

**PAKISTAN'S NUCLEAR FUTURE:
WORRIES BEYOND WAR**

**Henry D. Sokolski
Editor**

January 2008

Visit our website for other free publication
downloads

<http://www.StrategicStudiesInstitute.army.mil/>

[To rate this publication click here.](#)

This publication is a work of the U.S. Government as defined in Title 17, United States Code, Section 101. As such, it is in the public domain, and under the provisions of Title 17, United States Code, Section 105, it may not be copyrighted.

The views expressed in this report are those of the authors and do not necessarily reflect the official policy or position of the Department of the Army, the Department of Defense, or the U.S. Government. This report is cleared for public release; distribution is unlimited.

Chapter 6 was originally prepared as a report for the International Panel on Fissile Materials (IPFM). The authors are grateful to IPFM for allowing a revised version to be submitted to the journal, *Science & Global Security*. It appeared in Vol. 14, Nos. 2-3, 2006. The authors are happy to acknowledge discussions with Frank von Hippel and Harold Feiveson, and close collaboration with Alexander Glaser. They wish to thank the Program on Science and Global Security for its generous support and hospitality and to note useful comments by the reviewers for *Science & Global Security*.

Chapter 7 was originally commissioned by the Henry L. Stimson Center. The views expressed in this chapter do not necessarily reflect those of the Pakistan Nuclear Regulatory Authority, the Government of Pakistan, or any organization under whose auspices this manuscript was prepared.

Comments pertaining to this report are invited and should be forwarded to: Director, Strategic Studies Institute, U.S. Army War College, 122 Forbes Ave, Carlisle, PA 17013-5244.

All Strategic Studies Institute (SSI) publications are available on the SSI homepage for electronic dissemination. Hard copies of this report also may be ordered from our homepage. SSI's homepage address is: www.StrategicStudiesInstitute.army.mil.

The Strategic Studies Institute publishes a monthly e-mail newsletter to update the national security community on the research of our analysts, recent and forthcoming publications, and upcoming conferences sponsored by the Institute. Each newsletter also provides a strategic commentary by one of our research analysts. If you are interested in receiving this newsletter, please subscribe on our homepage at *www.StrategicStudiesInstitute.army.mil/newsletter/*.

ISBN 1-58487-333-7

CONTENTS

Foreword.....	vii
1. Pakistan's Nuclear Woes <i>Henry D. Sokolski</i>	1
I: ISLAMABAD'S PROLIFERATING PAST	11
2. Kahn's Nuclear Exports: Was There a State Strategy? <i>Bruno Tertrais</i>	13
3. Could Anything Be Done to Stop Them? Lessons from Pakistan's Proliferating Past <i>George Perkovich</i>	59
II: MAINTAINING SOUTHWEST ASIAN DETERRENCE	85
4. Pakistan's "Minimum Deterrent" Nuclear Force Requirements <i>Gregory S. Jones</i>	87
5. Islamabad's Nuclear Posture: Its Premises and Implementation <i>Peter R. Lavoy</i>	129
6. Fissile Materials in South Asia and the Implications of the U.S.-India Nuclear Deal <i>Zia Mian, A. H. Nayyar, R. Rajaraman, and M. V. Ramana</i>	167

III. PAKISTAN’S NEXT SET OF NUCLEAR HEADACHES	219
7. Preventing Nuclear Terrorism in Pakistan: Sabotage of a Spent Fuel Cask or a Commercial Irradiation Source in Transport <i>Abdul Mannan</i>	221
8. Security Issues Related to Pakistan’s Future Nuclear Power Program <i>Chaim Braun</i>	277
9. Bad Options: Or How I Stopped Worrying and Learned to Live with Loose Nukes <i>Thomas Donnelly</i>	347
ABOUT THE CONTRIBUTORS	369

FOREWORD

This volume was completed just before Pakistani President Musharraf imposed a state of emergency in November 2007. The political turmoil that followed raised concerns that Pakistan's nuclear assets might be vulnerable to diversion or misuse. This book, which consists of research that the Nonproliferation Policy Education Center (NPEC) commissioned and vetted in 2006 and 2007, details precisely what these worries might be.

Dr. Ashley Tellis of the Carnegie Endowment for International Peace and Dr. Peter Lavoy, now the National Intelligence Officer for Southwest Asia at the National Intelligence Council, were instrumental in the selection of authors as well as producing original research. Thanks is also due to Ali Naqvi and Tamara Mitchell of NPEC's staff who helped organize the workshop at which the book's contents were discussed and who helped prepare the book manuscript. Finally, special thanks is due to Professor Douglas C. Lovelace, Jr., Ms. Marianne Cowling, and Ms. Rita Rummel of the Strategic Studies Institute (SSI). This is the ninth in a series of edited volumes NPEC has produced with SSI. To the book's authors and all who made this book possible, NPEC is indebted.

Henry Sokolski
Executive Director
The Nonproliferation Policy
Education Center

CHAPTER 1

PAKISTAN'S NUCLEAR WOES

Henry D. Sokolski

Raise the issue of Pakistan's nuclear program before almost any group of Western security analysts, and they are likely to throw up their hands. What might happen if the current Pakistani government is taken over by radicalized political forces sympathetic to the Taliban? Such a government, they fear, might share Pakistan's nuclear weapons materials and know-how with others, including terrorist organizations. Then there is the possibility that a more radical government might pick a war again with India. Could Pakistan prevail against India's superior conventional forces without threatening to resort to nuclear arms? If not, what, if anything, might persuade Pakistan to stand its nuclear forces down? There are no good answers to these questions and even fewer near or mid-term fixes against such contingencies. This, in turn, encourages a kind of policy fatalism with regard to Pakistan.

This book, which reflects research that the Nonproliferation Policy Education Center commissioned over the last 2 years, takes a different tack. Instead of asking questions that have few or no good answers, this volume tries to characterize specific nuclear problems that the ruling Pakistani government faces with the aim of establishing a base line set of challenges for remedial action. Its point of departure is to consider what nuclear challenges Pakistan will face if moderate forces remain in control of the government and no hot war breaks out against India. A second volume of commissioned research planned for

publication in 2008 will consider how best to address these challenges.

What proliferation risks might the current government still be tempted to take? What is required of Pakistan to maintain nuclear deterrence with India? What new vulnerabilities will the expansion of Pakistan's civilian nuclear sector require Islamabad to attend to? Finally, how daunting a task might it be to keep Pakistan's nuclear weapons assets from being seized or to take them back after having been seized? Each of these questions is tackled in the chapters that follow.

Along the way, a number of interesting discoveries are made. First, from the historical analyses done by Bruno Tetrakis and George Perkovich, we learn that despite the significant nuclear export control efforts of the current Pakistani government, it might well proliferate again. Why? The same reasons that previous Pakistani governments tolerated and, at times, even sanctioned the nuclear-rocket export-import activities of Dr. A. Q. Khan: Perceived strategic abandonment by the United States, lack of financing for its own strategic competition against India, insufficient civilian oversight of a politically influential military and intelligence services, and a perceived need to deflect negative international attention from Pakistan to third countries. (See Table 1 at the end of this chapter for a historical review.)

One or more of these factors were in play throughout the last 3 decades. Two still are. Certainly, the United States has done all it can to reassure Pakistani officials about Washington's commitment to Pakistan's security. Yet, there still is Pakistani cause for concern. Might Washington tie future security and economic assistance to Pakistani progress toward democratic elections and cracking down more severely against

radical Islamic groups in Pakistan? As for the matter of being isolated, Pakistan now has to be concerned not just about maintaining good relations with Washington, but somehow fending off the encircling efforts of India. Most recently, these activities included formal military-to-military ties with Iran; the construction of a major naval port at Chahbahar near Pakistan's own new naval base at Gwador; the joint construction with Iran of roads to Afghanistan (and Indian aid efforts to Afghanistan); the stationing of Indian intelligence officers at Zahedan, Iran close to Baluchistan rebel activities in Pakistan; the creation of an Indian air base in Tajikistan; Indian energy investments and commerce with Iran and countries in the Gulf; and continued Indian military, nuclear, and rocket enhancements. All of these developments have put Pakistan's military and political officials on edge.

As for oversight of the military and intelligence services, this remains an open question. The elections may give some indication of things to come, but for now the military and intelligence arms of the government are still in clear control of much of Pakistan's political, military, and economic activities. A new president may try to reduce the amount of power the military and intelligence sectors have over Pakistan but this is a long-term undertaking.

This, then, brings us to an enduring nuclear challenge Pakistan faces no matter who is running the government: What must Pakistan's military do to deter nuclear war against India? Greg Jones of RAND, Peter Lavoy, and Zia Mian and his coauthors all have different takes on what will be required. Mr. Jones takes a somewhat optimistic view. Pakistan and India currently have roughly the right level of forces and are unlikely to increase them dramatically for the

next 20 years. Pakistan's nuclear force requirements would have to grow dramatically, Mr. Jones notes, merely to destroy just 5 percent of India's population (This would require a five-fold increase in Pakistan's current nuclear force.) or only a relatively small portion of India's conventional forces (a task which would require a doubling of Pakistan's current nuclear forces). Enlarging Pakistan's forces to these levels, he argues, would be quite costly. Using history as a guide, Mr. Jones argues that India, meanwhile, seems unlikely to press Pakistan by building up its nuclear forces.

Perhaps, but others are not so certain. In his chapter, "Islamabad's Nuclear Posture: Its Premises and Implementation," Dr. Peter Lavoy notes that the prospect of the U.S. and Indian strategic partnership "shifting" the "strategic balance" announced in 2005 set off a series of nuclear alarms in Islamabad. The first of these fears is that India, with U.S. high-technology targeting and intelligence assistance, might knock out Pakistan's nuclear assets in a "preventative" attack. This, in turn, has already prompted Pakistan's National Command Authority to announce that if the nuclear deal alters the nuclear balance, the command would have to reevaluate Pakistan's commitment to minimum deterrence and to review its nuclear force requirements. This, in turn, will require making Pakistan's nuclear weapons assets even more survivable through increased mobility, hardening, and numbers. The second Pakistani worry is much more basic: The U.S.-India nuclear deal could enable India to outstrip Pakistan's capacity to make nuclear weapons.

How likely is this? The short answer is very. A much more detailed analysis can be found in the chapter by Zia Mian, A. H. Nayyar, R. Rajaraman, and M. V. Ramana entitled, "Fissile Materials in South Asia and

the Implications of the U.S.-India Nuclear Deal.” Here the authors detail how critical the import of additional uranium fuel might be to expand India’s ability to make more nuclear weapons while expanding its nuclear power industry. The authors also cite one Indian expert who suggests that India will attempt to build roughly 400 nuclear warheads—at least four times what the Pakistanis currently possess. Matching this number and controlling the nuclear system deployments that might be made would demand a good deal of Pakistan’s government and nuclear establishment. So far, the Pakistani government has hedged its bets against this contingency by beginning construction of a new plutonium production reactor and a new reprocessing plant.

Beyond this, Pakistan has announced plans to expand its own civilian nuclear power sector roughly 20-fold by the year 2030 to 8.8 gigawatts generating capacity. The idea would be to have a nuclear weapons-making mobilization base that could be used to make power if India did not make more weapons. This hedging strategy seems to be reasonably cautious. It, however, cannot be implemented without running several important attendant risks.

Besides being uncompetitive against non-nuclear energy alternatives, such a nuclear buildup is likely to increase the vulnerability of Pakistan’s civilian reactor sector to sabotage and attack. The good news is that the Pakistani government understands this point. In his detailed analysis, “Preventing Nuclear Terrorism in Pakistan,” Abdul Mannan, a senior official serving in Pakistan’s nuclear regulatory agency, details the ramifications of a terrorist attack against Pakistan’s civilian nuclear sector. Mr. Mannan believes attacks against Pakistan’s nuclear facilities are far less likely

to inflict damage than a possible attack against spent fuel that is likely to be shipped from Pakistan's power reactors to Pakistan's reprocessing plant. Fortunately, such attacks, even in or near Karachi, are unlikely to produce many fatalities. Unfortunately, they could contaminate a considerable amount of property, and will require the decontamination and quarantining of large numbers of people. To cope with these contingencies, Mr. Mannan calls for the establishment of an extensive list of civil defense measures to be taken. He is optimistic that Pakistan can take these steps to assure nuclear power's safe expansion.

Dr. Chaim Braun of Stanford's Center for International Security and Cooperation, though, is not so sure. In his analysis, "Security Issues Related to Pakistan's Future Nuclear Power Program," Dr. Braun examines Pakistan's nuclear reactor operating history, its ability to license new reactors and regulate their operation properly, to train sufficient numbers of new qualified nuclear operators and regulators for the planned expansion of Pakistan's nuclear power sector, and to screen this new staff to assure none have terrorist organization ties. His final assessment is troubling. Pakistan, he fears, will have great difficulty avoiding a major nuclear accident or terrorist-induced sabotage, as well as defending the planned number of civilian facilities against military attacks. Among his key concerns is Pakistan's current lack of qualified and security-screened nuclear personnel. To staff up for the planned nuclear reactor expansion, he estimates that Pakistan will need to find and train 1,000 qualified nuclear regulators and operators per year over the next 20 years. Dr. Braun also believes that Pakistan's nuclear expansion will create a large number of tempting terrorist targets—spent fuel ponds—all of which could be vulnerable to terrorist or military attacks.

This, then, suggests one of the most sensitive challenges an expanded nuclear program in Pakistan presents—the possible seizure of the plants by subnational groups and the need to take them back by force, if necessary. Thomas Donnelly examines this issue in his analysis, “Bad Options.” What we learn is that even in the case where the Pakistani government invites U.S. forces to help it to retake the most sensitive Pakistani nuclear facilities at Kahuta, the logistics and military challenges facing U.S. and Pakistani forces are extremely daunting. Besides the logistical challenges of landing a large enough force to retake the city-sized complex at Kahuta, the expeditionary force would have to be prepared to fight its way through a single access road and move quickly enough to assure no material was passed off to terrorist organizations or other opposing groups. Assuming success and taking control of the facility, many questions would remain. Is all the nuclear material that could be fashioned into bombs accounted for? How could we know? Would the United States hand the material it had secured back to the Pakistani government immediately or hold in trust until the dust of civil disorder had settled? If so, would we render it “safe” and what might this mean? To get the answers to these questions, Mr. Donnelly strongly recommends that the government of Pakistan and the United States work together closely on these issues now.

What is the upshot of all of this analysis? One bottom line is that the government of Pakistan has its hands full with more than enough nuclear issues even if it never goes to war against India, is attacked by Indian forces, or is overthrown by radical Islamic parties. Certainly, to deal with all of the nuclear issues these analyses have raised, one would need to have a

fairly robust and active national government capable of mastering nuclear regulation, nuclear physical security, emergency preparedness, peacetime military strategic planning, energy research and development, and electrical system planning. It is most unlikely that such a government would be the kind that could be overthrown or destabilized very easily.

This insight brings us to the second series of studies to be commissioned on Pakistan's nuclear future. These will focus on what can be done to reduce Pakistan's need to expand its civilian nuclear sector. On the one hand, what can be done with India and China to reduce Pakistan's justified fears that India will expand its own nuclear stockpile? Could more be done to address Pakistan's energy needs in a more cost effective manner without building additional nuclear generators? How might India and Pakistan cooperate in promoting less nuclear powered futures for both their countries and one in which the nuclear physical security threats are kept to a minimum for both countries? More generally, what can be done to reduce Pakistani fears of being encircled or overwhelmed by Indian conventional forces (the key propellants for possible future proliferation, nuclear buildups, and war)? What might be done to reduce the most likely escalation threats? Finally, what might be done to pacify Pakistani politics so that greater mutual confidence could be built with India? These questions will serve as the basis for the next volume.

	President	Prime Minister	Chief of Army Staff	PAEC / KRL	Events
1987	Zia ul-Haq	Muhammad Khan Junejo	Zia ul-Haq (MA Beg as VCoAS)	MA Khan / AQ Khan	AQ Khan visit to Iran (Jan.) Iran-Pakistan meeting in Dubai Iran-Pakistan cooperation agreement
1988	Zia ul-Haq (January 1 to August 17) Ghulam Ishaq Khan (August 17 to December 31)	Muhammad Khan Junejo (January 1 to May 29) Zia ul-Haq (June 9 to August 17) Benazir Bhutto (December 2 to December 31)	Zia ul-Haq (January 1 to August 17) Mirza Aslam Beg (August 17 to December 31)	MA Khan / AQ Khan	
1989	Ghulam Ishaq Khan	Benazir Bhutto	Mirza Aslam Beg	MA Khan / AQ Khan	
1990	Ghulam Ishaq Khan	Benazir Bhutto (January 1 to August 6) Ghulam Mustafa Jatoi (August 6 to November 6) Nawaz Sharif (November 6 to December 31)	Mirza Aslam Beg	MA Khan / AQ Khan	AQ Khan offer to Iraq Pressler sanctions (Oct.)
1991	Ghulam Ishaq Khan	Nawaz Sharif	Mirza Aslam Beg (January 1 to August 16) Asif Nawaz Janjua (August 16 to December 31)		Iran-Pakistan meeting AQ Khan visit to Iran
1992	Ghulam Ishaq Khan	Nawaz Sharif	Asif Nawaz Janjua		AQ Khan visit to Iran
1993	Ghulam Ishaq Khan (January 1 to July 17) Wasim Sajjad (July 17 to November 14) Farooq Leghari (November 14 to December 31)	Nawaz Sharif (January 1 to April 18) Balakh Sher (April 18 to May 26) Nawaz Sharif (May 26 to July 18) Moin Qureshi (July 18 to October 19) Benazir Bhutto (October 19 to December 31)	Asif Nawaz Janjua (January 1 to January 8) Abdul Wahid Kakar (January 8 to December 31)		Second round of Iran-Pakistan negotiations (Fall) Bhutto deal with North Korea (Dec.)
1994	Farooq Leghari	Benazir Bhutto	Abdul Wahid Kakar		Second negotiation between Iran and the AQ Khan network
1995	Farooq Leghari	Benazir Bhutto	Abdul Wahid Kakar		First AQ Khan meeting with Libya
1996	Farooq Leghari	Benazir Bhutto (January 1 to November 5) Miraj Khalid (November 5 to December 31)	Abdul Wahid Kakar (January 1 to December 1) Jehangir Karamat (December 1 to December 31)		Possible 'nukes' deal with North Korea

Table 1. Pakistani Leadership and Nuclear Exports, 1987-2002.

	President	Prime Minister	Chief of Army Staff	PAEC / KRL	Events
1997	Farooq Leghari (January 1 to December 2) Wasim Sajjad (December 2 to December 31)	Miraj Khalid (January 1 to February 17) Nawaz Sharif (February 17 to October 12)	Jehangir Karamat		Libya-Pakistan meeting in Istanbul AQ Khan visit to Libya Shipment to Libya Karamat visit to DPRK
1998	Muhammad Rafiq Tarar	Nawaz Sharif	Jehangir Karamat (January 1 to October 7) Pervez Musharraf (October 7 to December 31)		
1999	Muhammad Rafiq Tarar	Nawaz Sharif (January 1 to October 12) Pervez Musharraf (October 12 to December 31 as Chief Executive)	Pervez Musharraf		AQ Khan visit to North Korea
2000		Pervez Musharraf	Pervez Musharraf		Final deal with Libya Shipment to Libya
2001					Shipment to Libya
2002					Shipment to Libya (including weapon design?) AQ Khan visit to North Korea

Table 1. Pakistani Leadership and Nuclear Exports, 1987-2002 (concluded).

PART I:
ISLAMABAD'S PROLIFERATING PAST

CHAPTER 2

KAHN'S NUCLEAR EXPORTS: WAS THERE A STATE STRATEGY?

Bruno Tertrais

HOW THE NETWORK OPERATED

Pakistani nuclear-related exports began about a decade after their imports network was set up in the mid-1970s. The Pakistanis thus had acquired a very significant experience in dealing with nuclear transfers, legal and illegal. Contacts and procedures used for Pakistani imports were sometimes of direct use to exports when they involved transfers from Western firms, intermediaries and shell companies.

The network exported two different things: know-how on uranium enrichment and weapons design, and centrifugation technology. Its clients were North Korea, Iran, Iraq, Libya, and maybe others. Once fully matured, it comprised several main “nodes”: the United Arab Emirates (UAE) (the “company’s headquarters” starting in 1999), Malaysia, Turkey, and South Africa – not including various personal properties around the world.¹ There were half a dozen “workshops” around the globe, with Dubai serving as the main platform for re-exporting.² A. Q. Khan set up dozens of shell companies to that effect, sometimes just for one-time use.

A total of about 50 people were actively involved in the network.³ But Khan operated with a dozen key close associates, who were sometimes in competition

with each other. It was a real “family business.” Those included:

1. Buhary Syed Abu Tahir, a Sri Lankan national. He was, so to say, the “chief operating officer” of the exports network. His involvement started in the second part of the 1980s.⁴ His “headquarters” was the Dubai-based firm, SMB Computers.

2. S. M. Farouq, an India-born businessman based in Dubai (and Tahir’s uncle), who made the initial contacts with Iran and was also involved in the Libya deal.⁵

3. Heinz Mebus, a German businessman and college classmate of Khan, who was also involved in the early deals with Iran.⁶

4. Peter Griffin, a British national who designed the Libyan “Machine Shop 1001.” He imported machines from Spain and other European countries for that project.⁷

5. Paul Griffin, Peter’s son, who operated Gulf Technical Industries, one of the main Dubai-based front companies.⁸

6. Urs Tinner, a Swiss national and long-time associate of Khan, who oversaw the production of centrifuge parts in Malaysia as a “consultant” until 2003.

7. Friedrich Tinner (Urs’s father, president of the Swiss firm CETEC).

8. Marco Tinner (Urs’s brother, president of the Swiss firm Traco). Both Friedrich and Marco were involved in the Iran and Libya enterprises. Their role was essentially to buy components from Europe.

9. Gotthard Lerch, another long-time associate, a German national who has been described as Tahir’s main contractor. Involved in both the Iran and Libya cases, he was, in particular, in charge of the South African “node.”⁹

10. Gerhard Wisser, a German mechanical engineer and an old acquaintance of Lerch, who involved him in the Libya operation. Wisser in turned involved Daniel Geiges (a Swiss mechanical engineer who worked in his company, Krisch Engineering) and Johan Meyer (a South African engineer).¹⁰

11. Mohammed Farooq, a KRL official in charge of procurement and sales abroad.¹¹

The main companies reportedly involved in centrifuge exports were Khan Research Laboratories (Pakistan), which provided ring magnets, aluminium and maraging steel, flow-forming and balancing equipment, vacuum pumps, noncorrosive pipes and valves, end-caps and baffles, and power supply; Scomi Precision Engineering (Malaysia), which provided aluminium and maraging steel, end-caps and baffles; SMB Computers (UAE) which provided noncorrosive pipes and valves, end-caps and baffles, and power supply; ETI Elektrotechnik (Turkey), which provided aluminium and maraging steel, power supply; and Trade Fin (South Africa) which provided flow-forming and balancing equipment, vacuum pumps, non-corrosive pipes and valves.¹² Other companies involved included Bikar Mettale Asia (Singapore), Hanbando Balance Inc. (South Korea), Krisch Engineering (South Africa), CETEC (Switzerland), Traco (Switzerland), and EKA (Turkey).¹³ Equipment for Libya was imported by the Tinner family from Spain (vacuum pumps, flow-forming machines), Italy (special furnaces), France, the United Kingdom and Taiwan (machine-tools), as well as Japan (a 3-D measuring tool).¹⁴

As will be seen, however, there is evidence that high-level political and military leaders were also involved in nuclear exports. This occurred despite the written assurances given twice to the United States (first by Zia ul-Haq in November 1984, then in October

1990 by president Ghulam Ishaq Khan) and countless official statements testifying to the immaculate state of Pakistan's proliferation record.

