznavi on February 13, 2008, from an undisclosed location as part of the army's annual field-training exercise. Production of the missile appears to be complete, with the last batch reportedly delivered to the army in April 2007.[13]

Pakistan's Shaheen-1 is a reverse engineered M-9 missile originally supplied by China. The solid-fueled, single-stage missile has been in service since 2003, can strike targets in excess of 450 kilometers—though some observers suggest the range is closer to 700 kilometers—and can deliver a payload of up to 1,000 kilograms. The Shaheen-1 is carried on a four-axle, road-mobile launcher similar to the one that carries the Ghaznavi, and like the Ghaznavi, fewer than 50 such launchers are deployed. The army last test-launched the Shaheen-1 on January 25, 2008.

Islamabad claims that its two-stage Shaheen-2 medium-range ballistic missile, unveiled seven years ago at the Pakistan Day parade but still under development, has a range of 2,050 kilometers and can carry a 1,000-kilogram payload. The missile is carried on a six-axle, road-mobile launcher, and satellite images of the National Defense Complex near Fatehjang appear to show 15 launchers at various stages of being equipped with their missile erector. The army conducted two operational readiness launches of the missile on April 19 and April 21, 2008, indicating that the Shaheen-2 is close to becoming operational.

The 1,200-kilometer medium-range Ghauri (Hatf-5) is Pakistan's only liquid-fueled nuclear-capable ballistic missile. First deployed in

2003, the single-stage missile can deliver a payload of 700–1,000 kilograms. The Ghauri might be replaced by the Shaheen-2.

Cruise missiles. Pakistan also is developing two cruise missiles that U.S. Air Force intelligence estimates may be nuclear capable. The ground-launched Babur (Hatf-7) has been test-launched five times, most recently on December 11, 2007. U.S. intelligence agencies estimate that the missile has a range of about 320 kilometers, while media reports frequently suggest the range is from 500 to 700 kilometers. Pakistani officials describe the Babur as a "low-flying, terrain-hugging missile with high maneuverability, pinpoint accuracy, and radar-avoidance features."[14] The Babur appears to be similar to the new Chinese DH-10 air-launched cruise missile and the Russian AS-15. The Babur is significantly slimmer than Pakistan's ballistic missiles, which suggests that Pakistani engineers have made progress in warhead miniaturization, perhaps based on a new and smaller plutonium warhead. A submarine-launched version of the Babur, which has been rumored to be in the work, has not yet materialized.

The air-launched Ra'ad (Hatf-8), or "Thunder," which has the same range as the Babur, was first test-launched on August 25, 2007 by a Mirage aircraft; a second test-launch occurred on May 8, 2008. A Pakistani military spokesman described the Ra'ad as a low-altitude, terrain-following missile with high maneuverability and as equipped with "special stealth capabilities" to provide "a great strategic standoff capability on land and at sea."[15] ■

Nuclear Notebook is prepared by Robert S. Norris of the Natural Resources Defense Council and Hans M. Kristensen of the Federation of American Scientists. Direct inquiries to NRDC, 1200 New York Avenue, N.W., Suite 400, Washington, D.C., 20005 (or 202-289-6868), and visit www.thebulletin.org for more nuclear weapons data.

NOTES

1. Defense Intelligence Agency, "A Primer on the Future Threat," *The Decades Ahead: 1999–2020* (July 1999), p. 38. Reprinted in Rowan Scarborough, *Rumsfeld's War: The Untold Story of America's Anti-Terrorist Commander* (Washington, D.C.: Regnery, 2004), pp. 194–223.
2. R. Jeffrey Smith and Joby Warrick, "Nuclear Aims by Pakistan, India Prompt U.S. Concern," *Washington Post*, May 28, 2009.
3. International Panel on Fissile Materials, "Global Fissile Material Report 2008" (Princeton, N.J.: International Panel on Fissile Materials, 2008), pp. 13, 16.
4. See "Table: Approximate Fissile Material Requirements for Pure Fission Nuclear Weapons," *Bulletin of the Atomic Scientists*, March/April 2003, vol. 59, no. 2, p. 76.
5. David Albright and Paul Brannan, Institute for Science and International Secu-

rity, "Update on Khushab Plutonium Production Reactor Construction Projects in Pakistan," April 23, 2009, available at www.isis-online.org/publications/southasia/Khushab_23April2009.pdf. Our best estimate of the new reactors' size is that they will be in the 40–100-megawatt range. See Thomas B. Cochran, "What Is the Size of Khushab II?" Natural Resources Defense Council, September 8, 2006; David Albright and Paul Brannan, Institute for Science and International Security, "Commercial Satellite Imagery Suggests Pakistan is Building a Second, Much Larger Plutonium Production Reactor: Is South Asia Headed for a Dramatic Buildup in Nuclear Arsenals?" July 24, 2006; William J. Broad and David E. Sanger, "U.S. Disputes Report on New Pakistan Reactor," *New York Times*, August 3, 2006; Shahzeb Jillani, "Pakistan Nuclear Report Disputed," BBC News, August 7, 2006. We believe that the estimate of up to 1,000 megawatts made by Albright and Brannan in "Commercial Satellite Imagery" is too large.

6. For descriptions of Pakistan's nuclear construction projects, see Institute for Science and International Security reports at http://www.isis-online.org.

7. Farhan Bokhari, "Pakistani Official Addresses Nuclear Security Concerns," *Jane's Defence Weekly*, February 6, 2008, p. 6.

8. Thomas Dodd, "Interview: Pervez Musharraf, President of Pakistan," *Jane's Defence Weekly*, February 13, 2008, p. 34.

9. David Sanger, "Pakistani Strife Raises U.S. Doubts on Nuclear Arms," *New York Times*, May 4, 2009.

10. Robin Walker, "Pakistan's Evolution as a Nuclear Weapons State: Lt. Gen. Khalid Kidwai's CCC Address," a news brief published by the Center for Contemporary Conflict, U.S. Naval Postgraduate School, November 1, 2006, available at www.ccc.nps.navy.mil/news/kidwaiNov06.asp.

11. Nicholas Kralev and Barbara Slavin, "Clinton Warns of Pakistani Nuke Risk," *Washington Times*, April 24, 2009; David Sanger, "Pakistani Strife Raises U.S. Doubts on Nuclear Arms," *New York Times*, May 4, 2009.

12. U.S. Defense Security Cooperation Agency, "Pakistan—F-16A/B Mid-Life Update Modification Kits," press release, June 28, 2006, p. 2.

13. "Pakistan Hands Over Nuclear-Capable Ballistic Missiles to Army," *Islamic Republic News Agency*, April 26, 2007.

14. Paul Garwood, "Pakistan Test-Fires Cruise Missile," Associated Press, March 21, 2006. It is worth mentioning that the Babur bears a close resemblance to U.S. cruise missiles. Several U.S. cruise missiles landed virtually intact on Pakistani territory during strikes on terrorist camps authorized by President Bill Clinton.

15. Mohit Joshi, "Pak Test Fires Nuclear Capable Hatf-VII," *Asian News International*, May 8, 2008.

Robert S. Norris and Hans M. Kristensen, "Nuclear Notebook: Pakistani nuclear forces, 2009," *Bulletin of the Atomic Scientists*, September/October 2009, vol. 65, no. 5, pp. 82–89.

DOI: 10.2968/065005008