Thus, the network was not a "Wal-Mart," as International Atomic Energy Agency (IAEA) Director General Mohammed El-Baradei wrongly characterized it. Rather, it was an "Import-Export Enterprise." From the initial import-oriented network under the direction of M. A. Khan, a separate, export-oriented branch developed under the direction of A. Q. Khan starting in the mid-1980s. In the late 1990s, it became more decentralized as A. Q. Khan realized he was under surveillance. It became a "privatized subsidiary" of the imports network.

The story cannot be reduced to the simple "reversal of the flow" described by some. However, there were clear links between the import and export networks. Some of the components that A. Q. Khan exported were also components he needed for the national program; thus, starting in the mid-1980s, he reportedly began to order more components than necessary for the national program.¹⁵

Also, several key individuals involved in Pakistani exports were also involved in the imports. Mohammed Farooq, A. Q. Khan's principal deputy, was reportedly in charge of overseas procurement for KRL.¹⁶ Others were long-time associates, whom he had met in the 1960s and 1970s. They included Peter Griffin (who was involved in early imports of inverters from the UK); Gotthard Lerch (who used to work at Leybold Heraeus, which was to become a key contractor of Pakistan); Otto Heilingbrunner (same); Henk Slebos (who studied with A. Q. Khan, used to work at Explosive Metal Works Holland, and sold various equipment to Pakistan over the years, including bottom bearings in 2001 which

were probably meant for Iran or Libya); Friedrich Tinner (who used to work at Vacuum Apparate Technik, a firm which sold equipment to Pakistan in the 1970s); and Heinz Mebus (who was involved in the first centrifuge transfers to Iran in the mid-1980s).

Other elements of commonality exist between the two networks. Tactics designed to fool Western exports controls were learned for imports and used for exports. States such as the UAE and Turkey were major platforms for both imports and exports. And the Bank of Credit and Commerce International (BCCI) was, it seems, one of the conduits used (until its demise in 1991) for payments made to Pakistani officials.¹⁷

Iran.

The issue of transfers to Iran is complex. To this day, it remains difficult to tell the exact degree of implication of the various Pakistani centres of power in decisions related to the sharing of nuclear technologies with Tehran. One individual played a central role: Mirza Aslam Beg, Vice Chief of Army Staff (VCoAS, 1987-88), then CoAS from August 1988 until August 1991.¹⁸ There seem to have been three different phases.

Phase 1: 1986-88. First, beginning in 1986 there was a period of limited cooperation probably approved by general Zia-ul-Haq himself. In November 1986, the Pakistani press reported that Zia had answered favorably to an Iranian request for nuclear cooperation.¹⁹ A secret bilateral agreement was signed between the Pakistan Atomic Energy Commission (PAEC) and its Iranian counterpart in 1987, which provided *inter alia* for the training of Iranian scientists.²⁰ A. Q. Khan's dealings with Iran started at the same time. He may have visited Iran as early as January 1987.²¹ Later

that year, a negotiation took place in Dubai for the selling of P1 centrifuge diagrams, an enrichment plant diagram, and spare parts for at least one P1 machine (but probably many more, since the offer involved 2,000 machines).²²

President Zia, it seems, had authorized the initiation of bilateral nuclear cooperation while asking for it to remain limited.²³ He did not want Iran to get the bomb. He was wary of A. Q. Khan whom he saw as “politically naïve and a publicity seeker”; he was reportedly upset when Khan upstaged him in the famous 1987 interview that revealed to the world that Pakistan had the bomb.²⁴

Khan was reportedly telling military authorities that the transfers were of very limited importance, since they concerned only used and or obsolete equipment.²⁵ He probably felt “covered” by Zia’s approval for limited nuclear technology transfers to Iran. But he may also have been encouraged by general Mirza Aslam Beg, in his capacity as Army Vice Chief of Staff, who was ready to do more, and was probably in a position to do so: he was in fact the real CoAS, since Zia was also President. Beg reports that emissaries from Iran first approached Pakistan near the end of the Iran-Iraq war, with broad requests for military sales, which were, according to him, denied by President Zia. This is consistent with what a former Pakistani ambassador to Iran reported, namely that Zia refused to abide by an Iranian request made in Tehran in January 1988 for mastery of the fuel cycle.²⁶

Phase 2: 1988-91. After Zia’s death, the two parties may have envisioned a more complete cooperation, under pressure from general Beg, but probably with the knowledge of political authorities. A. Q. Khan was certainly encouraged to act in this direction by General

Beg and President Khan when they abruptly came to power after Zia's death in August 1988. According to a Pakistani account, A. Q. Khan's first move when Benazir Bhutto came to power (December 1988) was to ask her to make him PAEC director; when she refused, he chose to place his loyalty with Beg and G. I. Khan.²⁷

General Beg came back from a February 1990 visit to Iran with assurances from Tehran regarding support for Pakistan about Kashmir.²⁸ He has mentioned an Iranian request for the bomb made in Islamabad that same year.²⁹ He has consistently denied having approved such transfers, but has confirmed the scope of nuclear discussions between Tehran and Islamabad at the time. According to him, the contacts had been made at Iran's initiative; he and Benazir Bhutto (who remained Prime minister until August 1990) were playing "ping-pong" with their interlocutors, constantly telling them to go and see the other party.³⁰ A former U.S. administration official, Henry Rowen, says that Beg threatened in January 1990 to transfer military usage nuclear technology should Washington stop arms sales to Pakistan.³¹ A. Q. Khan himself says that the transfers were explicitly authorized by Beg.³²

There is evidence that Benazir Bhutto's government knew about this cooperation. She was told in 1989 by Hashemi Rafsandjani that the Pakistani military had offered nuclear technology to Iran, and that Rafsandjani wanted her approval – which she says she did not give.³³ (According to Beg, she told him that the Iranians had offered four billion dollars for nuclear technology.³⁴) A. Q. Khan says that the transfers were in fact encouraged by the military adviser to Mrs. Bhutto, General Imtiaz Ali.³⁵ And one meeting in Karachi between Khan and the Iranians reportedly took place at the request of another Bhutto adviser.³⁶ Mrs. Bhutto says that by 1989

she had made her way into the inner circle of nuclear decisionmaking.³⁷ She had been extensively briefed on her own country's program by the U.S. administration during her June 1989 visit to Washington.³⁸ (Former U.S. Ambassador Dennis Kux confirms that she was probably "in the loop" until early 1990.³⁹) In fact, her knowledge of nuclear transfers may also have been a factor in her dismissal. She was pressed hard by the United States about Pakistan's nuclear program. In the summer of 1990, she became seen as a problem, and A. Q. Khan reportedly asked Beg for her sacking.⁴⁰ Thus, even though there is no evidence that Mrs. Bhutto approved any transfer, she was aware of Iran-Pakistan discussions; and some of her advisers may have given the nod to Beg and Khan.

Phase three: 1991-95. In a third phase, the two countries seem to have begun a closer cooperation, in line with a growing convergence of interests.

Two events changed Pakistani perspective. One was the invasion of Kuwait. The other was the imposition of U.S. sanctions under the Pressler amendment, which became inevitable on October 1, as U.S. President George Bush refused to certify that Pakistan did not have a military program.

An Iranian-Pakistani nuclear cooperation was coherent with General Beg's strategic choices. Beg initially approved Pakistan's participation in the coalition against Iraq; but by the end of 1990, he changed his mind and made it public in late January 1991.⁴¹ He actively sought a partnership with Iran in order to protect both countries against the United States.⁴² (He ended up grudgingly accepting Pakistani participation in the coalition as long as it was limited to the defense of Saudi Arabia.) Political reasons were not the only ones at play. General Beg and others

thought it was a good way to finance the defense budget and Interservice Intelligence (ISI) operations in Afghanistan and Kashmir, especially in light of coming U.S. sanctions. Several former officials of Nawaz Sharif's first government (November 1990-July 1993) have separately confirmed that in 1991, General Beg tried to convince Mr. Sharif to undertake large-scale nuclear cooperation with Iran.⁴³

There were indeed high-level contacts to that effect between the two governments during 1991. Envoys of Hashemi Rafsanjani (including Mohsen Rezai, head of the Pasdarans from 1981 until 1987) visited Sharif in February and July 1991. Pakistani authorities have confirmed that Beg was involved in transfers to Iran in 1991.⁴⁴ In November 1991, general Asif Nawaz (who had succeeded Beg in August) went himself to Tehran; meanwhile, Beijing reportedly gave its blessing to Iran-Pakistan cooperation.⁴⁵ General Beg himself has confirmed that contacts with Iran continued after Benazir Bhutto's departure in August 1990.⁴⁶

It is difficult to know with certainty what became of these projects. Some claim that Pakistan and Iran did agree on nuclear cooperation and discussed the possibility of a mutual defense treaty.⁴⁷ According to Beg, an agreement was indeed reached in 1991 for nuclear cooperation in return for conventional weapons and oil.⁴⁸ However, several sources have stated that the Pakistani political authorities refused to go ahead. One claims that president G. I. Khan sought Sharif's approval for the deal; when he refused, the deal was abandoned.⁴⁹ According to U.S. Ambassador Robert Oakley, Nawaz Sharif and G. I. Khan told Rafsanjani that Pakistan would not implement the 1991 agreement.⁵⁰

What is clear is that the bilateral cooperation that was envisioned by the two countries was a two-way street; it did not concern only nuclear technology, but also conventional arms, probably oil, as well as mutual political support. In the nuclear realm, the known transfers of that period involved diagrams for P1 and P2 centrifuges, and 500 used P1 centrifuges in a disassembled form. (Three actual P2 machines may also have been delivered.⁵¹) The negotiation for these purchases took place in the fall of 1993, and the deal was reportedly struck in October 1994.⁵² The goods were delivered in 1994 and 1995. They included a document describing, *inter alia*, “the casting of enriched and depleted uranium metal into hemispheres, related to the fabrication of nuclear weapons components.”⁵³ According to a reported IAEA account, no less than 13 meetings took place between Tehran and representatives of the network in the years 1994 to 1999.⁵⁴ Some shipments reportedly took place after 1995, perhaps as late as 2000.⁵⁵

This second influx of Pakistani technology to Iran took place during Mrs. Bhutto’s second mandate (October 1993–November 1996). Given the extent of government-to-government contacts, it certainly took place with the knowledge of several key authorities. She has confirmed that an offer had taken place and that there was a debate in Pakistan’s ruling circles about it.⁵⁶

The full scope of Pakistani exports and transfers to Iran—be they envisioned, planned or realized—is probably not yet known. Several questions still need to be addressed. Did the infamous “Chinese blueprint” for a nuclear weapon ever find its way into Iran? How many P1 spare parts and P2 parts (ring magnets in particular) were actually delivered to Iran by the Khan

network?⁵⁷ Given the similarities between the Pakistani Khushab reactor and the planned Iranian Arak reactor, was there any Pakistani help involved?

Iraq.

Available sources indicate that the initial contact with Iraq was made just a few weeks after the invasion of Kuwait. A note from the Iraqi intelligence services, dated October 6, reports that A. Q. Khan was ready to help Baghdad to “establish a project to enrich uranium and manufacture a nuclear weapon.” It reported that A. Q. Khan was prepared to give Iraq “project designs for a nuclear bomb.” Equipment was to be transferred from European companies to Iraq via a Dubai-based company.⁵⁸ The Iraqi government, however, feared that it was a sting operation.⁵⁹

Such a gesture would have been consistent with General M. A. Beg’s opposition to Pakistani participation in the international coalition (an opposition he began to express at the end of 1990). At the same time, however, if Beg was keen to help Iran, it would have been illogical for him to support the development of an Iraqi bomb at the same time. Helping Saddam Hussein, Iran’s mortal enemy, to get nuclear weapons might have been consistent with Beg’s political preferences (a staunch opponent of U.S. influence in the region), but completely at odds with his personal culture (a Shi’a with strong admiration for Iran).

North Korea.

The Pakistan-North Korea strategic connection was established as early as in 1971, when Z. A. Bhutto made Pyongyang a major source of conventional

arms procurement. The Iraq-Iran war cemented the partnership between the two countries, both of which aided Tehran's missile program.⁶⁰ According to Indian sources, Pakistan and North Korea began their missile and nuclear cooperation in 1988.⁶¹ Most sources agree, however, that the nuclear side of the bilateral cooperation began only around 1993. A defense cooperation package was agreed upon at the occasion of Benazir Bhutto's December 1993 visit to Pyongyang.⁶² A. Q. Khan seems to have "paved the way" for Bhutto's visit. He and the military involved Benazir Bhutto for the missile deal, because of the good relations of her father with North Korea.⁶³ A. Q. Khan travelled extensively to North Korea. He was given a tour of Pyongyang's nuclear facilities in 1999.⁶⁴ That same year, Democratic People's Republic of Korea (DPRK) experts were seen visiting the Khan Research Laboratories (KRL).⁶⁵ But the extent of his personal initiative in the matter of nuclear transfers remains open to question. It is possible that he felt that he was "covered" by the military authorities because of the Iran precedent. In any case, it seems likely that the military knew about the nuclear exports. General Jehangir Karamat (CoAS from 1996 to 1998, and ambassador to the United States until 2006) seem to have played a significant role in the DPRK-Pakistan connection.⁶⁶ It is also possible that the DPRK sometimes would serve as a conduit for Chinese assistance to Pakistan.

The usual explanation of what happened with North Korea is that it was a quid pro quo. This is what the U.S. Government believed in the late 1990s.⁶⁷ However, the story seems to be more complex. Nuclear exports seem to have begun much later than missile imports. Benazir Bhutto insists that the North Korean missiles were bought, not exchanged for nuclear technology.⁶⁸

(Some well-informed analysts insist that the latter were financed by “*money and rice.*”⁶⁹) Later, the Pakistani “reserve crunch” might have prompted Pakistan to turn from cash to nuclear technology in return for missile technology.⁷⁰ A former aide to Kim Il-Sung states that this deal was concluded in the summer of 1996.⁷¹ Centrifuges went to North Korea between 1997 and 1999, but other transfers took place until around July 2002.⁷² According to an early Musharraf account, “probably a dozen” centrifuges were sold.⁷³ Most available sources refer to P1 technology, but some have suggested they may have included P2 centrifuges.⁷⁴ The transfer of P2s was later confirmed by Musharraf, who mentions in his memoirs a total of “nearly two dozen” centrifuges.⁷⁵ There are also allegations of a broader cooperation in the nuclear area.⁷⁶

The missile imports were discovered by the United States around 1997-98.⁷⁷ In April 1998, the State Department applied sanctions against KRL. At about the same time, Washington also discovered that Islamabad exported nuclear technology to Pyongyang.⁷⁸ It asked Nawaz Sharif to cease transfers; Sharif made a commitment not to transfer nuclear weapons to Pyongyang, but refused to go further.⁷⁹

Whatever the reality, the most detailed studies about the DPRK-Pakistan ballistic and nuclear relationship have refrained from drawing definitive conclusions about its nature, especially given the uncertainties about the exact scope of the nuclear relationship.⁸⁰

Libya.

The nuclear relationship with Libya began in the mid-1970s. It is likely that Tripoli financed Pakistan’s nuclear program up to several hundred millions of

dollars. During an internal Department of State (DoS) meeting in 1976, one of the participants mentioned “an intelligence report that Libya has agreed to finance the Pakistani reprocessing project in return for some unspecified future nuclear cooperation.”⁸¹ However, initial transfers to Libya were limited to knowledge and expertise through training. This first phase ended with the deposition of Z. A. Bhutto. Concrete transfers took place only after the reinvigoration of Libya’s program in 1995. Contact was made with A. Q. Khan at that time.⁸²

In 1997, Libya received 20 complete L1 centrifuges, and most of the components for another 200. In 2000, it received two complete but “second-hand” L2 centrifuges, as well as two small cylinders of UF₆. In early 2001, it received one larger cylinder containing 1.7 tons of UF₆. In late 2001 or early 2002, documentation on nuclear weapons design, including the “Chinese blueprint,” was transferred. A. Q. Khan was still directly in touch with the officials in charge of Libya’s nuclear program in 2002.⁸³ In late 2002, components for a large number of L2s began to arrive.⁸⁴ Libya is probably the only documented case of Pakistani nuclear exports where the expression “Wal-Mart” (used by IAEA Director El-Baradei) could apply.

There is little evidence of direct involvement of Pakistani authorities in the Libya deal. Some have even pointed out that Khan himself was not always involved in all transactions. The network, it seems, had then taken on a life of its own.⁸⁵

Saudi Arabia.

There is no hard evidence of Pakistani-Saudi cooperation on nuclear issues in the public domain. The

hypothesis of such cooperation rests on a combination of ample anecdotal evidence and strong political logic.

Saudi financial support for Pakistan's nuclear program in the 1970s is well-documented (see above). U.S., Israeli, and Saudi sources (including Mohammad al-Khilawi, a diplomat who defected to the United States in 1994) reported in the early 1980s that Saudi financial support for the Pakistani program was continuing.⁸⁶ The BCCI may have been one of the conduits used.⁸⁷ This would make the banks a key institution, both involved in imports and exports. Khalid Hassan, a former adviser to Ali Bhutto, confirmed that Saudi Arabia was indeed an essential foreign fundgiver to the Pakistani program. Nawaz Sharif called Prince Abdallah for his opinion before giving the go-ahead to the 1998 tests.⁸⁸

In 1990, Saudi Arabia was reportedly tempted to get Pakistani nuclear weapons for its CSS-2 missiles.⁸⁹ Islamabad is said to have refused because of the political risks involved.⁹⁰ In May 1999, Prince Sultan (then defence minister) was the first-ever foreign leader to visit Kahuta. A. Q. Khan, for his part, visited Saudi Arabia at least twice (November 1999, September 2000).⁹¹ Saudi leaders have attended Pakistani Ghauri test launches (2002 and 2004).

The nuclear question seems to have been raised anew after 2001, including in discussions with Islamabad.⁹² Prince Sultan was reportedly given a tour of Pakistani nuclear installations in August 2002.⁹³ President Bush himself is reported to have included Saudi Arabia in a list of countries of proliferation concerns in January 2003, and Ryad may have begun direct financing of KRL around that time.⁹⁴ According to U.S. ambassador Chas Freeman, in 2003 King Fahd asked for a nuclear

guarantee in case Iran produced the bomb.⁹⁵ Whatever was said by Washington, it is doubtful that in the post-September 11, 2001 (9/11) context Riyadh believes it will always be protected by the United States. (The 2003 U.S. military withdrawal from Saudi Arabia may have been another incentive.) According to the *Guardian*, three options for the Saudi nuclear future were considered that year by Riyadh: a nuclear deterrent; a security guarantee; or a nuclear-weapons free zone in the region.⁹⁶ (Prince Turki implicitly confirmed the existence of the document by stating it was not followed by action.⁹⁷) A visit by Prince Abdallah in October 2003 was reportedly the next occasion for Islamabad and Riyadh to discuss nuclear cooperation. Several sources have asserted that a “nukes for oil” barter was agreed upon on this occasion. Riyadh may have formally asked for nuclear warheads to equip its CSS-2.⁹⁸ Other sources say that several Saudi C-130s made return trips to Pakistan between October 2003 and October 2004, followed by visits of nuclear experts in 2004-05 under cover of the Hajj.⁹⁹ (The same sources say that Riyadh’s decision to recall 80 diplomats in January 2004, and general Musharraf’s unexpected trip to Saudi Arabia in late June 2005, were caused by the windfall of the Abdul Qadeer Khan affair.¹⁰⁰) In April 2006, a French media outlet stated that Prince Khaled, vice-minister for defense, visited KRL in October 2004. It affirmed that nuclear cooperation between the two countries was now well underway. It stated that an agreement on nuclear cooperation was made on the occasion of King Abdallah’s visit to Islamabad in February 2006, followed by a visit to KRL by Prince Sultan bin Abdulaziz, defense minister, in April.¹⁰¹ A few weeks later, a German report stated that the Al-Sulayyil base, where CSS-2s are believed to be hosted, now houses Pakistani *Ghauri* missiles.¹⁰²

Most of these elements are unconfirmed reports, but they are extraordinarily persistent. The doubts about Ryad's intentions have been further raised by the country's decision in April 2005 to ask the IAEA for a "Small Quantities Protocol" (SQP), exempting the Kingdom from intrusive monitoring of nuclear activities.

Other Countries.

It was reported in 1999 by a Pakistani newspaper that the UAE made a request for nuclear assistance to A. Q. Khan during a visit of minister of information Shaykh Abdullah Bin Zayid Al Nahyyan; A. Q. Khan reportedly said that he would not give nuclear weapons to the UAE "on a platter," but would consider nuclear training and education.¹⁰³ There are good reasons to believe that the UAE could have expressed an interest in nuclear weapons: (1) its central role in the foundation of the BCCI, which was probably used as a conduit for Pakistani imports and exports; (2) its pivotal role as a "node" in Khan's exports network; (3) its unease about the development of Iran's nuclear program; (4) its possession of *Black Shaheen* cruise missiles (as well as a few ageing *Scud B* ballistic missiles), which could probably host a small-size nuclear warhead.

It was reported in 2004 that an offer for nuclear technology and hardware was made by A. Q. Khan to Syria.¹⁰⁴ A. Q. Khan gave several lectures in Damascus in late 1997 and early 1998.¹⁰⁵ But he is also suspected of having met a top Syrian official in Beirut to offer assistance with a centrifuge enrichment facility.¹⁰⁶ After 2001, A. Q. Khan's meetings with Syrians were reportedly held in Iran.¹⁰⁷ Not much is known about the Syria case. Some intelligence sources reportedly

believe that the country has imported centrifuges from the network.¹⁰⁸ However, other sources have stated that the offer was declined.¹⁰⁹

Other countries have been mentioned. It was reported in 2004 that A. Q. Khan offered nuclear assistance to Egypt, which is said to have turned down the offer.¹¹⁰ Some suspect that A. Q. Khan may have transferred centrifugation technology to Brazil.¹¹¹ There have also been throughout the 1980s and 1990s several mentions of Turkey as a possible recipient of Pakistani nuclear technology.¹¹² Finally, several sources claim that Pakistan exported its URENCO centrifugation technology to China, which had a relatively weak centrifuge enrichment program.¹¹³

PAKISTANI NUCLEAR EXPORTS: WAS THERE A STATE POLICY?

An Individual Initiative?

Most knowledgeable observers of the Pakistani scene agree that A. Q. Khan had an important degree of autonomy. If nuclear weapons exports had been a consistent State policy, then it would have been logical that PAEC had a role in it too, which does not seem to have been the case. This does not exonerate Pakistani authorities, but as an informed observer put it, "Khan likely exceeded whatever mandate he received from the Pakistani leadership."¹¹⁴ He may have felt that he was "covered" for whatever he did by the large amount of trust and autonomy he was enticed with.¹¹⁵ It seems, in fact, that A. Q. Khan was able to manipulate the government, and the Pakistani authorities did not want to know what was going on. For instance, he would tell the Prime minister that he needed to go to

Iran for reasons of national security, and that would be enough.¹¹⁶ “As long as Khan’s group delivered the goods, no state authority questioned his tactics.”¹¹⁷ That Pakistani Air Force planes were chartered does not necessarily indicate a government implication in nuclear transfers: In the case of North Korea, a legitimate explanation was the missile and other arms transfers (such as air defense systems); in the case of Libya, the explanation would have been the export of conventional weapons.

The network’s actions were made easy by the secrecy and compartmentalization of Pakistan’s program until the late 1990s, which did not create the best conditions for oversight. Security precautions were made to protect KRL from the outside world, not to protect the outside world from KRL—and security officers reported to Khan.¹¹⁸ Another reason was that KRL had become, by the late 1980s, a large weapons manufacturer embedded in Pakistan’s military-industrial complex; many officials did not have an interest in rocking the boat. An Army investigation for details about KRL and PAEC procurements went nowhere.¹¹⁹

However, at some point, it became not good enough. Three events changed the picture: the 1998 tests, the 1999 coup, and the 2001 attacks and their aftermath. There was a progressive reorganization of Pakistan’s nuclear program between 1998 and 2001. The nuclear laboratories, which for a long time had a large operational and financial autonomy, were reined in. A. Q. Khan was forced to retire from KRL in March 2001.

Several explanations exist as the reasons for this decision. Some U.S. administration officials have said that this was an American request.¹²⁰ It may also have been Musharraf’s own initiative—or a combination of

both. After the 1998 tests, Pakistan was under strong pressure from the United States to show responsible behavior, and it was in dire need of Western assistance. There was an ISI investigation of Khan's finances in 1998-99.¹²¹ Another inquiry by the newly-created National Accountancy Bureau at the request of Musharraf revealed unapproved financial transactions; it was not pursued due to the sensitivity of the matter.¹²² Then came reports of North Korean experts visiting KRL. Although the visits were even then denied by A. Q. Khan, according to Musharraf the event triggered surveillance of his activities.¹²³ According to several sources, the ISI—which since 1999 reported directly to Musharraf—followed A. Q. Khan to Dubai in the fall of 2000. When asked for an explanation by Musharraf, who was concerned about financial improprieties, he complained about the surveillance, gave false excuses, and continued his travels.¹²⁴ The same thing happened when he was asked by Musharraf to explain an aircraft landing in Zahedan, Iran.¹²⁵ But A. Q. Khan probably felt invulnerable. He was clearly reluctant to abide by the new rules, which included a better oversight of nuclear officials. He was making it known that he disapproved of the reorganization of Pakistani nuclear policy.¹²⁶

The official version, which includes in particular the report that Pakistani authorities only discovered A. Q. Khan's unsanctioned activities after the ISI raided a cargo plane leaving for North Korea in 2000, is not convincing.¹²⁷ But there was definitely a personal element in his activities.

Why, then, given that extensive transfer of nuclear technology to North Korea and Libya could have taken place from 2001 to 2003, at the exact time of Pakistan's consolidation of nuclear policymaking, and well after

Khan's dismissal in March 2001, was he allowed to continue his travels?¹²⁸ The reason may be that he had the keys to the imports network, still vital for the Pakistani nuclear program.¹²⁹ Note that A. Q. Khan remained Special Adviser to the Chief Executive on Strategic and KRL Affairs after his dismissal, until a Nuclear Command Authority (NCA) decision stripped him of this title on January 31, 2004.

Khan's motivations were complex and evolved over time. They cannot be reduced to a single factor. According to David Sanger, "to understand A. Q. Khan, you have to understand ego, greed, nationalism, and Islamic identity."¹³⁰ A first motivation was to ensure his personal role and legitimacy in Pakistan's nuclear program: Transfers were the counterpart of imports made for the sake of the Pakistani program, or of financial assistance given to Pakistan by countries such as Libya or Saudi Arabia. A. Q. Khan also reportedly wanted to deflect attention from Pakistan.¹³¹ He said in his debriefing sessions that he thought that "the emergence of more nuclear states would ease Western attention on Pakistan."¹³² A second motivation, which seems to have gained in importance over time, was pure and simple greed. Supply created demand: Excess inventories of centrifuges and spare parts (notably P1 centrifuges, since they were being replaced by P2s) were looking for customers. A third element was pure and simple hubris. A. Q. Khan was a man who enjoyed defying authority and norms. He talked about centrifugation technology as if it was his own property. This is where the Islamic dimension comes into play: He may have been willing to be recognized as the one who gave the Bomb to the *Umma*. He reportedly said that his transfers "would help the Muslim cause."¹³³ That said, some of those who know him say A. Q. Khan

is not an Islamist, and that he emphasized his faith to bolster his support in the country. A. Q. Khan may simply have wanted to “defy the West” – given that all known customers were on unfriendly terms with the United States and Europe.

A State Policy?

Most known exports happened between 1988 (the death of Zia) and 1999 (the Musharraf takeover). In August 1988, the program came into the hands of Senate chairman G. I. Khan (who immediately became President according to succession rules) and CoAS Mirza Aslam Beg.

In the ensuing decade, the structure of Pakistani power was complex, and divided among three individuals: the President, the Prime Minister, and the CoAS. For this reason, it is obviously difficult to answer the question “Who knew what?” As two knowledgeable observers put it, “The diffusion of authority enabled national security organizations to manipulate the system and become nearly autonomous. In this environment, Khan would have needed to convince only one of the centers of power that sharing nuclear technology with foreign entities would be in Pakistan’s interest.”¹³⁴

What seems clear is two-fold. First, the Prime Ministers during that period (Benazir Bhutto and Nawaz Sharif in particular) were not completely out of the loop. Indeed, the Pakistani government openly acknowledges the role of two (conveniently dead) individuals close to the Bhutto family: General Imtiaz Ali, military secretary to Z. A. Bhutto and defense adviser to his daughter, Benazir; and family dentist Zafar Niazi.¹³⁵ Second, a handful of Pakistani leaders

seem to have played a key role. One was General Mirza Aslam Beg, vice-CoAS, then CoAS from August 1988 until August 1991. There is ample evidence of his involvement in Iranian-Pakistani nuclear cooperation. As stated above, his personal background (a Shi'a) and political preferences led him to take a consistent pro-Iranian, anti-Western stance. Another key individual was Ghulam Ishaq Khan. One quasi-official statement reported G. I. Khan as being actually *in charge* of the nuclear program from 1975 until 1991.¹³⁶ As defense minister, he was involved in the decision to make Kahuta a separate entity under A. Q. Khan.¹³⁷ He was a member of the three-man KRL oversight board when it was created in 1976.¹³⁸ As finance minister, he was present at the first 1983 cold tests.¹³⁹ He also gave tax-free status to the BCCI, which was used as a conduit for Pakistani nuclear imports and exports.¹⁴⁰ Being chairman of the Senate, he automatically became president, at the same time as M. A. Beg became CoAS, after Zia's death, and remained in that position until July 1993. He was close to Beg and broke with him only when it became clear that he wanted to topple Nawaz Sharif. (G. I. Khan also opposed Beg's preferred candidate for his own succession, General Hamid Gul, a former ISI chief.) In 1990, A. Q. Khan acknowledged that G. I. Khan had been a key supporter of the nuclear program.¹⁴¹ He even described him as guarding the program "like a rock."¹⁴² When he died, A. Q. Khan had a mausoleum built for him in the "G. I. Khan Institute," for which he had been the project director. Finally, it is hardly conceivable that successors to M. A. Beg as chiefs of Army staff (Generals Azif Nawaz, Abdul Wahid Kakar, Jehangir Karamat, and Pervez Musharraf) were *completely* unaware of *any* transfers of nuclear technology. At the very least, they proved

unwilling to ensure that Khan was not able to proceed with unsanctioned exports. General Jehangir Karamat in particular may have been a key player in his capacity of CoAS from December 1996 until his resignation in October 1998. He was on good terms with A. Q. Khan. He reportedly ensured KRL participation in the 1998 tests.¹⁴³ (He was nominated ambassador to the United States in November 2004: but in March 2006, the Pakistani press announced his early departure from his position, for unknown reasons.) A. Q. Khan has reportedly admitted that both Kakar and Karamat knew and approved of his dealings with North Korea.¹⁴⁴

During 1987 to 1999, A. Q. Khan, who was certainly good at manipulating the system, may have been himself manipulated so as to ensure “plausible deniability.” A. Q. Khan’s personal profits were reportedly known by the ISI since 1988, but Pakistan’s military authorities refused to act.¹⁴⁵ In 1989, the ISI reported suspicious activities to President G. I. Khan, but, as the protector of A. Q. Khan, he just told Khan that he needed to be careful.¹⁴⁶ Knowledgeable observers suggest that a combination of factors in the year 1987 led to the emergence of the network: the shift towards P2 centrifuges, creating a large “excess inventory” of P1s; the arrival of M. A. Beg as VCoAS; the “Brasstacks” crisis with India; and the “dress-down” given by Zia to A. Q. Khan for having boasted about Pakistan’s nuclear capability in an interview.

So, were nuclear exports a personal initiative or a State policy? The answer is: a little bit of both, in various proportions, according to the circumstances. Different transfers probably reflected different situations. There are, first, the three cases where the network was not directly involved: China, North Korea, and possibly Saudi Arabia. The possible quid pro quo with China

(centrifugation technology in return for UF6 or heavily enriched uranium [HEU], as well as a weapon design) would have been a state policy. Some claim that such a deal was concluded in the mid-1980s. In any case, the scope of Pakistan's nuclear cooperation with China, which extends for more than a decade, strongly suggests governmental approval. The transfers to North Korea may have been a State policy made with knowledge of some high-level Pakistani authorities (including perhaps Benazir Bhutto and Nawaz Sharif), although this point remains unclear. In any case, no element of Islamic solidarity was present there. Rather, it was the need to ensure the continued development and reliability of the liquid-fuel (*Ghauri*-type) family of Pakistani ballistic missiles. Finally, any nuclear cooperation discussions with Saudi Arabia would have been, in all likelihood, sanctioned by the highest political and military authorities.

And then there are the cases where the network was directly involved: Iran, Libya, Iraq, possibly Syria, and others. Iran is the most complex case. The launching of a military-oriented nuclear cooperation was probably not sanctioned by President Zia ul-Haq. However, during 1988 to 1995, exports to Iran were known by most Pakistani leaders, including Prime Ministers Bhutto and Sharif, and deliberately encouraged by some, such as M. A. Beg and G. I. Khan. The case of Libya was probably a Khan initiative. To some, including Khan himself, this may also have been "payback time." When Tripoli agreed to give financial support for the Pakistani program in the early 1970s, it asked for nuclear technology in return. (Z. A. Bhutto never committed himself to go that far.¹⁴⁷ But he may have created expectations in Ghaddafi's mind.) Finally,

offers to Iraq and possibly to Syria were probably A. Q. Khan's own initiative.

It seems reasonable to say that there was no constant and consistent state policy governing the nuclear exports made, or sanctioned, by Pakistani officials in the past 30 years. Concrete interests, personal and national, seem to have been the primary driver behind these exports. They were made possible by the large freedom of manoeuvre given to A. Q. Khan's activities until the end of the 1990s. But there has been, at least in one instance, in the late 1980s, an attempt to make nuclear exports part of a broader national strategic orientation.

Some argue, however, that Pakistani nuclear exports do reflected a consistent State policy. According to Simon Henderson, there were two successive Pakistani strategies. First was a strategy of exchanges or barter: one with China (centrifuge technology for HEU and bomb design), and one with North Korea (centrifuge technology for ballistic missiles). Second was a strategy designed to blackmail the United States, through exports to Muslim States.¹⁴⁸ Alternatively, different actors of the Pakistani leadership may have had different strategies.

FUTURE RISKS

There is no reason to believe that the current Pakistani leadership would today deliberately transfer expertise and knowledge to other States or nonstate actors, at least in peacetime. The risk of further deliberate transfers of nuclear technologies by the Pakistani authorities appears much weaker today – at least as long as there is an objective alliance between Pakistan and the United States. And there are good

reasons to believe that Pakistan has put its nuclear house in order, as deduced from a series of decisions and reorganizations made between 1998 and 2003. The Strategic Planning Directorate (SPD) is a serious organization manned by serious people.

The Risk of Further Unsanctioned Transfers.

However, risks have not disappeared. It is not certain that the additional security procedures set up by Pakistan since 2001 make it impossible to have significant unsanctioned transfers of know-how and expertise by lower-level scientists or engineers. No less than 10,000 to 16,000 people are employed by PAEC.¹⁴⁹ A total of 6,500 scientists and 45,000 people are reportedly involved in the whole nuclear program.¹⁵⁰

Precedents are not reassuring. The full story of the travels of Sultan Bashiruddin Mahmood (a former PAEC director), Chaudry Abdul Majid (a former New Labs director), and Mirza Yusuf Baig (a PAEC engineer) to Afghanistan has yet to be written. The same for Suleiman Asad and Muhamed Ali Mukhtar's alleged links with Al-Qaida.¹⁵¹ Some of these individuals were previously associated with A. Q. Khan, including Mahmood who had been his first boss in 1975. The old question of "Who will guard the guardians?" remains relevant in Pakistan.¹⁵²

In the past, key government officials were known for their Islamist sympathies. This was apparently the case for key scientists such as Abdul Qadeer Khan and Bashiruddin Mahmood, or military leaders such as Mirza Aslam Beg and Hamid Gul (a former ISI director).¹⁵³ This was also the case of Muhammad Aziz Khan (a former chairman of the joint chiefs of staff and as such responsible for nuclear procurement until 2004,

and known to consider the United States as the enemy number one of the Muslim world). Some scientists and engineers may have divided loyalties if approached by a nonstate Islamist actor. For a long time, this was not viewed as a problem by those overseeing the program: It was thought that piety was conducive to respect for authority.¹⁵⁴

Risks of transfers would also exist in a crisis situation: Pakistan could pre-delegate launch authority for fear of preemption or decapitation.¹⁵⁵ Putting nuclear weapons systems on alert involves the relocation of several elements (physics packages, assembled warheads, and delivery systems), making them vulnerable during transit. Also, it should be noted that a pilot flying a nuclear-armed aircraft is reportedly given all necessary codes before taking off.¹⁵⁶ One former official has even mused with the idea of a deliberate transfer to a nonstate actor in wartime in order to ensure a capability to retaliate on Indian soil; such a scenario would fall into the category of sanctioned transfers.¹⁵⁷

The lack of real checks and balances and democratic controls in today's Pakistan might make it still possible in a post-Musharraf future for a Pakistani CoAS to order, on his own, a direct transfer of key technologies or equipments.

The Risk of Further Sanctioned Transfers.

If Iran encountered technical problems in the advancement of its nuclear program, it surely would like to benefit again from Pakistan's expertise. But it is very unlikely that Islamabad would agree. At the same time, two critical Iranian players of the Pakistan-Iran discussions of the 1980s are still in power in Tehran:

Rafsanjani (head of the Expediency Council) and Mohsen Rezai (secretary of the Expediency Council and a former candidate in the 2005 elections whose views on the United States are close to Ahmadinejad's). Their knowledge about the Pakistani system may put them in a position to approach certain players. In any case, new state-sponsored transfers would certainly suppose a breakdown in U.S.-Pakistan relations. Note also that Islamabad would have to make a choice between Riyadh and Tehran.

As far as Saudi Arabia is concerned, three scenarios can be conceived. A first scenario is a Pakistani nuclear guarantee without deployments, such as the one given by the United States to Japan. Ballistic missiles based in south-western Pakistan would have the range to cover a significant portion of the Saudi neighborhood, including U.S. bases (though not Israel).¹⁵⁸ Some Pakistani planners acknowledge that such an option would be conceivable.¹⁵⁹ It would not question the existence of U.S.-Saudi and U.S.-Pakistan alliances.¹⁶⁰

A second scenario would be a security guarantee involving nuclear deployments on Saudi soil, such as the one given by the United States to Germany. It would not be a violation of the Nuclear Nonproliferation Treaty (NPT), and if Pakistan continues to build up its arsenal, would not detract from immediate deterrence needs vis-à-vis India. It would be a win-win proposal, since Pakistan would gain in survivability against a hypothetical Indian preemptive strike (although even *Shaheen-2* missiles would not be able to threaten Delhi from Saudi territory). Being detectable, such deployments would only be conceivable if relations were good between Washington on the one hand, and Riyadh and Islamabad on the other. However, Pakistani planners acknowledge that such deployments would

be unacceptable to Israel.¹⁶¹ One of them calls the scenario “worse than the Cuban [missile] crisis.”¹⁶²

A third scenario would be a Saudi bomb, either with the help of Pakistan or completely indigenous. Though highly unlikely, it is not completely farfetched given the Kingdom’s wealth. A Nuclear Energy Research Institute was inaugurated in 1988, and Saudi publications show an interest in nuclear physics and technology.¹⁶³ The Saudi request for access to the small quantities protocol (SQP) in 2005 (immediately followed by an unexpected visit by Musharraf on June 25 and 26) raised eyebrows. Some sources assert that a second nuclear research center was created in 1975 at the Al-Suyyalil base.¹⁶⁴ This is where the CSS-2 missiles were stored in 1998—the same year as the creation of the Nuclear Energy Research Institute. Washington reportedly told Islamabad that the sale of Pakistani nuclear weapons to Saudi Arabia is a red line Pakistan should not cross.¹⁶⁵

Since 1999, Pakistan has made considerable efforts to put its nuclear house in order, and a sense of responsibility on nuclear matters seems to pervade the country’s leadership today. However, it will take time before Pakistan can be considered as “just another nuclear country.” Two conditions may have to be met: the establishment of a long-term alliance between the United States and Pakistan, based on the recognition of enduring common interests, allowing the restoration of mutual trust; and the diffusion of a culture of responsibility in the vast Pakistani nuclear complex, beyond the elites.

ENDNOTES - CHAPTER 2

1. There were a number of Pakistan-born and Iran-born officials and advisors in the entourage of M. M. Mandela et Mbeki, sometimes referred to as the "Karachi connection." A. Q. Khan's wife was a South African national.

2. Sudan was also a major platform of the network, at least during 1999 to 2001, in particular for materials destined to Iran. Ian Traynor and Ian Cobain, "Clandestine Nuclear Deals Traced to Sudan," *The Guardian*, January 5, 2006.

3. David Albright, "A. Q. Khan Network: The Case Is Not Closed," Testimony to the Subcommittee on International Terrorism and Nonproliferation, Committee on International Relations, House of Representatives, U.S. Congress, May 25, 2006.

4. Polis Dijara Malaysia, "Press Release by Inspector General of Police In Relation to Investigation on the Alleged Production of Components for Libya's Uranium Enrichment Program," February 20, 2004, accessed at www.ccc.nps.navy.mil/si/2007/Aug/tertraisAug07.asp.

5. Gordon Corera, *Shopping for Bombs. Nuclear Proliferation, Global Insecurity and the Rise and Fall of the A. Q. Khan Network*, London: Hurst & Co., 2006, pp. 59-60, p. 136.

6. *Ibid.*, p. 65.

7. Polis Dijara Malaysia.

8. Some sources also claim the involvement of Noman Shah, former son-in-law of A. Q. Khan.

9. Details on the South Africa operation are contained in High Court of Transvaal, "The State vs. 1. Daniel Geiges 2. Gerhard Wisser," (undated document, 2006), accessed at www.ccc.nps.navy.mil/si/2007/Aug/tertraisAug07.asp. The operation has been referred to as "Project A.F." (for "Arab Fuckers" [sic]); documents discovered in the investigation are reported to have involved Iran, Pakistan, India, and South Africa's own program. See Steve Coll,

"Atomic Emporium," *The New-Yorker*, August 7 and 14, 2006, p. 57.

10. Juergen Dahlkamp, Georg Mascolo, and Holger Stark, "Network of Death on Trial," *Der Spiegel*, March 13, 2006.

11. Simon Henderson, "Nuclear Spinning: The Iran-Pakistan Link," *National Review Online*, December 11, 2003; John Lancaster and Kamran Khan, "Pakistanis Say Nuclear Scientists Aided Iran," *The Washington Post*, January 24, 2004. Other officials arrested in December 2003 and January 2004 included Yassin Chauhan, Nazir Ahmed, and Islam ul-Haq, all KRL officials.

12. Special Report, "The A. Q. Khan Network: Crime . . . And Punishment?" *WMD Insights*, Issue 3, March 2006.

13. *Ibid.*

14. David Albright and Corey Hinderstein, *Uncovering the Nuclear Black Market: Working Toward Closing Gaps in the International Nonproliferation Regime*, Washington, DC: Institute for Science and International Security, July 2, 2004, www.isis-online.org/publications/southasia/nuclear_black_market.html; Polis Dijara Malaysia; "Nuke trail traced to M'sia, Pakistan, Libya," *The Korea Herald*, February 16, 2006.

15. William J. Broad, David E. Sanger, and Raymond Bonner, "A Tale of Nuclear Proliferation," *The New York Times*, February 12, 2004.

16. See Lancaster and Khan, "Pakistanis Say Nuclear Scientists Aided Iran."

17. Stephen Fidler and Farhan Bokhari, "Pakistan Investigates BCCI Role in Sale of Nuclear Know-How," *The Financial Times*, February 4, 2004.

18. A U.S. scholar says that M. A. Khan personally confirmed this (interview with U.S. scholar, Washington, October 2005).

19. NTI Global Security Newswire, Iran Nuclear Chronology.

20. *Ibid.*; Corera, p. 64. Steve Coll, "Atomic Emporium," *The New-Yorker*, August 7 and 14, 2006, pp. 56-57, reports that according to Leonard Weiss, the agreement was signed in 1985.

21. Yossef Bodansky, *Pakistan's Islamic Bomb*, Houston: Freeman Center for Strategic Studies, July 1998; Rajesh Kumar Mishra, *Pakistan as a Proliferator State: Blame it on Dr. A. Q. Khan*, Paper n° 567, India: South Asia Analysis Group, December 20, 2002.

22. The IAEA was shown in January 2005 a copy of a document reflecting "an offer said to have been made to Iran in 1987 by a foreign intermediary," involving the supply of "a disassembled machine (including drawings, descriptions and specifications for the production of centrifuges); drawings, specifications and calculations for 'a complete plant'; and materials for 2000 centrifuges machines." Vienna, Austria: IAEA, *Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran*, GOV/2006/15, February 27, 2006, p. 3. An Iranian opponent from the NCRI stated in a press conference in Vienna in November 2004 that Pakistan provided to Iran, in 2001, a small quantity of highly enriched uranium (HEU). However, this statement was made in answer to a question and was not subsequently used in NCRI propaganda documents. See Press Conference By Mohammad Mohadessin, Foreign Affairs Committee Chairman, National Council of Resistance of Iran, November 17, 2004; and Elaine Sciolino, "Exiles Add to Claims on Iran Nuclear Arms," *New York Times*, November 18, 2004.

23. Lancaster and Khan, "Pakistanis Say Nuclear Scientists Aided Iran"; and John Wilson, "Iran, Pakistan and Nukes," New Delhi, India: Observer Research Foundation, 2005.

24. Dennis Kux, *The United States and Pakistan 1947-2000. Disenchanted Allies*, Washington DC: Woodrow Wilson Center Press, 2001, p.284.

25. See John Lancaster and Kamran Khan, "Musharraf Named in Nuclear Probe," *Washington Post*, February 3, 2004; Mubashir Zaidi, "Scientist Claimed Nuclear Equipment Was Old, Official Says," *Los Angeles Times*, February 10, 2004.

26. Kathy Gannon, "Iran Sought Advice in Pakistan on Attack," Associated Press, May 12, 2006.

27. M. A. Chaudhri, "Pakistan's Nuclear History: Separating Myth from Reality," *Defence Journal*, May 2006.

28. Seymour Hersch, "On the Nuclear Edge," *The New-Yorker*, March 29, 1993.

29. Gannon, "Iran Sought Advice in Pakistan on Attack."

30. Kathy Gannon, "Explosive Secrets from Pakistan," *Los Angeles Times*, January 30, 2004. Gannon says she interviewed Beg himself on this subject in 2003.

31. Matt Kelley, "Pakistan Threatened to Give Iran Nukes," Associated Press, February 27, 2004; and Douglas Frantz, "Pakistan's Role in Scientist's Nuclear Trafficking Debated," *Los Angeles Times*, May 16, 2005.

32. David Rohde, "Pakistanis Question Official Ignorance of Atom Transfers," *New York Times*, February 3, 2004; Lancaster and Khan, "Musharraf Named in Nuclear Probe"; David Armstrong, "Khan Man," *The New Republic*, November 9, 2004.

33. Frantz, "Pakistan's Role . . ."; Douglas Frantz, "Iran Closes in on Ability to Build a Nuclear Bomb," *Los Angeles Times*, August 3, 2003.

34. Gannon, "Iran Sought Advice in Pakistan on Attack."

35. Rohde, "Pakistanis Question . . ."; Lancaster and Khan, "Musharraf Named . . ."; Armstrong, "Khan Man."

36. Zaidi; Gaurav Kampani, *The Military Coup: Implications for Nuclear Stability in South Asia*, CNS Report, CNS/MIIS, October 1999.

37. Kux, p. 209.

38. Hersch.

39. Kux, p. 299.

40. Hassan Abbas, *Pakistan's Drift into Extremism. Allah, the Army, and America's War on Terror*, New Delhi: Pentagon Press, 2005, p. 142. Mrs. Bhutto claims to have ordered, during her first mandate, that no Pakistani nuclear scientist leaves the territory without her written permission (quoted in Rohde, "Nuclear Inquiry . . .").

41. Kux, p. 313.

42. See John Lancaster and Kamran Khan, "Pakistanis Say Nuclear Scientists Aided Iran," *Washington Post*, January 24, 2004. Beg's concept was called "strategic defiance." The more precise expression "strategic depth" is attributable to General Hamid Gul, then-chief of ISI.

43. See Lancaster and Khan, "Pakistanis Say Nuclear Scientists Aided Iran"; and Gaurav Kampani, *Proliferation Unbound: Nuclear Tales from Pakistan*, Monterey, CA: Center for Nonproliferation Studies, Monterey Institute for International Affairs, February 2004. One of the former officials, Chaudhry Nisar Ali Khan, says that Beg declared to him at the time: "Iran is willing to give whatever it takes, \$6 billion, \$10 billion. We can sell the Bomb to Iran at any price." Wilson, "Iran, Pakistan and Nukes"; see also Gannon, "Explosive Secrets from Pakistan." Ishaq Dar mentions 12 billion dollars, see Shaukat Piracha, "Beg asked Nawaz to give nuclear technology to a 'friend', says Ishaq Dar," *Daily Times*, September 21, 2005. Still another one claims that Iran offered Beg "around 8 billion dollars" in 1991 (quoted in Powell and McGirk.).

44. Lancaster and Khan, "Musharraf Named in Nuclear Probe."

45. Kenneth R. Timmerman, *Countdown to Crisis. The Coming Nuclear Showdown with Iran*, New York: Crown Forum, 2005; and Udayan Nambodiri, "Dr. Khan's story: Thy Hand, Great Gen!," *Pioneer*, February 6, 2004.

46. Gannon, "Explosive Secrets from Pakistan"; David Rohde, "Nuclear Inquiry Skips Pakistan Army as Musharraf Tries to Protect Its Club," *New York Times*, January 30, 2004; and Nambodiri.

47. Timmerman, pp. 101-107.

48. See Rohde, "Nuclear Inquiry..."
49. Abbas, p. 148.
50. Lancaster and Khan, "Pakistanis Say Nuclear Scientists Aided Iran."
51. Corera, p. 233.
52. *Ibid.*, p. 69.
53. IAEA, *Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran*, p. 5.
54. Bill Powell and Tim McGirk, "The Man Who Sold The Bomb," *Time Magazine*, February 6, 2005.
55. William J. Broad and David E. Sanger, "New Worry Rises after Iran Claims Nuclear Steps," *The International Herald Tribune*, April 17, 2006.
56. See Corera, p. 76.
57. According to the IAEA, Iran had inquired into the delivery of 900 ring magnets suitable for P2 machines from a foreign entity in mid-2003. IAEA, *Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran*, p. 4.
58. "Memo # 78m, Subject: Proposal," Iraqi intelligence document, October 6, 1990.
59. David Albright and Corey Hinderstein, "The A. Q. Khan Illicit Nuclear Trade Network and Implications for Nonproliferation Efforts," *Strategic Insights*, Vol. V, Issue 6, July 2006.
60. Joseph S. Bermudez, Jr., *DPRK-Pakistan Ghauri Missile Cooperation*, Washington, DC: Federation of American Scientists, May 21, 1998.
61. George Wehrfritz and Richard Wolfe, "How North Korea Got the Bomb," *Newsweek*, October 27, 2003.

62. One source claims that the arrangement was agreed in December 1994, when Benazir Bhutto arranged it in Pyongyang at the request of Abdul Waheed Kakar, the Army CoAS. This may be a mistake and in fact a reference to Bhutto's December 1993 visit. Lancaster and Khan, "Musharraf Named in Nuclear Probe."

63. Corera, p. 87.

64. Powell and McGirk, "The Man Who Sold The Bomb."

65. Pervez Musharraf, *In The Line of Fire. A Memoir.* New-York : Free Press, 2006, pp. 288-289.

66. David Armstrong, "Khan Man," *The New Republic*, November 11, 2004; Lancaster and Khan, "Musharraf Named"

67. See Strobe Talbott, *Engaging India. Diplomacy, Democracy and the Bomb*, New Delhi: Penguin Books, 2004, p. 150.

68. See Corera, p. 89.

69. Owen Bennett Jones, *Pakistan: Eye of the Storm*, New Haven: Yale University Press, 2003, p. 206.

70. Congressional Research Service, *Weapons of Mass Destruction: Trade Between North Korea and Pakistan*, Report for Congress, March 11, 2004; Douglas Frantz, "Pakistan's Role in Scientist's Nuclear Trafficking Debated," *Los Angeles Times*, 16 May 2005.

71. See Corera, p. 92.

72. *Ibid.*, pp. 92-93.

73. "President's Interview with *New York Times*," www.presidentofpakistan.gov.pk, September 12, 2005.

74. Mubashir Zaidi, "Scientist Claimed Nuclear Equipment Was Old, Official Say," *Los Angeles Times*, February 10, 2004; William J. Broad and David E. Sanger, "New Worry Rises after Iran Claims Nuclear Steps," *The International Herald Tribune*, April 17, 2006; Corera, p. 94.

75. Musharraf, *op. cit.*, p. 296.

76. See Christopher O. Clary, *The A. Q. Khan Network: Causes and Implications*, Monterey, CA: U.S. Naval Postgraduate School, December 2005, pp. 62-71.

77. See Koch, "Pakistan Persists with Nuclear Procurement"; and Kux, p. 343.

78. The existence of nuclear exports to Pyongyang was reported in the 1998 Bermudez article.

79. Strobe Talbott, *Engaging India. Diplomacy, Democracy and the Bomb*, New Delhi: Penguin Books, 2004, pp. 150-151.

80. See Clary, *The A. Q. Khan Network . . .*, pp. 62-71.

81. Department of State, Memorandum of conversation, Subject: Proposed Cable to Tehran on Pakistani Nuclear Reprocessing, Secret, May 12, 1976, p. 3.

82. Wyn Q. Bowen, *Libya and Nuclear Proliferation. Stepping Back from the Brink*, Adelphi Paper n° 380, London: International Institute for Strategic Studies (IISS)/Routledge, 2006, pp. 30-43.

83. Corera, p. 190.

84. IAEA, *Implementation of the NPT Safeguards Agreement of the Socialist People's Libyan Arab Jamahiriya*, GOV/2004/12, February 20, 2004, p. 5.

85. See Corera.

86. "Saudi Nuclear Pact," *The Washington Post*, January 19, 1981; Marie Colvin and Peter Sawyer, "How an Insider Lifted the Veil on Saudi Plot for an 'Islamic Bomb'," *Sunday Times*, July 24, 1994; "Mohammed al-Khilewi: Saudi Arabia is Trying to Kill Me," *The Middle East Quarterly*, Vol. V, No. 3. Saudi Arabia was also reported to finance the Iraqi program.

87. "A Blind Eye to the Islamic Bomb," Dateline, Special Broadcasting Service, June 23, 2004.

88. See Abbas, pp. 162-163. At this occasion, Saudi Arabia reportedly proposed to guarantee to Pakistan preferential prices for its oil deliveries in order to cushion the cost of expected sanctions. Roula Khalaf, Farhan Bokhari, and Stephen Fidler, "Saudi Cash Joins Forces With Nuclear Pakistan," *The Financial Times*, August 5, 2004.

89. President H. G. W. Bush was reportedly told about this by U.S. intelligence in late November 1990. Bergman.

90. Mansoor Ijaz, "Pakistan's Nuclear Metastasis: How Widespread is the Cancer?" *The Weekly Standard*, January 8, 2004. According to the author, another option was to set up a secret nuclear base on the territory of another Gulf monarchy.

91. After the November 1999 visit, a Saudi nuclear expert reportedly declared: "Saudi Arabia must make plans aimed at making a quick response to face the possibilities of nuclear warfare agents being used against the Saudi population, cities or armed forces." Gopalaswami Parthasarathy, "Pakistan Plays Nuclear Footsie; Does Anyone Care?" *Wall Street Journal*, January 2, 2004.

92. "Saudi Arabia Takes Steps To Acquire Nuclear Weapons," *Defense & Foreign Affairs*, October 30, 2002. See also "Saudi Looking to Go Nuclear? Intel Analysts Say Royal Family Wants to Keep Up with Tehran," *Geostrategy-Direct Intelligence Brief*, June 19, 2003.

93. Selig S. Harrison, "U.S. Must Clamp Down on Pakistan Nuke Dealing," *San José Mercury News*, May 30, 2003.

94. See Corera, p. 168.

95. Harrison.

96. Ewan MacAskill and Ian Traynor, "Saudis Consider Nuclear Bomb," *The Guardian*, September 18, 2003. This information was confirmed by Simon Henderson in "Toward a

Saudi Nuclear Option: The Saudi-Pakistani Summit," *Policywatch*, No. 793, Washington, DC: The Washington Institute for Near East Policy, October 16, 2003.

97. Khalaf *et al.*

98. Arnaud de Borchgrave, "Pakistani-Saudi Trade Nuke Tech for Oil," UPI, October 20, 2003; Uri Dan, "Saudis Trying to Buy Nukes," *New York Post*, October 22, 2003; David R. Sands, "Israeli General Says Saudis Seek to Buy Pakistani Nukes," *Washington Times*, October 23, 2003; Ze'ev Schiff, "Iran: Pakistan Helping Saudis Develop Nukes," *Haaretz*, December 8, 2004.

99. "Pak-Saudi N-link Alive," *News Insight*, April 15, 2005; Amir Mir, "Probe into Nuclear Cooperation Worries Pakistan, S. Arabia," *South Asia Tribune*, July 6, 2005. The participation of Saudi scientists in Khan-organized conferences is also reported. William J. Broad and David E. Sanger, "As Nuclear Secrets Emerge in Khan Inquiry, More are Suspected," *New York Times*, December 26, 2004.

100. Mir.

101. "Face au défi iranien, une bombe saoudienne?" *Intelligence online*, April 21, 2006.

102. "Report Alleges Saudi Arabia Working on 'Secret Nuclear Program' with Pakistani Assistance," *WMD Insights*, May 2006, p. 4.

103. "Government Offers UAE Nuclear Training But Not Atomic Bomb on Platter," *Jasarat*, May 26, 1999; quoted in Gaurav Kampani, "Second Tier Proliferation: The Case of Pakistan and North Korea," *The Nonproliferation Review*, Fall/Winter 2002, p. 114.

104. Louis Charbonneau, "Some in U.S. Think Syria Has Atomic Centrifuges – Sources," *Reuters*, May 5, 2004; Central Intelligence Agency, *Unclassified Report to Congress on the Acquisition of Technology Related to Weapons of Mass Destruction and Advanced Conventional Munitions*, Washington, DC, January 1-December 31, 2004.

105. Douglas Frantz, "Black Market Nuclear Probe Focuses on Syria," *Los Angeles Times*, June 24, 2004.

106. Kampani, *Proliferation Unbound* . . .

107. Frantz, "Black Market Probe . . ."

108. Charbonneau, "Some in US . . ."

109. Interview of a senior U.S. official quoted in Robert Windrem, "Pakistan: 'The Crazy Soup'. Nuclear Politics—And the 'Islamic Bomb'," NBC News, *msnbc.com*, February 6, 2004. See also Andrew Koch, "A. Q. Khan Network: Case Closed?" Statement Before the Subcommittee on International Terrorism and Nonproliferation of the House of Representatives, 109th Congress, 2nd Sess., Washington, DC: Committee on International Relations, May 25, 2006.

110. Albright and Hinderstein, "Unraveling the A. Q. Khan . . .", p. 113.

111. See Carmen Gentile, "Brazil Realizes Its Nuclear Ambitions," *ISN Security Watch*, May 16, 2006.

112. See Mustafa Kibaroglu, "Turkey's Quest for Peaceful Nuclear Power," *The Nonproliferation Review*, Spring-Summer 1997, p. 35; and Deniz Zeyrek, "Pakistan's offer for cooperation," *Radical*, June 1, 1998.

113. David Albright and Mark Hibbs, "Pakistan's Bomb: Out of the Closet," *Bulletin of Atomic Scientists*, Vol. 48, No. 6, July-August 1992; Corera, p. 45.

114. Clary, *The A. Q. Khan Network* . . ., p. 89.

115. Gordon Corera raises the intriguing possibility that A. Q. Khan himself might not have been the dominant partner in the network's exports activities. See Corera, p. 66.

116. NPEC Seminar, Washington, April 2006.

117. Peter Lavoy and Feroz Hassan Khan, "Rogue or Responsible Nuclear Power? Making Sense of Pakistan's Nuclear Practices," *Strategic Insights*, Vol. III, Issue 2, February 2004.

118. See Corera, p. 95.

119. Corera, p. 145.

120. David Sanger, "The Khan Network," Conference on South Asia and the Nuclear Future, Stanford University, June 4-5, 2004.

121. Corera, p. 145.

122. Abbas, p. 231; Corera, pp. 145-146.

123. Musharraf, *op. cit.*, p. 189.

124. See Frantz, "Pakistan's Role"; and William Langewiesche, "The Point of No Return," *The Atlantic Monthly*, January-February 2006.

125. Interview in Nuclear Jihad, *Discovery Times* (TV channel), April 17, 2006.

126. These events followed the restructuring of the NCA announced in February 2000. See "Dr. Qadeer Khan Bids Farewell to KRL," *Dawn*, April 2, 2001. Ishfaq Ahmed, head of PAEC, was also replaced.

127. Lancaster and Khan, "Musharraf Named in Nuclear Probe"; David Rohde and David E. Sanger, "Key Pakistani Is Said to Admit Atom Transfers," *New York Times*, February 2, 2004.

128. Sanger, "The Khan Network"; Edward Harris, "Khan Visited Uranium-Rich African Nations," Associated Press, April 2004.

129. Personal communication by a U.S. expert, drawing on conversations with former SPD officials.

130. Sanger in "Nuclear Jihad."

131. Lancaster and Khan, "Musharraf Named in Nuclear Probe."

132. Rohde and Sanger, "Key Pakistani Is Said"

133. *Ibid.* Some sources have reported that A. Q. Khan participated in Lashkar-e-Toiba meetings. Kaushik Kapisthalam, "Pakistan's Forgotten al-Qaeda Nuclear Link," *Asia Times*, June 4, 2004; B. Raman, "The Omens from the White House," South Asia Analysis Group Papers, No. 381, December 23, 2001.

134. Lavoy and Hassan Khan.

135. NTI Global Security Newswire, "Pakistan Military Distances Itself From Khan," July 10, 2006.

136. Mushahid Hussain, "Media Off Target with Pakistan Nuclear Scare," *Asia Times*, November 7, 2001. An unnamed Pakistani official makes him "the grandfather" of the Pakistani Bomb (quoted in Clary, *The A.Q. Khan Network*, p. 44).

137. Chaudhri, "Pakistan's Nuclear History...."

138. Shahid ur-Rehman, *Long Road to Chagai*, Islamabad: Print Wise Publications, p. 53; S. Shabbir Hussain and Mujahid Kamran, *Dr. A. Q. Khan on Science and Education*, Lahore, Pakistan: Sang-e-Meel Publications, 1997, p. 212.

139. Usman Shabbir, "Remembering Unsung Heroes: Munir Ahmad Khan," *Defence Journal*, May 2004; Chaudhri, "Pakistan's Nuclear History...."

140. Clary, *The A. Q Khan Network*, p. 44.

141. "Dr. A. Q. Khan speaks to Defence Journal," *Defence Journal*, December 1990.

142. Quoted in Corera, p. 50.

143. Rai Muhammad Saleh Azam, "When Mountains Move—The Story of Chagai," *Defence Journal*, June 2000.

144. Lancaster and Khan, "Musharraf Named in Nuclear Probe."

145. John Wilson, "Notes from the Nuclear Underground," *The Pioneer*, June 9, 2006.

146. Corera, p. 96.

147. Herbert Krosney and Steve Weissman, *The Islamic Bomb*, New York: Times Books, 1981, p. 65.

148. NPEC Seminar, Washington, April 2006.

149. Estimates based on Chaudhri, "Pakistan's Nuclear History"

150. Corera, p. 213.

151. Mahmood and Majid were arrested on October 23, 2001 ("Two Retired Nuclear Scientists Admit to Meeting Osama bin Laden," *Dawn*, November 12, 2001). Mahmood had been fired from PAEC in 1998, perhaps due to a very peculiar conception of "Islamic science." See Rory McCarthy, "Worrying times?" *The Guardian*, November 8, 2001; and T. Sreedhar, "New Threat from the Taliban," *The Hindu*, May 18, 2001. Suleiman Asad and Muhamed Ali Mukhtar were sent to Burma at the end of 2001, officially to help build a nuclear reactor.

152. The ISI has no role in nuclear security (see David Rohde, "Nuclear Inquiry . . ."). But it may have a role in the monitoring of SPD security personnel.

153. Some sources have reported that A. Q. Khan, Bashiruddin Mahmood, and Hamid Gul participated in the Lashkar-e-Toiba meetings. Kaushik Kapisthala, "Pakistan's Forgotten al-Qaeda Nuclear Link," *Asia Times*, June 4, 2004; B. Raman, "The Omens from the White House," South Asia Analysis Group Papers, No. 381, December 23, 2001.

154. Ehsan Masood, "A. Q. Khan: Nuclear Outcast, but Scientific Benefactor," *SciDevNet*, February 6, 2004.

155. Peter R. Lavoy and Major Stephen A. Smith, "The Risk of Inadvertent Nuclear Use Between India and Pakistan," *Strategic Insight*, February 3, 2003.

156. This procedure was confirmed by General Durrani's report (p. 33). However, according to one account, the pilot would reportedly receive the codes only once he had left the country's airspace (Bennett Jones, p. 212.)

157. Personal communication by a former ISI director, October 2004.

158. A *Ghauri-2* missile based in Baluchistan could cover a significant part of the Middle East. *Shaheen-2* missiles would also be conceivable, but they are the "crown jewels" of the Pakistani deterrent.

159. Interview with Pakistani officials, Rawalpindi, October 2005.

160. According to Saudi defector Mohammad Al-Khilawi, such a guarantee was a condition given by Riyadh to its financing of the Pakistani program. Colvin and Sawyer.

161. Interviews with Pakistani officials, Rawalpindi, October 2005.

162. CERJ-NPS Seminar on South Asia, Paris, November 18, 2005.

163. Mark Gorwitz, *Saudi Arabian Nuclear Science Bibliography: Open Literature Citations*, Washington, DC: Federation of American Scientists, May 2005; see also *Saudi Arabia Country Profile*, Stockholm, Sweden: Stockholm International Peace Research Institute (SIPRI).

164. Colvin and Sawyer.

165. Amrir Mir, "Probe Into Nuclear Cooperation Worries Pakistan, S. Arabia," *South Asia Tribune*, July 6, 2005.

CHAPTER 3

COULD ANYTHING BE DONE TO STOP THEM? LESSONS FROM PAKISTAN'S PROLIFERATING PAST

George Perkovich

This chapter briefly narrates the basic story of Pakistan's quest for nuclear weapons and the inability of the U.S.-led international community to end it. The *detailed* story remains unknown outside of a few individuals in Pakistan, many of whom are now dead. U.S. intelligence archives also contain bountiful details unavailable to me. Hence, this is the Disney version of the story.

The public record indicates that there was no magical moment when a particular covert action could have been taken or a breathtaking policy decision made that would have caused Pakistan to abandon its nuclear enterprise full stop. If the "private" record affirms this assessment, then the Disney rendition allows us to derive useful lessons from the Pakistan nuclear story. That is, there was no silver bullet action that could have diverted Pakistan from acquiring nuclear weapons, but this still leaves open the question whether a steady strategy of multiple thrusts could have changed Pakistan's course fundamentally. This is what I attempt to explore in the second half of the chapter.

It is difficult to say precisely when Pakistan's nuclear quest began. We do know that the first Indian nuclear test in 1974 did *not* start Pakistan on its quest, as Pakistani propagandists used to insist. A seminal episode was the January 1972 meeting

in the Chief Minister of Punjab's home in Multan, where Prime Minister Zulfikar Ali Bhutto reportedly exhorted a gathering of Pakistan's nuclear technology establishment to produce a fission bomb in 3 years, as the Americans had with the Manhattan Project. Bhutto said he would spare no expense in helping them do it.¹

The timing was telling. Pakistan was still bleeding from the amputation of half its former self: Civil war in 1971 had just severed East Pakistan from West Pakistan; the eastern part became the independent country of Bangladesh. Bhutto, convening in the Punjabi heart of West Pakistan, was launching the bomb initiative only a month after the ignominious defeat of the Punjabi-dominated Army at the hands of unmartial Bengalis and their Indian supporters. Nuclear weapons would rebuild Pakistan's strength, heal its wounds, buttress its pride, and ensure better results in a future war. (The 1971 defeat followed unsuccessful Pakistani military campaigns in 1948 and 1965).

If nuclear weapons could equalize Indian power, Bhutto also felt they could equalize his personal power with that of the always-dominant Army. By inaugurating and overseeing the nuclear weapons program, Bhutto would control an asset as strategically meaningful as the instruments controlled by the Army, a form of internal balance-of-power politics.

But a wrinkle should be added to the story here, a bit of backstory. In October 1964, China conducted its first nuclear weapons test. Days later, on October 24, Chairman of the Indian Atomic Energy Commission Homi Bhabha went on All-India radio and professorially explained that "atomic weapons give a State possessing them in adequate numbers a deterrent power against attack from a much stronger State." In an example of the perennial false salesmanship of the

Indian nuclear establishment, he mentioned the remarkably low cost of a stockpile of 50 “atomic bombs” —\$21 million—and described benign uses of peaceful nuclear explosives as well. Bhabha concluded his broadcast by urging the great powers to pursue nuclear disarmament in order “to create a climate favourable to countries which have the capability of making atomic weapons, but have voluntarily refrained from doing so.”² Bhabha’s broadcast clearly intimated that India could build nuclear weapons if it wanted to, and that it would be cost effective to do so. He intended both to reassure the Indian public and to prompt political leaders to support whatever initiatives he may have then wished to pursue. Bhabha died 14 months later, but not before winning prime ministerial authorization to begin design work on peaceful nuclear explosives.

However, Bhabha’s message to reassure a *domestic* audience shaken by China’s nuclear achievement also was heard by an *external* audience, Pakistan. In terms of power, Pakistan was to India as India was to China. Bhabha’s implicit recommendation for India to balance China made sense for Pakistan to balance India. Zulfikar Ali Bhutto listened to Bhabha’s broadcast and became convinced that India was going to build the bomb and Pakistan would have to follow suit in order to deter its more powerful and domineering neighbor. Bhutto was then a minister in President Ayub Khan’s cabinet. He and other Pakistani elites had noted Bhabha’s broadcast and subsequent claims that India could make a bomb in 18 months if it wanted to. As I detail in *India’s Nuclear Bomb*, a British journalist in early 1965 reported “deep anxieties . . . in the key ministries in Rawalpindi—particularly at Defence—over the possibility that 110 million Pakistanis will wake up one fine morning in

the latter half of 1965 to learn from Radio Delhi that India has become the world's sixth nuclear Power."³ It was in this article by Patrick Keatley in 1965(!), that Bhutto uttered his famous statement: If India got the bomb "then we should have to eat grass and get one, or buy one of our own."

This backstory further informs the subsequent Pakistan nuclear narrative. In early March 1965 Ayub and Bhutto had met Chou En-lai in Beijing. At this meeting—Bhutto hinted in testimony in his 1977 trial—he sought China's help in acquiring nuclear weapons capability. Bhutto's reliability deserves to be questioned, but we do know that China eventually provided fulsome assistance to Pakistan.

The year 1965 also brought a war that foreshadowed how nuclear weapons capability would embolden Pakistani leaders to escalate efforts to wrest Kashmir away from India. I believe, but cannot prove, that Pakistan initiated the 1965 war to take the Kashmir valley from India before India acquired nuclear weapons, which Ayub and Bhutto feared would be sometime in the next year. Given how focused Bhutto and others were on the feared Indian rush to build the bomb and the deterrent effects an Indian bomb would have on Pakistan, it is inconceivable that this factor did not enter into the Pakistani decision to launch the 1965 war. After Pakistan acquired basic nuclear explosive capability in 1987 it was emboldened in 1989 to invest heavily in a sustained insurgency against Indian occupation of Kashmir. And then, after the tests of 1998, the Pakistan Army still more boldly wrested away a chunk of Indian-held territory near Kargil, leading to a brief but intense military conflict.

To sum up this first Act, then, we see that Pakistani leaders' obsession with stymieing or besting India,

and proving their nobility by taking the Kashmir Valley from it, determined that the first hint of India's acquisition of nuclear weapons capability would drive Pakistan to match. Nuclear weapons would be the ultimate equalizer, the denier of Indian superiority, the proof of Pakistani mettle and durability. As long as the Pakistani (largely Punjabi) obsession with India would remain, the determination to acquire an equalizer to its power would be unstoppable. And the depth of the desire and the importance of the object desired meant that deals would be sought and made with China and anyone else who could help to acquire nuclear capability, by hook or by crook. It is nearly impossible to conceive how the Pakistani obsession with equalizing India could have been temporized by the United States or anyone else, and how once India pursued nuclear weapons capability Pakistan could have been persuaded not to follow.

When the nuclear quest officially began in 1972, the technical leaders initially sought to follow something like an Indian model by using international nuclear cooperation to develop a large peaceful nuclear complex that would include plutonium reprocessing. One of Pakistan's major shortcomings was the lack of highly trained scientists and engineers. International cooperation would be necessary not only to acquire technology but also to develop cadres of engineers. By 1973, after an earlier dalliance with the United Kingdom Atomic Energy Agency, the Pakistan Atomic Energy Agency contracted with a Belgian firm to secretly build a pilot-scale reprocessing plant in Pakistan, which eventually became known as PINSTECH.⁴ This plant was not sufficiently large to be the source of an ambitious nuclear weapons capability, but cooperation in building and operating it could prepare Pakistani

cadres to scale up a reprocessing program later. Pakistani nuclear officials also entered negotiations with France to acquire an industrial-scale reprocessing plant. Pakistan hoped to obtain the facility free from safeguards. This was possible insofar as France had not yet signed the Nuclear Nonproliferation Treaty and therefore was not legally obligated to insist on safeguards at plants it cooperated in building in other countries. But the talks proceeded slowly and fitfully.

The initial plan, at least as it was related to me years later by the then-Chairman of the Pakistan Atomic Energy Commission, Munir Ahmad Khan, was not to divert or misuse foreign-supplied reactors and a reprocessing plant to produce nuclear-weapons fuel, but rather to use the know-how gained from this cooperation to indigenously produce parallel capabilities that could yield a bomb. It is probably more accurate to say that Pakistan was planning to use whatever assistance it could get away with using to acquire material for a bomb, and if it could be done via the French-supplied plant, it would, and if somehow material could not be diverted, then Pakistan would use the knowledge and contacts gained to build their own means later.

But Pakistan was not India, and an Indian-sized and paced nuclear program was infeasible for Pakistan. Moreover, the world after the Indian test of 1974 was not the world in which the United States, Canada, and others had supplied India with the reactor, heavy water, and reprocessing plant it used to produce its first nuclear explosive. Pakistan got knocked backward by the political shock waves of the Indian test. The world's advanced nuclear technology states were now moving to tighten controls on exports of reactors, reprocessing plants, and other sensitive technologies

and know-how. Plans to develop a large nuclear establishment with foreign help and then build off it a weapons capability became much less promising. All the more so, given that Pakistan had no remotely feasible economic rationale for needing the plutonium reprocessing plant it had contracted the French state-backed firm, Societe Generale Nucleaire (SGN), to build. In 1975, Prime Minister Bhutto evinced frustration at the slow pace of negotiations with the French over the reprocessing plant. The French were now insisting that Pakistan implement International Atomic Energy Agency (IAEA) safeguards on the proposed facility.

The Indian test also reduced the appeal of the plutonium-route for Pakistan, given the amount of time it would take to build a production reactor and a reprocessing plant even if foreign cooperation was forthcoming. Pakistani leaders psychologically could not wait.

Prime Minister Bhutto therefore must have been highly receptive when a Pakistani engineer residing in Holland wrote him in 1974, after the Indian test, offering his services to Pakistan's nuclear program, particularly in the area of uranium enrichment. Bhutto responded by inviting Khan to meet the next time the latter was in Pakistan, which happened in December 1974. A. Q. Khan began what became a vicious rivalry by denouncing Munir Ahmad Khan's leadership of the nuclear program and his plans to base it on plutonium. Bhutto invited A. Q. to return to Pakistan and lead a uranium-enrichment effort, which Khan did in January 1976, as the plutonium route was looking more difficult.

A. Q. Khan is now a household name around the world, but he was a nobody when he departed his Dutch engineering firm, FDO, and returned to

Pakistan to begin an illustrious proliferation career. Open sources do not specify which logistical means he used, but Khan provided to Pakistan blueprints for a URENCO uranium enrichment plant and, according to Shahid-Ur-Rehman, components of at least one centrifuge. In this sense, Khan himself was the first model for the proliferation network he later famously established, many of whose key personnel are/were based in Europe.

While A. Q. Khan was making his plans to return to Pakistan, Prime Minister Bhutto visited Washington in 1975 to play a game that the United States and Pakistan have repeated many times since. Bhutto knew that many people, especially Realists such as Secretary of State Henry Kissinger, would expect Pakistan to build nuclear weapons after India's test. As Bhutto departed Pakistan, he told the press that Pakistan's nuclear weapons policy was "under constant review" and depended on whether the United States would help Pakistan acquire sufficient conventional weapons to obviate the need for nukes. In Washington, Bhutto duly leveraged the promise of nuclear restraint for renewed U.S. arms sales. (The United States had cut off such sales since the 1965 war.) American officials were not completely naïve. They sought a promise from Bhutto that Pakistan would "forego or at least postpone development of a nuclear explosion option," in the words of a draft State Department memo.⁵ Bhutto obliged by signing a secret note typed on a small piece of stationery promising that in "developing its nuclear technology, Pakistan would not divert any of its urgently needed development resources to the expensive efforts required to produce a nuclear explosion provided its defence in the conventional field is assured."⁶ Here U.S. officials were completely

naïve if they thought that this formulation—or any promise, really—would slow the Pakistani nuclear effort. Pakistani leaders, like those in many countries, have always thought (or been told) that nuclear weapons are inexpensive, the biggest bang or strategic asset for the buck. Moreover, if Pakistan did not lower its already paltry development spending in order to finance the bomb program, it would meet these terms. Furthermore, Pakistan was soliciting Arab states such as Libya and perhaps Saudi Arabia to underwrite the nuclear program, much as it later would sell nuclear assets to help pay for strategic programs. The best that can be said for the United States here is that its officials were probably willingly duped by Pakistani leaders, much as they are today.

Notwithstanding Bhutto's meaningless promise, Pakistan was gearing up to launch an enrichment program that would proceed as fast as its procurement and engineering efforts would allow. To the extent that he was trading time for military cooperation and good will, Bhutto, like Iranian officials today, was cunningly selling the liability of his state's technical program as an asset. Pakistan could not technically go faster, but it could be paid off for promising to go slow.

Meanwhile, the United States was pressing hard to minimize, if not eliminate, the threat posed by the French-Pakistan reprocessing plant. Pakistani officials had not intended this plant to be a decoy, but in some ways it was becoming one, while the real action was in the enrichment field. Bhutto visited Paris in late 1975 and encountered stiff insistence that Pakistan accept safeguards on the proposed plant. By early 1976, the Ford Administration was openly pressing Pakistan to abandon the bid for the plant and France to pull out of its agreement to provide it. Pakistan had retroactively

in 1976 announced plans to build eight nuclear power plants that would give a technical-economic rationale to the reprocessing plant. (This resembles Iran's announcements of reactor-building plans after its otherwise alarming uranium enrichment and heavy water production plants were discovered under construction in 2002). The United States encouraged Canada to use its leverage as supplier of Pakistan's KANUPP reactor near Karachi to press Pakistan to drop its reprocessing plans.

Nonetheless, France and Pakistan proceeded with the reprocessing plant deal in March of 1976, as Pakistan capitulated to France's late insistence that the plant operate only under IAEA safeguards. In August, as Secretary of State Henry Kissinger was visiting Pakistan, the United States offered to sell Pakistan A-7 attack aircraft if Islamabad would agree to abandon the reprocessing plant deal with France. The multilateral dispute continued, as the United States and Canada pressed Pakistan, and the United States pressed France, to forego construction of the plant. In November, the U.S. Defense Department agreed to sell Pakistan 110 A-7 attack planes, contingent on congressional and State Department approval, the latter of which would be contingent on Pakistan's abandonment of the reprocessing plant. (The United States was less successful in the 1980s using conventional arms sales to motivate Pakistan to abandon its uranium enrichment program). By December 1976, the French government tried to relieve pressure by announcing it would not supply nuclear reprocessing plants in the future, after the Pakistan project was completed. French officials hinted they would not be displeased if Pakistan canceled the contract.⁷ The Canadian government pressed on and announced that it would suspend its

nuclear cooperation agreement with Pakistan and not supply uranium fuel for the Karachi Nuclear Power Plant.

The year 1977 brought changes that further dampened enthusiasm for Pakistan's overt nuclear program: General Zia ul-Haq launched a military coup and placed Zulfikar Ali Bhutto in prison, from where he would be hanged in 1979. The United States in 1977 also had imposed economic sanctions on Pakistan, invoking the Symington Amendment of 1976, which called for withholding military and economic aid to any country that, without fullscope safeguards, imports uranium enrichment or plutonium reprocessing facilities.

Throughout this period from 1976 through 1978, the United States led the formation of the Nuclear Suppliers Group. At the instigation of Congress, the United States also adopted legislation that would set tough American standards for nuclear exports, which would then be promoted internationally. The most fundamental rules of what we now refer to as the nonproliferation regime were being established. Central among them was the demand that states receiving international nuclear technology or material should put all of their nuclear facilities under safeguards, not merely the facilities to which assistance is directed. If upheld, such a fullscope safeguards rule would deprive Pakistan of the sort of assistance its initial nuclear plans counted upon, much as India's had. Fortunately, for Pakistani bomb seekers, however, A. Q. Khan already had stolen foreign assistance. Khan also had brought with him valuable knowledge of individuals and businesses that could supply components for a centrifuge plant. Thus, as the elements of the nonproliferation regime slowly took shape, Pakistan was already tunneling around them. (The fullscope safeguard requirement was not

adopted by the Nuclear Suppliers Group until 1992, although it became part of U.S. law in 1978.)

In August 1978, with growing U.S. pressure and doubts about Pakistan's intentions, France revoked its nuclear cooperation contract with Pakistan. The French decision reflected not only appreciation of the dangers of nuclear proliferation, and the effects of international pressure and the loss of civilian government in Pakistan, it also stemmed from internal political dynamics as the deal's chief high-level proponent, Prime Minister Jacques Chirac, had stepped down, leaving the more skeptical President Valéry Giscard d'Estaing a freer hand to terminate the contract.

Meanwhile, for all of the concentration and ultimately successful international effort to dissuade France – a modern, Western democracy – from helping Pakistan on the plutonium route to the bomb, Pakistani engineers and procurement specialists raced secretly to build the undeclared enrichment plant at Kahuta.

In 1979, the Soviet Union invaded Afghanistan. Pakistan became an indispensable partner of the United States in compelling the Red Army to leave. This was an absolute and immediate strategic imperative. In the ensuing years, intelligence services would occasionally report evidence of Pakistan's further progress in acquiring nuclear weapons capability, but Pakistan's indispensability on the frontline of the Afghan war immunized it from severe punishment or pressure. It is important to remember that the Pressler Amendment of 1986 was encouraged by the Reagan administration as a means to deflect Congress (encouraged indirectly by Israel) from imposing serious sanctions on Pakistan over its nuclear weapons program. The Amendment forestalled sanctions as long as the President could certify that Pakistan did not possess a nuclear explosive

device. From 1986 through 1989, the President made this certification annually, to the discomfort of some nonproliferation officials who felt that intelligence and veracity were contorted beyond recognition to do so. And then, once the Soviet forces had been fully withdrawn, and the Berlin Wall had fallen, in 1990, President Bush acknowledged that he no longer could certify Pakistan's nonpossession of a nuclear explosive. Major sanctions were imposed on Pakistan.

It was too little, too late, however. Pakistan already had achieved a rudimentary nuclear weapons capability in 1987.

The 1990s were in many ways a lost decade for Pakistan and for U.S. relations with it. The Pressler sanctions hastened the practical U.S. withdrawal from Pakistan. To Pakistanis—of all classes—the United States was now acting like an abusive, arrogant man who seduced and lavished gifts on his mistress when he was desperate in the 1980s and then discarded her when his fortunes improved with the Soviet Union's demise. Being sanctioned across the board for a nuclear weapons program that the United States had indulged as long as it was convenient, Pakistanis lost what little sense of propriety they felt toward international nonproliferation rules. The A. Q. Khan proliferation network flourished. And while we may never know the degree to which Pakistani state officials at high levels knew about this proliferation, it is safe to believe that their contempt for the discretionary way the United States had applied proliferation sanctions to Pakistan made most of them undisposed to lose sleep over whatever norms and rules the Khan network was transgressing. These were norms and rules that tolerated (if not tacitly endorsed) Israel's possession of a nuclear arsenal, treated China's nuclear activities inconsistently, and had been switched on and off

toward Pakistan as it served U.S. interests. Besides, India already had tested a nuclear explosive.

As the United States sanctioned itself out of Pakistan and basically ignored Afghanistan, Pakistani intelligence was cultivating the Taliban. The freedom fighters of the Afghan War were becoming the Taliban and al-Qaeda of 2001. This dangerous effect of nonproliferation sanctions need not have arisen—the United States could have stayed involved at least in Afghanistan—but the tendency of sanctions to isolate the sanctioner—the United States—from the targeted country needs to be considered more openly.

In May 1998 Pakistan followed India and tested nuclear weapons (though the number of devices actually detonated is unclear from open sources). One could recount this episode in detail: who argued against testing, what the United States offered Pakistan not to do it, how Pakistani intelligence fabricated reports that Israel was about to launch preemptive airstrikes against Pakistan's nuclear assets. But the key point is simple: Pakistan's obsession with matching India overrides all else, so there was no way Pakistani leaders would not test. The most telling thing to note is that India claimed to have tested five nuclear devices (on May 11 and 13) and Pakistan claimed that it had detonated six. Mythology is more important than veracity: The myth that Pakistani leaders seek to maintain is that anything India can do, they can do one better.

Importantly for our story, the nuclear tests of 1998 strengthened the logic established in 1989 of nuclear weapons capability shielding low-intensity warfare. The Pakistan Army was now emboldened by the public demonstration of Pakistan's nuclear weapons prowess, to infiltrate and take a piece of Indian-held Kashmir, begetting the Kargil War of 1999.

This invites a provocative argument: If the United States did not try hard enough to stop Pakistan's nuclear weapons program, placing other objectives higher, the same can be said for U.S. and international interactions with Pakistan over the Kashmir conflict and the terrorist tactics used therein (still being used today). Indeed, the two phenomena or threats are related. Pakistan's nuclear weapons provide deterrent cover for the insurgency/terrorism it has nurtured. Once nonproliferation sanctions had been imposed, there were few other policy options open to the United States, and it basically withdrew, leaving the Pakistani relationship with terrorist organizations unaddressed. In hindsight, the two threats—proliferation and terrorism—should have been treated together, and the effect of sanctions in removing the United States from the scene should have been analyzed more carefully. The key challenge—which was overlooked or dodged—was and still is to reduce the Army's dominance of Pakistani politics, economics, and ideology, because the Army's obsession with bleeding India produces the security threats that Pakistan poses to the United States. The situation today in Iran may pose a similar challenge—proliferation emboldening Iranian actors to increase support for insurgents/terrorists in Israel and Lebanon—while the United States has long sanctioned itself out of any relationship with Iran. (United Nations [UN] sanctions, which all states are legally bound to implement, can be much more effective for the economic and political isolation they impose).

Thoroughness argues for extending the story and describing how Pakistan has continued to expand its stockpile of fissile materials, now including plutonium, and how its arsenal has grown unabated and in parallel

with advances in missile delivery systems. Yet there is little that outside actors could do to channel or abate this activity, other than promote a global halt to fissile material production and a framework for limiting nuclear and missile arsenals that would include China, which, in turn, would not participate without the United States and Russia agreeing to limit military programs that threaten China.

Pakistan's management and control of its nuclear arsenal and infrastructure is a more productive object of interaction. There is little one can narrate here based on public sources, other than to say that since 2000, the Pakistani Army under General Kidwai, the man in charge of the strategic forces, has taken great pains to establish systems and procedures to reduce the risk that unauthorized actors could acquire nuclear materials and weapons. At the same time, the Pakistani Army (unlike Indian political leaders) treats its nuclear arsenal as a useable, vital military instrument, and so establishes doctrine and operations to be able to deploy this arsenal quickly and decisively. This preparation to use nuclear weapons necessarily entails risks that could be seen as part of the proliferation problematique.

Thus, this simplified story ends with a focus now not on preventing Pakistan's acquisition of a nuclear arsenal, but rather on preventing its loss of control over this arsenal. The concern now includes how Pakistan's ongoing imports to sustain its strategic force can be prevented from morphing once again into an export program, a nuclear Wal-Mart. And, less widely appreciated, the Pakistan story should require us to think harder about how to keep Pakistan, Iran, and perhaps others from being emboldened to increase insurgent or terrorist activities under the deterrent cover of nuclear weapons capability.

Pakistan's nuclear experience and the effects of U.S. and other actors' efforts to shape it offer many lessons. Specifying what one wants to learn can illuminate the nature of the proliferation challenge. The following are questions that lead the inquiry in diverse directions.

1. What does the Pakistan case teach about why countries seek nuclear weapons?

2. What does it teach about whether and how countries can be *persuaded* to abandon the *desire* to acquire nuclear weapons?

3. What does the Pakistan case teach about the feasibility of *blocking states from acquiring* nuclear weapons and the means of such prevention?

4. What does Pakistan teach about the risks and/or benefits of nuclear weapons acquisition, for the acquiring state and for international security? What can be done to lower the risks and raise the benefits?

a. Deterrence: If deterrence does not emerge automatically, what are the conditions under which it arises? (This could be a benefit).

b. Low-intensity-conflict: Deterrence may be created at one level of potential conflict—i.e., major war—but nuclear weapons-possessing states may be emboldened to undertake aggression at lower levels of conflict thanks to the belief that escalation can be blocked by nuclear deterrence. Such lower levels of conflict can include support of insurgents, terrorism, or seemingly limited state intervention. Since 1987, Pakistan has undertaken each of these sorts of aggression.

c. Onward proliferation: A state's capacity to produce weapons-grade fissile materials and nuclear weapons inherently raises the potential of proliferation from that state to other actors through acts of state commission or omission of effective controls.

d. Domestic politics: Acquisition of nuclear weapons may affect the power of ruling regimes and institutions, and/or it may affect the dynamics of political contests within a state. This has many potential implications. For example, if democracy is an antidote to major aggression—the democratic peace theory—but nuclear weapons acquisition helps entrench nondemocratic regimes, then proliferation can exacerbate international insecurity by impeding political transitions toward democracy.

e. Unauthorized use: Acquisition of nuclear weapons creates multiple problems of decision making and control. There are risks associated with the acquiring state's goals, decisionmaking, and command and control. There are risks that the state could lose control of nuclear weapons or material to actors that do not share state attributes and could be less deterrable.

5. Who are the key actors who in the past could have affected Pakistan's nuclear behavior and who might in the future? The United States is the principal external actor to be analyzed here, but could U.S. action have been more effective if others had cooperated with it? Who? How?

The narrative half of this chapter implicitly answers most of these questions. Let me here treat the most relevant of them explicitly, although briefly so as to avoid repetition.

Conventional wisdom holds that the Pakistan case teaches that a state facing a larger, more powerful adversary, especially one that possesses nuclear weapons, will seek nuclear weapons to protect its security by balancing the adversary's power. I would argue that this proposition is correct (and obvious), but that it misses equally important dynamics. Many states

face more powerful nuclear-armed adversaries and do not seek nuclear weapons. And this forbearance cannot be explained by U.S. security guarantees, alliance, or extended nuclear deterrence. The *physical* security variable underlying the Realist conventional wisdom misses the key point about Pakistan. Pakistani elites, particularly the Punjabi-dominated Army, share a political-psychological obsession with proving national self-worth and strength in comparison to India. This obsession with matching, surpassing, or frightening and weakening India made it inevitable that Pakistani elites would seek nuclear weapons if this is what India was doing. No form of security guarantee or military alliance by the United States would have kept Pakistan from seeking nuclear weapons. It is an identity issue driven by India's very existence more than by any specific military-security threat India poses to Pakistan.

Pakistan could not be persuaded to give up the desire for nuclear weapons, so the only viable nonproliferation strategy was to block it physically from acquiring the capability to make them. The lessons are too numerous and complicated to summarize here. The foregoing narrative demonstrated how national and international nonproliferation rules could not be negotiated and then enforced quickly enough to keep up with Pakistan's dedicated technology acquisition program. As long as there are multiple technological pathways to the bomb and new ones that can be discovered, the task of mobilizing governments to devise, negotiate, implement, and enforce proscriptions on this or that technology will take so long that smart proliferators will adapt. While the United States and Canada spent years pressing Pakistan and France to shut down the plutonium option, A. Q. Khan

was secretly importing everything Pakistan needed to enrich uranium. After the international system concentrated on blocking centrifuge proliferation, the Pakistanis beat the system by constantly breaking into smaller subcomponents and materials the elements they needed to import. They stayed ahead of the global technology control and customs system.

Pakistan's capacity to avoid physical-denial efforts by the United States and the international community does not mean, however, that such denial will not work in other cases. The international community can and should learn much by studying the Pakistani case. Pakistan benefited enormously by not being a party to the Non Proliferation Treaty (NPT): There were not fullscope safeguards in Pakistan; there was nothing like the Additional Protocol and teams of IAEA inspectors roaming around possibly to discover illicit imports. Most importantly, Pakistan was not violating major treaty commitments in acquiring the bomb, so the risks of doing so were much smaller than those facing treaty parties. U.S. intelligence learned that Pakistan was enriching uranium to build the bomb long before Pakistan achieved its goal; it merely learned too late to block key acquisitions of designs and prototypes. Then conflicting interests and Pakistan's NPT nonmember status kept the United States from wanting or being able to rally international pressure sufficient to give Pakistan pause.

The one major benefit of nuclear proliferation conceivably would be to create deterrence relationships that lower or eliminate the risk of war between a certain set of adversaries. Kenneth Waltz has been the most illustrious proponent of this view. Indian and Pakistani champions of nuclear weapons celebrated the tests of 1998 by proclaiming that deterrence and

stability were now at hand. However, they spoke too soon. The two states now may (or may not) have established tacit understanding of the imperative of avoiding war under the nuclear shadow, but they had to experience a war in 1999 and a major crisis in 2001-02 to get there.

The major problem is that deterrence works best (and perhaps only) if the antagonists accept the territorial status quo among them. If one or more nuclear-armed adversaries does not accept the status quo and instead still harbors ambitions to act physically within the territory held by the adversary, nuclear weapons can embolden the unsatisfied actor to undertake provocations of an intensity low enough that the provocateur calculates the victim will be unlikely to respond massively, for fear of escalating to the possible use of nuclear weapons. This famous stability-instability paradox has operated in Indo-Pak relations since Pakistan first acquired basic nuclear weapons capability in 1987. As long as Pakistan does not accept the territorial status quo in Kashmir, the risk remains. (Similar risks could attend proliferation in the Middle East if acquirers of nuclear weapons identify sufficiently with the Palestinian cause to provide a form of extended deterrence to cover actions to wrest away Israeli-occupied territories in the West Bank, Jerusalem, or even perhaps the Golan Heights.)

The Pakistan-backed insurgency in Kashmir began as the Cold War was ending. With this geopolitical shift, U.S. favoritism toward Pakistan over India would shift, too, and the United States and India would gradually grow closer while Pakistan began to be seen in a much more troubling light. Still, the Kashmir conflict has been so intractable, and India has so strongly resisted any mediation, that U.S. officials

understandably stayed away from it. Washington could not escape entanglement in the Israeli-Palestinian conflict; if it could stay out of the Kashmir conflict, that would be one less mission-impossible for U.S. officials. The Kargil War under the shadow of possible nuclear escalation forced the United States to get more involved. The September 11, 2001 (9/11), events pushed us farther into subcontinental affairs. But then a tension emerged in U.S. policy: Pakistan's President Musharraf ordered his government to provide enough cooperation in hunting al-Qaeda and Taliban leaders in Pakistan and the Afghan border areas that Washington (at least until mid-2007) was disinclined to push him harder on Pakistan's nurturing (or tolerance) of jihadi groups operating against India in Kashmir and elsewhere. Top U.S. officials are still reluctant to see that Pakistan's nuclear import/export networks, its arsenal build up, the risk of nuclear war, and continued nurturing of terrorist groups are all rooted in Pakistan's refusal to accept formally the territorial status quo between India and Pakistan. Pakistan cannot win by force or negotiation that part of Kashmir that India now controls. But the failure to resolve the matter and formalize the status quo sustains the nexus of threatening actions and actors mentioned above. Washington cannot compel Pakistan to accept the status quo, or India to offer concessions that would better enable Pakistani leaders to do so. The point here is merely that top U.S. officials have never recognized the conceptual and strategic imperative of seeing the connection between these issues and working the problem comprehensively.

To extend the point, the dangers posed by Pakistan will not be fundamentally reduced if the Army's role in the society and state is not curtailed and a broader

civilian elite is developed. In this sense, U.S. proponents of “regime change” as a tool of counterproliferation are correct. Regimes do matter in causing the demand for nuclear weapons, in regulating onward proliferation, and in determining the risks of nuclear weapon use. The military regime in Pakistan has acted the “wrong” way in each of these areas. However, the Pakistan case also shows the limitations of a regime-centered nonproliferation strategy. Technology and materials matter, too, wherever they are, not merely when they are in a state led by “evil-doers.” Global rules are necessary to control distribution of technology, material and know-how, and to establish the bases for improved deterrence of proliferation and enforcement against those who violate rules. Double standards undermine the formation and enforcement of rules, in part because they give actors the moral and political license to violate rules that they or their countrymen believe are unfair to their group, be they Pakistanis, Muslims, etc. The existence of proliferation chains also makes universal rule-based approaches necessary, and regime-change strategies insufficient: Pakistan sought nuclear weapons because India did; India sought them because China did and because major powers lorded their nuclear status over countries like India; China sought nuclear weapons because the United States threatened it during the Korean War and Taiwan Straits crisis, and the Soviet Union became a competitor. . . . When causality implicates so many actors, it is untenable to rely on regime change as the central strategy for countering proliferation.

The Pakistani case alerted the world to the danger of onward proliferation and the risks of multinational networks of individuals, small businesses, and complicit or lax states. Nothing more needs to be

said about this here. Many of the necessary policy responses to proliferation networks must occur outside of public view, so it is difficult for me to judge success or failure, especially in U.S. efforts to persuade and/or assist Pakistani officials to preclude repeats of past proliferation episodes. The global environment certainly will affect the prospects of proliferation networks. If international rules will continue to allow states to build new uranium enrichment and/or plutonium reprocessing facilities under national control, then the demand for the services of proliferation networks will grow as will the supply. The “legality” of new construction one place will help provide cover for component manufacturers and others to conduct illicit trade with lowered risks of detection. There are several proposals for curbing fissile material production and establishing multinational fuel cycle centers. Progress in this direction could partially drain the pool of illicit suppliers.

Fortunately, history has not provided enough cases of nuclear proliferation to allow useful generalizations about proliferation’s domestic political effects. Pakistan has never enjoyed genuine democracy, in part because it lacks the political cultural attributes of democracy. This, in turn, stems from and reinforces the Army’s domination of the state, and of politics and, now, economics. The country will not evolve genuine democracy without the Army’s cooperation. It is safe to assume that whatever democratic trends may emerge in some avenues of Pakistani life, the Army will not relinquish its real control over nuclear infrastructure and weapons for as long as one can imagine. Call it Bhutto’s irony, but physical control over nuclear weapons is a core measure of power within the state. Bhutto tried to build nuclear weapons to have this

power for himself, to balance the Army. The Army handed him and took over the weapons program, and it would likely see retaining ultimate control over nuclear weapons as a final guarantor of its privileged and potent role in Pakistan, even if formal democracy returned.

Finally, while the United States has been the external actor most capable of influencing Pakistan's nuclear choices it has not had sufficient power to impose its will. Pakistan's obsession with India is so great that it would not willingly have abandoned its demand to acquire nuclear weapons to match or surpass India's nuclear capability. To deny Pakistan the opportunity to fulfill its demand would have required at a minimum close cooperation between the United States and China. This did not exist during the seminal period when China supplied Pakistan with a nuclear weapon design and other vital materiel, technology, and know-how. Thus, while the United States could have exerted itself harder in the 1970s and 1980s, it could not have sharply curtailed Pakistan's project without Chinese cooperation. China, in fact, was working in the opposite direction. Other vital assistance to Pakistan came from small-scale technology providers in Europe, the United States, Canada, and elsewhere. This suggests, at a minimum, that without much more threatening international legal proscriptions, tighter export controls, more effective customs management, etc., the Pakistani supply network could not have been blocked. The necessary changes would have to have been global, a prospect no more likely in the 1970s and 80s than today.

ENDNOTES - CHAPTER 3

1. Shahid-ur-Rehman, *Long Road To Chagai*, Islamabad, Pakistan: Print Wise Publication, 1999, p. 18.

2. George Perkovich, *India's Nuclear Bomb*, Berkeley, CA: University of California Press, 1999, p. 68.

3. *Ibid.*, p. 108.

4. Ur-Rehman.

5. Perkovich, p. 195.

6. *Ibid.*

7. Information Bank Abstracts, *New York Times*, December 31, 1976; in Lexis-Nexis Academic Universe, December 31, 1976, *web*. *lexis-nexis.com*.

PART II:
**MAINTAINING SOUTHWEST ASIAN
DETERRENCE**

CHAPTER 4

PAKISTAN'S "MINIMUM DETERRENT" NUCLEAR FORCE REQUIREMENTS

Gregory S. Jones

Introduction.

We have now passed the eighth anniversary of the nuclear tests that declared India and Pakistan overt nuclear powers. Pakistan had already been a de facto nuclear power for almost a decade before these tests, but becoming an overt power marked a transition to a more intensive phase of development of its nuclear arsenal. After 8 years, what is the current state of Pakistan's arsenal? Does it fulfill the objectives that Pakistan has established for it? These objectives are usually summarized as the requirement to provide an effective "minimum deterrent." But what does that term mean? Neither Pakistan nor India have wanted to state publicly what sort of stockpile is required but both insist that their current nuclear forces are effective minimum deterrents.

Rather than worry about the specifics related to this particular term, we have asked the question more broadly; how adequate is Pakistan's nuclear force? This question can only be answered by addressing what strategic function should the force fulfill. And none of this can be addressed without a discussion of India's nuclear forces. Since there are substantial uncertainties about the state of India's current nuclear readiness, any answer about Pakistan's nuclear forces can only be conditional.

Another important issue is how the adequacy might change in the future. In such an analysis, the uncertainties regarding India's nuclear forces are greatly magnified, so two quite different possible futures were studied to bound the problem. Also addressed was how the proposed U.S. nuclear cooperation with India might affect India's future nuclear arsenal. Another important factor in considering the future is the economic burden associated with Pakistan's current arsenal. As specifics are hard to come by, this issue was analyzed by comparing Pakistan's current arsenal to the nuclear weapons programs of France and South Africa.

Summary of Pakistan's Current Nuclear Arsenal.

Any evaluation of Pakistan's nuclear forces must begin with a review of its current arsenal. Table 1 is a summary of Pakistan's current arsenal. A more detailed description is in Appendix I. To place this arsenal in context, Appendix II contains a short history of Pakistan's nuclear weapons program.

Delivery Systems	Fifty 350 km <i>Ghaznavi</i> /M-11 Fifteen to Twenty 1,300-1,500 km <i>Ghauri</i> Six 750 km <i>Shaheen 1</i> Thirty four F-16s as backup delivery systems
Fissile Material Production Facilities	Centrifuge Enrichment at Kahuta, Silhala, Golra and Wah; 10,000 SWU per yr, 50 MWth Plutonium Production Reactor at Khushab
Fissile Material Stockpiles	1.1 to 1.35 Metric Tons Highly Enriched Uranium 40 to 80 kg plutonium
Nuclear Weapons	Two different designs; one for air delivery, one for ballistic missile delivery, 60 to 80 weapons; 5 to 10 kt yield
Weapons Readiness	Weapons kept in an unready state. "Missiles and warheads are not permitted together"
Command and Control	National Command and Control Authority in existence since 2000.

Table 1. Summary of Pakistan's Current Nuclear Arsenal.

The Adequacy of Pakistan's Current Nuclear Force.

How adequate is Pakistan's current nuclear force? Adequacy can only be addressed in terms of what strategic function Pakistan expects the force to fulfill. There has not been much official public discussion of this issue, but using a variety of sources it is possible to shed considerable light on this question.

In the broadest sense, Pakistan's nuclear force should protect the independent existence of the Pakistani state. And it is not hard to find various official statements that Pakistan sees India as the main threat to this independent existence. In classical deterrence literature, the purpose of the Pakistani nuclear force would be to protect Pakistan from a nuclear first strike from India. However, given the much larger size of India in terms of not only area and population but also economic and military power, Pakistan is clearly concerned that its independent existence could be threatened by India using means other than nuclear attack. The director of Pakistan's Strategic Plans Division, General Kidwai, has listed four situations in which Pakistan would use nuclear weapons against India.¹ These are:

1. India attacks Pakistan and conquers a large part of its territory.
2. India destroys a large part of either Pakistan's land or air forces.
3. India proceeds to the economic strangling of Pakistan.
4. India pushes Pakistan into political destabilization or creates a large-scale internal subversion in Pakistan.

Pakistan may respond to any of these situations by using nuclear weapons, and it is well known that Pakistan does not subscribe to a "No First Use Policy." Note that the first two of these situations would arise due to large-scale conventional warfare. The third condition could arise due to a naval blockade of Pakistan's two main ports. Given the superiority of India's navy, this is a real threat. The last situation is more ambiguous since India might not have to undertake overt action to bring the destabilization about. Indeed, such destabilization could occur without any Indian involvement whatsoever.

Pakistan has not indicated what its targeting strategy would be in the event of nuclear use, but one can make some inferences based on its nuclear arsenal. Its arsenal is not large enough to allow comprehensive strikes against India's conventional military forces. For example, there are approximately 20 Indian military airfields within 300-400 km of the Pakistani border. With a 10 kt warhead, it might take three warheads per airfield to destroy all of the aircraft on these bases. This would run to 60 weapons, which might be as many weapons as are contained in the entire Pakistani stockpile. Similarly, attacks on army divisions might require nine weapons per division. Indeed, if one of the grave situations described above occurred and Pakistan felt it necessary to launch initial nuclear attacks, it is not clear that the conventional military balance would be of much interest. Given that the numbers of weapons on each side could be roughly equal, attacks on India's nuclear forces would only be of interest if India configures its forces so that strikes with a small number of Pakistani weapons have the ability to eliminate a large number of Indian nuclear

weapons. If India is reasonably prudent in configuring its nuclear forces, a Pakistani nuclear attack on them would be unattractive, since more than one Pakistani weapon would have to be used for every Indian weapon eliminated.

Therefore it is likely that Pakistan will target mainly Indian cities. Pakistan's heavy reliance on the short-range *Ghaznavi*/M-11 indicates that its nuclear targeting strategy's object is principally to destroy Delhi. Given Delhi's large size and the relatively limited destructive power of 10 kt weapons, it would take at least 10 and perhaps up to 20 such weapons to destroy or damage enough of the city so that it would cease to function.² This statement may come as a surprise to those accustomed by the Hiroshima experience to think that one nuclear weapon will be sufficient to destroy an entire city. However, Hiroshima was a city of about one quarter million people and 24 km² in area. In contrast, Delhi is a city of 12.8 million people with an area of 1,055 km², which means that Delhi today is about 50 times larger (in population and area) than was Hiroshima in 1945. A single 10 kt weapon, which was airburst at a near optimal height, would have a lethal area of about 6 km² (this is also approximately the area in which most structures would be destroyed). Even if one considers the area where structures suffer some significant damage (as opposed to being destroyed, i.e., where the blast effects are 2 psi or greater), the damage area of such a weapon would be around 20 km². An attack on Delhi using twenty 10 kt airburst weapons would kill approximately 1.5 million people and injure perhaps another 3 million.³

Note that airburst weapons would produce no significant nuclear fallout. If, instead of airbursting the weapons, they are ground burst, the lethal area

of the weapon caused by its blast effects would be significantly reduced to only 3 km². However, ground bursting these weapons would result in significant amounts of fallout. Potentially the fatality area from the fallout could be several times (10 km² to 20 km²) that of the fatality area resulting from the blast effects from an airburst, but the actual fatalities would depend on how much of the fallout plume fell inside of the city boundaries, how quickly people fled from the fallout areas, and the sheltering potential of various types of structures. Despite various comments in the literature about the dangers of fallout drifting back on Pakistan, fallout levels high enough to cause injury due to radiation sickness would not likely extend more than 50 km from the locations where the weapons were detonated.

Pakistan's *Ghauri* ballistic missiles greatly increase the reach of its ballistic missile forces, though the missile is assessed to have a circular error probability (CEP) of 2,500 m. This is larger than the lethal radius (1,500 to 2,000 m) of a 10 kt warhead against most targets, and therefore this missile would likely also be used to attack large cities where its CEP would have little consequence. Given the small number of *Ghauri* missiles, Pakistan would probably not concentrate them on one or two cities but might use them to attack five or ten additional cities with one or two weapons. Such attacks would not destroy these cities, but hitting major cities like Mumbai (Bombay) with even a few weapons would significantly increase the terror resulting from Pakistan's attacks. Note that due to security concerns, Pakistan is unlikely to operate its nuclear forces outside of the Punjab, so a number of important Indian cities would still be out of range. These would include Kolkata (Calcutta), Bangalore, and Chennai (Madras).

Only when the *Shaheen 2* is deployed will Pakistan be able to hit these targets.

The discussion thus far has ignored India's nuclear forces, but any discussion of the adequacy of Pakistan's nuclear force must take India's nuclear forces into account. In particular, what are India's capabilities to respond to Pakistan's use of nuclear weapons? In a gross sense, India's nuclear force seems to be similar to that of Pakistan's. The Institute for Science and International Security (ISIS) has estimated India's weapons related plutonium stockpile at the end of 2003 as between 345 and 510 kg. Using five kg of plutonium per weapon, this would result in a potential stockpile of approximately 70 to 100 weapons, which is just a little higher than what was estimated for Pakistan for this same year. India claimed that it successfully tested thermonuclear designs in 1998 but these claims have not been generally accepted.⁴ Any weapons that India currently possesses are thought to be simple fission designs with yields in the 10 to 20 kt range. India has several ballistic missile delivery systems, mainly the *Agni 1* (range 700 km) and *Agni 2* (range 2,000 km). Given the size of Pakistan, either of these missiles could hit any target inside Pakistan, even if they were launched from well inside India. Indeed, the *Agni 2* has sufficient range so that it could be located almost anywhere in India and still reach all targets in Pakistan. Since, these two missile were only recently deployed, India probably also has an aircraft delivery capability, most likely via the *Mirage 2000* or *Jaguar*. The short-range (150 km) *Prithvi* may also have a nuclear delivery role.

These various components certainly give India the potential to match Pakistan weapon for weapon, not only as stockpiled weapons in peacetime but, if

need be, delivered ones in wartime as well. However, whether India has actually assembled a stockpile to match Pakistan's is unclear, as India seems to be pursuing the development of certain key elements in a very lackadaisical fashion.

One of the most striking examples of this very relaxed pace of development is India's overall military command authority for its nuclear forces. What is all the more amazing is that India has experienced several serious crises with Pakistan during this time. As is well-known, India and Pakistan had a major crisis in 2002 after a terrorist attack on India's Parliament in December 2001. Indian Prime Minister Vajpayee said in June 2002 that several weeks earlier India and Pakistan were not only close to war, but perhaps nuclear war as well.⁵ Yet it was only around this time that India began to discuss the necessity of having a formal military command structure for its nuclear forces, and it was not until January 2003 that India created a National Command Authority and the military's Strategic Forces Command (SFC). The SFC's first commander-in-chief was Air Marshal Asthana. Yet, in June 2004, when Air Marshal Asthana had completed his tour of duty in this post and was preparing to step down, it was reported that the SFC still did not have a permanent headquarters or adequate staff. Not surprisingly, this apparent lack of seriousness has led some even in India to doubt the credibility of India's ability to deter or effectively respond to a nuclear attack.⁶

Nor is this the only case where Indian development seems to be occurring at a very slow pace. It is well-known that India aspires to maintain a nuclear balance with China as well as with Pakistan. However, the 2,000 km range *Agni 2*, which has the longest range of any of India's current delivery systems, cannot cover

many important parts of China, including Beijing and the major cities on the east coast. As a result, India has been developing the longer range *Agni 3*, which, with a reported range of 3,500 km, could reach all of the important parts of China. Beginning in 2003, there were reports that the missile was going to be tested in the near future, but as of the first half of 2006, no such test had taken place. A recent report has indicated that technical difficulties delayed the test until 2005. In the first part of 2006, it was said that the missile was ready, but officials at India's Defense Research and Development Organization had been waiting approximately a year for government approval to conduct the test.⁷ Another report blamed the delay on bureaucratic infighting.⁸ The missile was finally tested in July 2006, but the test was a failure.

In at least one case, however, India has shown that it can react quickly if it sees the need. In response to the shock of Kargil, India decided to develop a ballistic missile with a shorter range than the 2,000 km *Agni 2*, clearly intended to be a Pakistan specific missile. The 700 km range *Agni 1* was the result of this development effort.⁹ The missile was first approved for development in October 1999 and first tested in January 2002. It was tested again in January 2003 and July 2004. It started deployment in 2003 at the same time as the *Agni 2*—a missile that had started development several years before the *Agni 1*. Now it is not totally clear why this missile was developed in the first place, given that the *Agni 2* could already be used to target Pakistan and, after the deployment of the *Agni 3*, the *Agni 2s* could be mostly targeted on Pakistan. Nor is it clear why, if India develops and deploys missiles, it will not develop the military command and control systems to accompany them.

It is now time to answer the question we asked at the beginning of this chapter: How adequate is Pakistan's current nuclear force? Certainly from Pakistan's point of view, its nuclear forces serve the useful function of increasing the costs to India if it should decide to eliminate Pakistan as an independent state. Pakistan could kill perhaps up to 10 million Indians and cause major damage to a number of its large cities. But one should not overstate this benefit. This level of destruction is nowhere near the levels that were feared during the Cold War when the threat was that every major city in the United States might be destroyed and more than 50 percent of the population might be killed. At least in the popular mind, such levels of destruction might bring the existence of civilization itself into question. In contrast, 10 million Indians are less than 1 percent of its population. Certainly this would be a very heavy price, but if India's broad view of its relations with Pakistan were such that India felt it desirable to force Pakistan into this desperate position to begin with, then the situation might be serious enough that India would just accept this loss as the price it needed to pay to eliminate whatever threat it perceived from Pakistan. Nor would this be unprecedented. Russian losses in World War II were at least 20 million. This was about 10 percent of its population. During its mobilization in the crisis in 2002, India must have at least considered some options where nuclear use by Pakistan was a possibility. The bottom line is that although Pakistan's current nuclear force raises the threshold for a major Indian attack, it does not guarantee Pakistan's survival as an independent country. In some circumstances, India might well attack and pay the price.

And India might well triumph even in the case where it used no nuclear weapons at all. This could be

because India chooses not to use such weapons. Or the slow pace of its development in nuclear forces raises the possibility that its nuclear forces could do little more than carry out a token response.

If India does have a nuclear force that fulfills its current potential (i.e., 50 to 100 readily deliverable weapons) then it can match Pakistan weapon for weapon. If India then decides to use these weapons to retaliate against a Pakistani first strike, Pakistan might only have succeeded in making its situation that much worse. Now, in addition to suffering the loss of an independent Pakistan, there would be very heavy losses among its population. Since Pakistan has only about 1/7th of India's population, the same loss suffered by both countries would be seven times the proportion of Pakistan's population when compared to that of India. Ten million fatalities would be over 6 percent of Pakistan's total population. And if Pakistan's losses were concentrated in its Punjab heartland, the proportional losses in this core region would be even higher.

How would Pakistan have to reconfigure its nuclear forces to deal fully with these problems? As long as Pakistan can only build low yield simple fission weapons of the types it currently possesses, it would have to greatly increase the number of weapons that it could deliver. To be able to kill 50 percent of India's population might require 100 times the number of weapons it now has. Many might consider this sort of Cold War level of destruction excessive, but killing just 5 to 10 percent of Indian's population would require a five to ten-fold increase in its number of weapons. Similarly just trying to compensate for the seven-fold difference in population between the two countries would require Pakistan to try to have seven times the number of weapons that India could readily deliver.

As was stated above, India's actual capabilities in this regard are uncertain, but if Pakistan were to assume that India has as many weapons as it has fissile material to build with, then it would again have to increase its current stockpile by about seven times. Increases of this magnitude are out of the question, as they would require proportionate increases in Pakistan's ability to produce fissile material, as well as similar increases in its missile forces.

Pakistan could also attempt to deal with these problems by targeting India's conventional forces so as to prevent the first and second situations (large scale loss of Pakistan's territory or severe losses in its conventional forces) where Pakistan would be compelled to use nuclear forces against Indian cities. This shift to a war fighting strategy would also require a larger Pakistani nuclear force, though exactly how much is uncertain. Pakistan would not need to eliminate all of India's conventional forces but only to tip the conventional balance in its favor. If Pakistan wanted to destroy six Indian ground force divisions (nine weapons per division) and the aircraft on 10 airfields (three weapons per airfield), Pakistan would need to use 84 weapons. Keeping its current stockpile in reserve to threaten Indian cities, the extra 84 weapons would require at least a doubling of Pakistan's current stockpile. Since, in the conventional conflict, mobile targets are harder to hit and tactical nuclear forces are more likely to be destroyed before their use, Pakistan might have to triple, instead of double, its stockpile. In addition, Pakistan might have to develop and deploy more tactical short-range delivery systems, which would further increase the costs of this strategy. A further problem is that such large increases in Pakistan's nuclear forces would lead to the need to divert funds

away from its conventional forces which would affect the conventional balance unfavorably requiring even more nuclear weapons to compensate. Furthermore, this strategy does nothing to protect against the third (economic blockade) or fourth (political destabilization) situations, where Pakistan has indicated that it would attack Indian cities with its nuclear forces. At any rate, it appears that Pakistan does not now wish to adopt this strategy, and is attempting to keep its nuclear program from affecting its conventional forces. (See section on "Economic Costs of Pakistan's Nuclear Weapons Program" below.) However, as we have indicated, Pakistan's current nuclear forces have serious limitations with regard to the range of situations where they may successfully protect Pakistan's independent existence.

The Future Adequacy of Pakistan's Nuclear Forces.

In some discussions of the development of nuclear arsenals, there is often the implicit belief that once a certain level of development is achieved, then no more effort is needed. However, in a situation where a nuclear balance is involved, then developments by one party can affect the adequacy of the arsenal of the other party.¹⁰ Pakistan's Ambassador to the UN has indicated that this reality is well-understood in Pakistan.¹¹ What then are the prospects for the adequacy of Pakistan's nuclear forces over the next 10 or 20 years? As with its current force, these prospects depend heavily on what India does with respect to its nuclear forces. As discussed above, there are some significant uncertainties regarding some aspects of India's current nuclear forces. In looking out so far into the future, the uncertainties are greatly magnified. In

order to deal with this uncertainty, two quite different futures for India's nuclear forces will be considered, which we hope will bracket the range of future Indian developments.

For our low-end future, we consider a case where India's development of its nuclear forces continues at a slow pace similar to what has gone on since 1998.¹² In this future, India continues to produce plutonium at its two production reactors.¹³ Uranium enrichment plays no major part in India's fissile material production for weapons. As a result, India might double its fissile material stocks in the next 10 to 20 years. We also assume that India does not conduct any further nuclear tests and therefore does not develop any thermonuclear weapons, or any other types of nuclear weapons with greatly enhanced yields. India also slowly continues to make its forces more militarily operational. In this case, Pakistan would probably be able to also double its fissile material stocks in this time period and still have a rough equivalence with India in terms of numbers of weapons and their destructive power. The adequacy of Pakistan's nuclear forces would probably be similar to what it is today, with the same strengths and weaknesses that were discussed in the prior section. However, the likelihood of an Indian response to any Pakistani first strike would probably be higher than today due to the improvement in India's militarization of its nuclear forces.

Even in this relatively low threat future, there is one possible development that holds the possibility of making a major change in the nuclear balance, namely that India will deploy some sort of anti-missile system. India has been in talks with Russia, Israel, and the United States regarding the purchase of their anti-missile systems. It has already purchased and

deployed Green Pine ballistic missile early warning radars, which were acquired from Israel. These anti-missile systems would only be able to defend small areas but given Pakistan's current dependence on the short-range *Ghaznavi*/M-11, having just the ability to defend the Delhi area could seriously affect Pakistan's nuclear strike capability. For now, India has not made any purchases, and it is not clear if it will. If it does, Pakistan will be hard pressed to respond. One option would be for Pakistan to deploy more long-range ballistic missile delivery systems, so that it might have the possibility of attacking a wider variety of Indian cities, including ones that are not defended. India might match this development by a further expansion of its defenses. Another possibility is that China might supply Pakistan with countermeasure technologies to reduce the effectiveness of any possible Indian anti-missile defenses. These countermeasure technologies might include maneuvering reentry vehicles or various forms of decoys. This assumes that China possesses this technology itself. Pakistan could also try to attack Delhi with its short-range (500 km) *Babar* cruise missile, which is currently underdevelopment, but India could concentrate its air defenses around this city to protect it.

For our high-end future, we consider a case where India undertakes a much more vigorous effort to expand its fissile material production, so that it increases its number of weapons four-fold (to around 400). Also, India resumes nuclear testing and in a 5 to 10-year period develops one Mt yield thermonuclear weapons, which it can deliver on its ballistic missile systems. It would be very difficult for Pakistan to match these developments; even considering that one-half of these weapons would probably be targeted on

China.¹⁴ Pakistan would have to triple both its uranium enrichment and plutonium production capacity just to increase its stockpile of simple fission weapons to match the number of weapons in India's stockpile. But the destructive power of Pakistan's arsenal would be far less than that of India's unless it could also develop thermonuclear weapons to match those of India. As an indigenous development, this would probably not be possible in this time period, but as with prior advances in Pakistan's nuclear weapons program, their development might be possible with major Chinese assistance.

Even if Pakistan develops its own thermonuclear weapons, the great increase in the number and destructive power of the Indian arsenal raises another major problem, namely, how does Pakistan protect its land-based ballistic missile force from an Indian first strike? The bottom line is that it probably cannot, given the limited area where Pakistan can build its missile deployment complexes and the security risks of frequent dispersals of its missiles from these complexes. The only long-term solution would be to deploy its ballistic missiles on submarines. Again, such a development would only be possible with sizeable Chinese aid. Indeed, the submarines would probably have to be built in China and sold to Pakistan. Even so, as will be discussed below, such a system is very expensive, and this overall Pakistani response of greatly expanding its fissile material production, developing thermonuclear weapons, and ballistic missile submarine deployment would lead to a serious reduction in Pakistan's conventional forces.

Some of the discussion of the merits of the proposed U.S. nuclear cooperation with India has focused on the concern that this arrangement will help India greatly

increase its fissile material stockpile for nuclear weapons and therefore tend to drive India and Pakistan toward the high-end future described above. The argument is that shortages of natural uranium have impeded India's expansion of its fissile material stockpile. The new agreement with the United States will give India unlimited access to the world yellowcake (semi-refined uranium ore) market to supply the power reactors that will be placed under safeguards, allowing India to funnel much of its indigenous uranium production into its weapons program.¹⁵

There are certainly many reasons to object to the proposed U.S. nuclear cooperation agreement with India, but the possibility that it will lead to a large-scale increase in India's fissile material production for weapons is not likely to be a major concern. It is true that if India wanted to use its power reactors to expand its fissile material stocks for weapons, this agreement would facilitate this expansion by allowing the power reactors to continue to produce electricity at full capacity while allowing the production of weapons grade plutonium. But how likely is it that India really does want to expand its fissile material production for weapons? India has had 8 years since its nuclear tests to expand its fissile material production capacity for weapons, but it has not. The most logical way for India to increase its fissile material production would be to build a copy of its current main plutonium production reactor, Dhruva, but it has taken no action in this area. If uranium shortages were restraining its fissile material weapons production, India would have a number of options to solve this problem that would not involve the proposed U.S. nuclear cooperation agreement. These include clandestine purchases of uranium from other countries. Yellowcake is not

subject to IAEA safeguards, and Iraq and Libya were able to readily purchase this material. Similarly, India made clandestine purchases of heavy water in the 1980s. Note that the uranium required to operate a Dhruva-type reactor costs only about \$5 million/year if purchased at current market prices, so that even if India had to pay well over market prices, the costs would not be that great. India could also have increased its indigenous production of uranium by mining its reserves faster. In the most extreme case, India could redirect its current uranium production away from its power reactor program and into weapons production. Since its nuclear power program is only a minor source of electricity, the sacrifice would be relatively small. After all, until 2005, an agreement between the United States and India would have seemed rather unlikely, so India would not have been foregoing these other expansion options just to wait for the U.S. agreement. In fact, India has not shown any desire to greatly expand its fissile material production for weapons, and it does not appear likely that any U.S.-Indian nuclear agreement will be a vehicle for this. Indeed, one result of this agreement is that India is planning to shutdown its plutonium production reactor, *Cirus*, in 2010, which will reduce its rate of plutonium production for weapons by around 30 percent.

Economic Costs of Pakistan's Current Nuclear Weapons Program.

One issue of interest is the economic burden of Pakistan's current nuclear program. This has implications for the possibility that Pakistan might significantly increase its nuclear weapons effort and also raises the issue of whether Pakistan's conventional

forces will suffer if this effort is increased too much. Ideally, one would simply want to know the dollar cost of Pakistan's efforts but there seems to be no easy way to determine these costs. Not only does Pakistan fail to provide information on the costs of specific programs, but also many important elements of its program rely on imports from other countries. In the case of the latter, it is not only uncertain what a market rate for these transactions might be but, in many instances, Pakistan may be receiving concessionary pricing.

It is clear that economic costs must seriously constrain Pakistan's nuclear program. Pakistan's defense budget is currently around \$3.7 billion, which is already a rather high 4.4 percent of Pakistan's gross domestic product (GDP). Given its large expenditures on its conventional military forces and in particular its army, Pakistan probably spends no more than 10 percent of its defense budget on its nuclear forces. Such a level of expenditures would make it very difficult to deploy certain types of nuclear systems. For example, France is currently deploying four new ballistic missile submarines (*Triomphant*-class). It is estimated that the cost of these ships, including ballistic missiles, nuclear warheads, and 25-year operating costs, is around \$40 billion.¹⁶ This would be over 40 percent of Pakistan's total defense budget for 25 years. Of course, this would only be the cost if France would agree to supply Pakistan with these items—a most unlikely event. Since it is beyond Pakistan's current (or near future) technical ability to build such submarines, the costs to Pakistan of building such systems at the present time are infinite. As was discussed above, it is possible that in the future the Chinese might provide such a system to Pakistan, though the costs of this transaction would be hard to estimate.

To get an idea of Pakistan's current expenditures on its nuclear forces, it is useful to look at the output of these expenditures, i.e., the components of Pakistan's nuclear arsenal. To gauge where Pakistan is on the spectrum of the smaller nuclear powers, we compare Pakistan to two other countries, France and South Africa. The former has a rather extensive nuclear arsenal for a mid-level power, whereas South Africa had a fairly minimal nuclear force.

In 35 years of nuclear testing, France has detonated 210 devices. It has developed nine different warhead types, including five that were thermonuclear. Including devices expended in nuclear testing, France has built around 1,400 nuclear weapons. It has built six different types of longer-range ballistic missiles, and is developing a seventh. It has built three different types of shorter-range missiles (two ballistic, one cruise) and is developing a fourth. It has constructed eight nuclear powered ballistic missile submarines, and is constructing a ninth. It has built 18 missile silos, 62 *Mirage IV* bombers and 60 *Mirage 2,000Ns*. France had five plutonium/tritium production reactors and is thought to have produced 4.5 to 7.5 metric tons of plutonium for its weapons program. With its gaseous diffusion enrichment plant at Pierrelatte, it is estimated to have produced 10 to 20 metric tons of highly enriched uranium for its weapons program.¹⁷ The burden of its nuclear program was highest in the early years with the nuclear program taking up an average of 24.3 percent of the defense budget between 1960 and 1969, 16.9 percent between 1969 and 1974, and 14 percent from 1974 to 1980.¹⁸ Nuclear forces were emphasized at the expense of conventional forces from 1960 to 1976.¹⁹

South Africa's nuclear effort was much smaller and took place from about the mid-1970s to 1990. Since its

weapon design was a simple gun type assembly, which was very likely to be successful, South Africa never tested any nuclear device. The weapon was expected to produce a yield of 14 kt with an uncertainty of plus or minus four kt. It produced only one weapon design and manufactured only six weapons. A seventh weapon was partially completed at the time of the program's termination. For weapon delivery, the South Africans were planning to use *Buccaneer* tactical strike aircraft, which had been purchased many years before there was a nuclear weapons program, and therefore their costs could not be attributed to that program. However, South Africa was also developing a 2,000 km range ballistic missile based on the Israeli *Jericho II* and was planning to adapt its nuclear warhead for that missile. Highly enriched uranium for the weapons program was produced in a dedicated enrichment facility known as the Y plant. It employed a unique aerodynamic process developed by South Africa. It is estimated that around 500 kg of material was produced for weapons use. One South African source gives it weapons expenditures as being only \$20 million per year.²⁰ However, this estimate attributes much of its expenditures on uranium enrichment to its civilian nuclear program and ignores the costs of its ballistic missile program. A more realistic estimate of the annual costs is around \$100 to \$200 million per year.²¹ Even this amount would only have been about 3 to 5 percent of South Africa's defense budgets at that time.

Pakistan's nuclear weapons effort seems closer to the scale of South Africa than that of France. Pakistan may have been able to achieve considerable economies due to receiving substantial aid from various countries, particularly China. Pakistan has likely tested only two devices and the purpose of these tests seems to

have been political rather than the exploration of nuclear weapons design or effects. Pakistan probably developed two different weapons, one for aircraft delivery and one for missile delivery. China very likely provided design information to Pakistan, reducing the effort needed to produce these weapons. Pakistan has probably produced 60 to 80 weapons, which would require a production rate five to ten times that of South Africa.

Pakistan has already deployed three different types of ballistic missiles, the *Ghaznavi*/M-11, the *Shaheen 1* and the *Ghauri*. The M-11s were likely supplied to Pakistan as complete weapons systems, though even in this case Pakistan had to build dispersed storage garages and support facilities. The *Ghaznavi* and the *Shaheen 1* seem to have been built in Pakistan though probably in facilities that China helped to construct. They seem to use the same TEL (transporter, erector, launcher) and their support facilities are probably quite similar, so it is possible that they could be deployed at the same facilities. The liquid-fueled *Ghauris* require their own separate deployment facilities not only because of their different propulsion system, but also because handling their liquid fuel around solid-fueled missiles would be quite dangerous. Having the *Ghauris* as part of its arsenal must significantly increase costs, not only because of the need for doubling the required missile support facilities, but also because Pakistan is more likely to have had to pay market prices for missiles obtained from North Korea as opposed to ones acquired from China. As is discussed below, internal bureaucratic infighting may have led to the deployment of both types of missiles.²² In addition, a fourth ballistic missile, the *Shaheen 2*, is under development and is expected to eventually be deployed. Though it is solid-

fueled, it is much larger than either the *Ghaznavi*/M-11 or the *Shaheen 1* and will require a different TEL than the one used for these two missiles. It will probably require somewhat different support facilities as well. Pakistan is also developing the short-range *Babur* cruise missile.

Pakistan has been producing highly enriched uranium for its weapons program from one or more centrifuge enrichment facilities since 1987. It is estimated that it has produced between 1.1 and 1.35 metric tons of highly enriched uranium. Using centrifuge enrichment technology is more economical than the gaseous diffusion or aerodynamic processes used by France and South Africa respectively, since its electricity consumption is only about 1-10th of that required by these other two processes. Pakistan has probably split its centrifuge capacity among various plants for reasons of strategic protection. While prudent, this need for multiple enrichment facilities will also increase costs. Since 1998, Pakistan has been operating a heavy water moderated plutonium production reactor, which has been estimated to have produced 40 to 80 kilograms of plutonium for its weapons program. It is not clear why Pakistan incurred the expense of producing plutonium, when it already had satisfactory weapons using highly enriched uranium. The expense is all the greater since Pakistan seems to have built a heavy water production facility to support this reactor.

Clearly, Pakistan currently has a much more extensive nuclear weapons program than South Africa had. Pakistan has roughly 10 times as many weapons. There was not only the expense of building these weapons but also of providing delivery vehicles for this arsenal. In addition, there are the inefficiencies of having both solid- and liquid-fueled missiles,

and producing both highly enriched uranium and plutonium, when, in both cases, one or the other would have been sufficient. Based on the analogy with South Africa then, it seems likely that Pakistan's nuclear forces entail costs in the low hundreds of millions of dollars per year. This is probably about as much as Pakistan can afford without starting to make significant cuts in its conventional forces. Table 2 presents a summary of the comparison of the nuclear weapons programs of these three countries.

	France	South Africa	Pakistan
Nuclear Tests	210	0	2
Nuclear Weapons	1,400 of nine types including five TN	6 of one type	60-80 of two types
Missile Delivery	Six types of longer range ballistic missiles Three types of shorter range	None deployed Tested ballistic missile based on Israeli design	Three types of ballistic missiles deployed Fourth ballistic missile tested Cruise missile tested
Other Delivery Systems	18 Missile Silos, 62 Mirage IV 60 Mirage 2000N	Buccaneers previously acquired	34 F-16
Fissile Material Production	Five plutonium/tritium production reactors Gaseous diffusion enrichment	Aerodynamic enrichment	One plutonium production reactor Centrifuge enrichment

Table 2. Comparison of Nuclear Weapons Programs of France, South Africa and Pakistan.

Conclusions.

Pakistan's current nuclear forces certainly raise the stakes for India in any major conflict with Pakistan, and it is unclear how ready India's nuclear forces are

to respond to a Pakistani nuclear first strike. However, even without any Indian nuclear response, the up to 10 million fatalities that a Pakistani nuclear strike on India might cause are not anywhere near the levels of destruction feared by the Superpowers during the Cold War, and they might be accepted by India as the necessary price to eliminate whatever threat it perceived from Pakistan. The bottom line is that Pakistan's nuclear forces are not a firm guarantee of its survival as an independent country.

Without a doubt, India's current nuclear arsenal has the potential to match Pakistani nuclear strikes weapon for weapon. If they do, Pakistan seems not to have addressed the severe damage that would result to Pakistan's society from an Indian counterstrike. Further, since Pakistan has only about 1/7th of India's population, the same loss suffered by both countries would be seven times the proportion of Pakistan's population when compared to that of India.

As long as Pakistan can only build low yield fission weapons, its can only redress these problems by increasing the number of its nuclear weapons by five- or ten-fold. Increases of this magnitude are out of the question, as they would require proportionate increases in Pakistan's ability to produce fissile material as well as in its missile forces. Even shifting to a nuclear warfighting strategy would not seem to be plausible since it would still require a doubling or tripling of Pakistan's nuclear forces. For the present, at least, Pakistan seems content with its rate of nuclear force increase, which is far below these levels.

The future adequacy of Pakistan's nuclear forces over the next 10 to 20 years depends heavily on the future course of India's nuclear forces. For our low-end projection of India's future nuclear forces, we

assume that it roughly doubles its nuclear arsenal and continues to field only low yield fission weapons. In this case, Pakistan would probably be able to also double its fissile material stocks and still have a rough equivalence with India in terms of number of weapons and their destructive power. The adequacy of Pakistan's nuclear forces would probably be similar to what it is today, with the same strengths and weakness. If India were to deploy an effective anti-missile system around some of its cities, it could seriously affect Pakistan's nuclear strike capability. Pakistan would either have to deploy more longer-range missiles so as to be able to strike undefended cities, or obtain countermeasure technologies from the Chinese.

For our high-end projection of India's future nuclear forces, we assume that it increases its number of nuclear weapons about four-fold (to around 400) and develops one Mt yield missile warheads. It would be very difficult for Pakistan to match these developments. Even greatly expanding its number of fission warheads would not allow Pakistan to come close to matching the destructive power of India's arsenal. Pakistan's only hope would be to receive major Chinese aid so that Pakistan could develop its own thermonuclear weapons. Even then, as long as Pakistan continued to rely on land-based ballistic missile systems, it would be vulnerable to a possible disarming Indian first strike due to the great increase in the destructive power of this Indian arsenal. The only long-term solution would be to deploy ballistic missiles on submarines. Again, this would require very substantial Chinese aid. Even so, such an expanded Pakistani arsenal would likely be very expensive and would result in a serious reduction in Pakistan's conventional forces.

There are many reasons to object to the proposed U.S. nuclear cooperation agreement with India but the possibility that it will lead to a large-scale increase in India's fissile material production for weapons is not likely to be a major concern. Though this cooperation agreement would allow India to use its power reactors to expand its supply of weapons grade plutonium without sacrificing electricity production from these reactors, there is little evidence that India is interested in such an expansion of its weapons grade plutonium stocks. India has had 8 years since its nuclear tests to expand its fissile material production for weapons, but it has done nothing, including not taking the most logical steps to do so, namely to build additional plutonium production reactors of the Dhruva type. Uranium shortages do not appear to be restraining India, since it has a number of options to circumvent such a problem, and, in any case, the uranium costs associated with its plutonium production are not large. India has not shown any desire to greatly increase its fissile material production for weapons, and it does not appear likely that any U.S.-Indian nuclear agreement will be a vehicle for this. One result of the proposed agreement is that India is planning to shut down its plutonium production reactor, Cirus, in 2010, which will reduce its rate of plutonium production by around 30 percent.

Compared to South Africa, Pakistan has a more extensive nuclear weapons program with roughly 10 times as many weapons. Pakistan has three deployed land-based ballistic missile systems and is developing a fourth. Pakistan's program has the inefficiencies of having both solid-fueled and liquid-fueled ballistic missiles and uses both highly enriched uranium and plutonium. In both cases, one or the other would have

sufficed. Based on the comparison with South Africa, the costs associated with Pakistan's current nuclear forces is likely in the low hundreds of millions of dollars per year. This amount is probably about as much as Pakistan can afford without starting to make significant cuts in its conventional forces.

ENDNOTES - CHAPTER 4

1. "Nuclear Safety, Nuclear Stability and Nuclear Strategy in Pakistan," A concise report of a visit by Landau Network-Centro Volta.

2. Note that one would not have to kill or destroy the entire city to achieve this result.

3. These results would apply generally to other Indian cities as well. For example, Mumbai (Bombay) has a population of 16.4 million and an area of 1,178 km².

4. Gregory S. Jones, *From Testing to Deploying Nuclear Forces: The Hard Choices Facing India and Pakistan*, IP-192, Santa Monica, CA: RAND, 2000.

5. "India Was Prepared for an Atomic War But We Were Confident That Our Neighbor Would Not Commit Such an Act of Madness." *Times of India*, June 17, 2002.

6. Rahul Bedi, "India's Nuclear Struggles," *Jane's Defense Weekly*, February 5, 2003, p. 79.

7. "India's Agni-III Missile Ready for Launch," *Times of India*, February 3, 2006.

8. Vivek Raghuvanshi, "Agencies' Dispute Slows Agni Missile Work," *Defense News*, April 10, 2006, p. 20.

9. Between 1989 and 1994, India tested a two-stage ballistic missile with a range of about 1,500 km, which was known as *Agni*. This missile was considered a "technology demonstrator" and

was never deployed. An improved version of this missile with a range of 2,000 km was first tested in 1999. It was known as *Agni 2*. The older version of this missile then began to be referred to as *Agni 1*. However, when the 700 km Pakistan specific ballistic missile was developed, it was called *Agni 1*, and the technology demonstrator went back to being called *Agni*.

10. Albert Wohlstetter, "Nuclear Sharing: NATO and the N + 1 Country," *Foreign Affairs*, Vol. 39, No. 3, April 1961.

11. "Pakistan will continue to develop its nuclear missiles and related strategic capability to maintain the minimum credible deterrence viz-e-viz our eastern neighbour, which is embarked on major programmes for nuclear weapons, missiles, anti-missile and conventional arms acquisition and development." "Explanation of Vote by Ambassador Munir Akram, Permanent Representative of Pakistan to the United Nations, on the Security Council Resolution on Non-Proliferation of Weapons of Mass Destruction, April 28, 2004," available at www.pakun.org/statements/Security_Council/2004/04282004-01.php.

12. We realize that this "low" future is not the lowest that is possible (in an extreme case, India could follow South Africa's path and denuclearize). However, we think that this future is more likely and in any case a more interesting one for analysis.

13. These are Cirus and Dhruva. We assume that India follows through with its plans to shut down Cirus in 2010 and that India does not build a reactor to replace it.

14. Some of the problems facing Pakistan in this situation are discussed in Gregory S. Jones.

15. See, for example, Zia Mian and M. V. Ramana, "Wrong Ends, Means, and Needs: Behind the U.S. Nuclear Deal with India," *Arms Control Today*, Vol. 36, No. 1, January/February 2006, pp. 11-14.

16. Robert S. Norris and Hans M. Kristensen, "French Nuclear Forces, 2005," *Bulletin of the Atomic Scientists*, Vol. 61, No. 4, July/August 2005, pp. 73-75.

17. Note that this listing is cumulative production. Since various items have been phased out over time, France may not have had all of these items at any one time. For example, it has only had four nuclear powered ballistic missile submarines in commission at any one time. See *ibid.*; and Robert S. Norris, Andrew S. Burrows, and Richard W. Fieldhouse, *Nuclear Weapons Databook, Volume V, British, French and Chinese Nuclear Weapons*, Natural Resources Defense Council Inc., Boulder, CO: Westview Press, 1994.

18. David S. Yost, "France's Deterrent Posture and Security in Europe, Part I: Capabilities and Doctrine," *Adelphi Papers*, #194, London: The International Institute for Strategic Studies, 1985, p. 14.

19. *Ibid.*, p. 55.

20. Waldo Stumpf, "Birth and Death of the South African Nuclear Weapons Programme," Presentation given at the conference "50 Years After Hiroshima," organized by USPID (Unione Scienziati per il Disarmo) and held in Castiglioncello, Italy, September 28-October 2, 1995.

21. Peter Liberman, "The Rise and Fall of the South African Bomb," *International Security*, Vol. 26, No. 2, Fall 2001; and Lieutenant Colonel Roy E. Horton III, USAF, "Out of (South) Africa: Pretoria's Nuclear Weapons Experience," Occasional Paper # 27, Boulder, CO: USAF Institute for National Security Studies, August 1999.

22. Making important decisions about nuclear delivery forces based on criteria other than economics is hardly unique to Pakistan. For example, for its V-bomber force, the United Kingdom conducted a competition. A choice was to be made between two contenders, the *Vulcan* and the *Victor*, but in the end, for political reasons, both aircraft were chosen for production despite the much higher costs involved.

APPENDIX I

PAKISTAN'S CURRENT NUCLEAR ARSENAL

Pakistan's current nuclear arsenal appears to rely almost exclusively on mobile land-based ballistic missile delivery systems. Pakistan has three deployed missile systems. These are the 350 km range *Ghaznavi/M-11*, the 750 km range *Shaheen 1*, and the 1,300-1,500 km range *Ghauri*. The first two missiles are solid-fueled; the last utilizes storable liquid fuels. The *Ghaznavi/M-11* is deployed in a complex of dispersed garages near Sargodha. The deployment areas of the other two missiles are unknown. The *Shaheen 1* reportedly uses the same TEL as does the *Ghaznavi/M-11*; and, since they are both solid-fueled, they could be deployed at the same locations. However, the liquid-fueled *Ghauri* would need a completely separate deployment location. Not only would it require a different supporting infrastructure, but its fuel (in particular, its concentrated nitric acid oxidizer) would be extremely dangerous to handle around solid-fueled missiles. As is related in the next section, Pakistan initially imported 34 M-11 missiles from China in 1993. The *Ghaznavi* appears to be an indigenously manufactured version of the M-11. Presumably, as the Chinese versions of the missile have aged, they have required remanufacture. Having tested the missile four times since 2002, Pakistan appears to be serious about maintaining this missile in its arsenal. This is somewhat surprising since with the longer-range *Shaheen 1* now available, one might expect Pakistan to shift its production to this missile. Clearly, this is not the case and it appears that the *Ghaznavi/M-11* will be an important part of Pakistan's arsenal for many years to come. The *Military Balance* gives the size

of Pakistan's missile force as 50 *Ghaznavi*/M-11, 15-20 *Ghauri*, and 6 *Shaheen 1*.²³

Though it is likely that Pakistan relies mainly on its ballistic missile force for its nuclear weapons delivery capability, its force of 34 F-16s also could be used in this role. Before 2003 when the *Shaheen 1* and *Ghauri* were deployed, these aircraft would have been the only means to attack targets that are beyond the range of the *Ghazavi*/M-11. However, given the growing strength on India's air defenses and the importance of the F-16s in the conventional air balance, these longer-range ballistic missile have likely taken over the deep nuclear strike role. Currently, the main utility of these aircraft in a nuclear strike role would be to attack mobile tactical targets that would be difficult to target with ballistic missiles.

Pakistan produces both highly enriched uranium and plutonium for its weapons program. The highly enriched uranium is produced by the use of centrifuges. The first facility was at Kahuta and additional plants of various sorts are also at Sihala, Golra, and Wah. In the mid-1990s, Pakistan's total enrichment capacity was estimated to be around 5,000 separative work units (SWU) per year, which would produce about 25 kg of heavy enriched uranium (HEU) per year.²⁴ Since its 1998 nuclear tests, its total enrichment capacity appears to have expanded to around 10,000 SWU per year (50 kg of HEU per year). Also since 1998, Pakistan has had a 50 MWth plutonium production reactor in operation at Khushab. Its production rate will depend on the reactor's capacity factor, but is probably around 10 kg of plutonium per year.

The ISIS has produced a set of reasonable estimates for Pakistan's total fissile material production as of the end of 2003.²⁵ Pakistan's total HEU inventory was

estimated to be between 1,000 and 1,250 kg and its total plutonium inventory was estimated to be between 20 and 60 kg. Assuming 20 kg of HEU or 5 kg of plutonium is required for each weapon, there would be a possible nuclear inventory at the end of 2003 of about 50 to 70 weapons. Taking into account fissile material production in 2004 and 2005 would lead to an estimate of about 60 to 80 weapons. These estimates are similar to many other that have been made for Pakistan. Note that while estimates such as these have been useful for sizing Pakistan's nuclear arsenal in the past, at some point in the future, fissile material inventories will not be the limiting factor in producing a nuclear arsenal.

With regard to the weapons themselves, presumably Pakistan possesses two weapon types: The first, a weapon produced at the beginning of Pakistan's program, is designed to be delivered by an F-16; and the second, a smaller lighter weight weapon, is suitable for ballistic missile delivery.²⁶ As to the possible yield of these weapons, the 1998 nuclear tests provide the only insight available. These tests probably did not serve the purpose for which nuclear tests are usually conducted, namely to provide information about the characteristics of the nuclear devices being tested. Such information would have already been supplied to Pakistan from China. Rather, the purpose of the tests appears to have been political, to respond to India's tests and to declare Pakistan an overt nuclear weapons state. Therefore Pakistan's main purpose would have been to conduct tests as quickly as possible after India's, and it would have likely used weapons from its existing arsenal for this purpose. And since India claimed that it had tested four weapons simultaneously on May 11, Pakistan claimed that it tested five weapons on May 28. However, again, this seems to have been for political

effect. Based on the small overall magnitude of the seismic signal on this date, it is far more likely that only one weapon was tested. The seismic signal on May 28 had a body-wave magnitude of 4.9, which is equivalent to a yield of 6 to 13 kt. Pakistan also conducted a single nuclear test on May 30. Its seismic signal had a body-wave magnitude of 4.3, which is equivalent to a yield of 2 to 8 kt. Both weapons then appear to have been simple fission devices, the first with a yield of around 10 kt and the second 5 kt. The difference in yield between the two tests might represent the difference between the aircraft-delivered design and the missile-delivered one, or it could have been the same weapon using different fissile cores. Also, since the uncertainty bounds overlap, it is possible that it was the same weapon tested twice. At any rate, it seems that the yield of Pakistan's nuclear weapons is likely in the range of 5 to 10 kt and probably no more than 15 to 20 kt.

As to the readiness of the Pakistani nuclear force, President Musharraf has indicated that the weapons are kept in an unready state. He has stated, "Missiles and warheads are not permitted together. There is a geographical separation between them."²⁷ At a minimum what this probably means is that the fissile cores are stored separately from the missiles and their warheads. Though some observers have contrasted this practice with the Superpower experience, actually the United States handled its weapons in the same way for the first decade or so of its weapons program. In the U.S. case, the fissile cores were kept separately from the high explosive parts of the warhead, not only for security reasons but for safety reasons as well. Indeed, given the technology of the era, the high explosive components could not be maintained at high levels of readiness for any great period of time.²⁸

Since 2000 Pakistan has had a formal command and control arrangement for its nuclear forces. This is the “National Command and Control Authority” jointly headed by President Musharraf and Pakistan’s Prime Minister.

ENDNOTES - APPENDIX I

1. *The Military Balance 2005-2006*, London: The International Institute of Strategic Studies, 2005.

2. Brian G. Chow, Richard H. Speier, and Gregory S. Jones, *The Proposed Fissile-Material Production Cutoff: Next Steps*, MR-586-1-OSD, Santa Monica, CA: RAND, 1995, p. 46.

3. *ISIS Estimates of Unirradiated Fissile Material in De Facto Nuclear Weapons States, Produced in Nuclear Weapon Programs*, April 1, 2004, revised June 30, 2005, available at www.isis-online.org/global_stocks/end2003/de_facto_nws.pdf.

4. The *Ghaznavi/M-11*, *Shaheen 1*, and the *Ghauri* all seem to have similar enough payloads so that a single weapon design would probably serve for any of the three missiles.

5. “Musharraf rules out accidental N-war with India,” *Times of India*, January 10, 2003.

6. For weapons in the 1940s and 1950s, a major limitation was that of battery technology. See B. H. Van Domelen and R. D. Wehrle, Sandia National Laboratories, “A Review of Thermal Battery Technology,” W. V. Hassenzahl, ed., *Electrochemical, Electrical, and Magnetic Storage of Energy*, Stroudsburg, PA: Hutchinson Ross Publishing Company, 1981, p. 227.

APPENDIX II

A SHORT HISTORY OF PAKISTAN'S NUCLEAR WEAPONS PROGRAM

It is widely accepted that Pakistan's formal nuclear weapons program began in the aftermath of its defeat in the December 1971 Indo-Pakistan War. In January 1972, Prime Minister Zulfikar Ali Bhutto convened a meeting with Pakistan's top scientists in the city of Multan where he announced that Pakistan would develop nuclear weapons. Like all nuclear weapons efforts, the main barrier to the production of weapons was the need to procure the special nuclear material (plutonium or highly enriched uranium) required for any such weapon.

Initially, Pakistan concentrated its efforts on acquiring plutonium. In December 1972, Pakistan's first nuclear power reactor (Kanupp), which had been supplied by Canada, began sustained operation. It would produce tens of kilograms of plutonium per year. Utilizing this material would require diverting it from IAEA safeguards, but this apparently was not considered a problem. However, Pakistan needed a reprocessing plant to separate the plutonium from the spent reactor fuel. Pakistan began negotiations with France for the purchase of a large reprocessing plant, which would be located at Chashma. In October 1974, a deal was signed to build the plant. U.S. opposition to this facility would eventually lead France to cancel the deal. Pakistan managed to build a smaller reprocessing facility known as the New Labs, with the help of Belgian and French companies. New Labs facility was probably completed sometime in the early to mid 1980s. By that time, Pakistan had shifted its main effort to the

production of highly enriched uranium and New Labs would not operate for many years, as Pakistan decided not to face the political controversy that would result from violating the IAEA safeguards at Kanupp, and there was no other source of spent fuel available.

As is now well-known, Pakistan acquired enrichment technology through the efforts of Dr. Abdul Qadeer Khan. He began work in 1972 at the Almelo facility in the Netherlands, which is part of the Urenco centrifuge enrichment project. Due to lax security, Khan was able to gain information about much of the centrifuge enrichment technology. When Khan returned to Pakistan for a visit in 1974, he was able to convince the Pakistani government to begin its own centrifuge enrichment project. In 1975 Khan returned to Pakistan permanently to head the centrifuge development effort. Key to this endeavor was Pakistan's ability to procure many centrifuge components from Urenco suppliers, as well as to purchase other facilities needed for the centrifuge effort. For example, in the late 1970s, Pakistan was able to buy an entire facility for the production of uranium hexafluoride (the chemical form required for the enrichment plant) from companies in West Germany. Construction of an enrichment facility at Kahuta began in 1978. By 1984 the plant was in operation producing low enriched uranium. By 1987 it was producing the highly enriched material needed for weapons production.

In the late 1970s, in response to Pakistan's nuclear weapons development efforts, the United States cut off aid to Pakistan. However, the Soviet invasion of Afghanistan at the end of 1979, led the United States to reverse course and strengthen ties with Pakistan. In 1981, the United States agreed to sell 40 F-16 fighters to Pakistan. The aircraft were delivered to Pakistan

between 1983 and 1987. Of these aircraft, 32 are thought to be still operational today.

In the mid-1980s, China supplied Pakistan with a nuclear weapon design suitable for tactical aircraft delivery. In addition it provided Pakistan with important components required to detonate a nuclear weapon.

A 1985 U.S. law known as the Pressler Amendment required the president to annually certify that Pakistan did not possess a nuclear device for U.S. aid to Pakistan to continue. With Pakistan's production of highly enriched uranium and its having both a viable nuclear weapon design and F-16s to deliver the weapons, providing the certification became increasingly difficult. But as long as the war in Afghanistan continued, the certification was provided. However, with the end of this war, there was no longer any need for such close ties with Pakistan. In October 1990, the president failed to provide the certification and aid to Pakistan was again cut off. This date should be considered the latest that Pakistan had become a de facto nuclear weapons state with an arsenal based on F-16 delivered highly enriched uranium weapons.

With the imposition of sanctions against Pakistan, it could not obtain spare parts for the F-16s or additional aircraft that had been ordered. This threatened to undermine the long-term viability of Pakistan's nuclear force. In 1993 China supplied Pakistan with 34 M-11 missiles. These utilize solid fuel and were reported to have a range of 300 km. The public reporting of this transfer was delayed until 1996. Even then it did not appear to be particularly significant since, with a range of only 300 km, the missiles could not be used to hit major Indian cities, if launched from Pakistan. However, more recent reporting assigns the missile a range of 350

km, which would allow the missile to reach New Delhi when launched from Pakistan.²⁹ Unclassified satellite photographs taken in early 2000 show a dispersed complex of 12 storage garages where these missiles and their TELs are deployed near Sargodha. Equipping these missiles with nuclear warheads would require the use of a warhead somewhat smaller and lighter than the one developed for F-16 delivery, but there is no reason to suppose that China would not have supplied Pakistan with such a warhead design.

In April 1998, Pakistan tested the *Ghauri* missile. It appears to be an unmodified imported North Korean *No Dong* missile. The *No Dong* is reported to have a range of 1,300 km, though the *Ghauri* is usually reported to have a range of 1,500 km. The importation of this missile appears to represent bureaucratic rivalry between A. Q. Khan's research organization (which was responsible for the importation of the *Ghauri*) and Pakistan's National Development Complex (which is developing Pakistan's solid-fueled missiles). This missile has been tested five additional times: April 1999, May 2002, May 2004, June 2004, and October 2004. The missile was officially handed over to the Pakistani military in January 2003.

Also in April 1998, Pakistan started sustained operation of its 50 MWth heavy-water plutonium production reactor at Khushab. The Chinese reportedly provide assistance in the construction of this reactor. In early 2000, unclassified satellite photos of this site showed what appears to be a heavy water production plant only a few miles south of the reactor.

On May 28 and May 30, 1998, Pakistan conducted nuclear tests in response to the ones conducted by India earlier in the month. These tests marked the transition from Pakistan as a *de facto* nuclear weapons state to that of an openly declared nuclear weapons state.

In April 1999, Pakistan tested the *Shaheen 1* ballistic missile. It utilizes solid fuel and has a range of 750 km. The missile was tested twice in October 2002, twice more in October 2003, and again in December 2004. The missile was officially handed over to the Pakistani military in March 2003.

In February 2000, Pakistan established a National Command Authority. Though little is known about it publicly, it is believed to be responsible for nuclear doctrine, as well as nuclear research and development, wartime command and control, and advice to President Musharraf about the development and employment of nuclear weapons.

Twice in 2002, Pakistan tested the *Ghaznavi*. It is believed to be a domestically produced copy of the Chinese M-11 ballistic missile. The missile was also tested in October 2003 and November 2004. The missile was formally inducted into service with the Pakistani military in February 2004.

In March 2004, Pakistan tested the *Shaheen 2* ballistic missile. This is Pakistan's first two-stage missile, with both stages using solid fuel. It has a range of about 2,000 km, which will allow it to hit almost any target in India. The missile was tested again in March 2005 and April 2006, but it has yet to be inducted into the military.

In August 2005, Pakistan tested the *Babur* cruise missile with a range of 500 km. It was tested again in March 2006 and may be deployed by the end of the decade.

In December 2005, the United States supplied Pakistan with two F-16s.³⁰

ENDNOTES - APPENDIX II

1. Duncan Lennox, ed., *Jane's Strategic Weapon Systems*, Issue 42, January 2005, p. 136.

2. "U.S. Combat Aircraft Delivered to Pakistan," *Arms Control Today*, Vol. 36, No. 1, January/February 2006, p. 31.

CHAPTER 5

ISLAMABAD'S NUCLEAR POSTURE: ITS PREMISES AND IMPLEMENTATION

Peter R. Lavoy

This chapter examines Pakistan's strategy for ensuring the security and survivability of its nuclear deterrent during periods of peace, crisis, and war. Toward this end, five main features of Pakistan's strategic deterrence policy are described in some detail. With an understanding of how Pakistani military planners perceive the basic requirements of their strategic deterrent, the ways in which the rapidly evolving U.S.-India strategic partnership threatens Pakistan's core defense precepts become apparent. A set of new long-term Pakistani strategic concerns stimulated by the expanding U.S.-India partnership is identified and analyzed. The basic point is that projected developments in India's nuclear and conventional military capabilities eventually could threaten the survivability of Pakistan's strategic deterrent, which has always been a major concern for the country's defense planners. The concluding section of the chapter examines how the Pakistan government officials might view three emerging strategic threats posed by India and its expanding international partnerships.

FIVE DIMENSIONS OF PAKISTAN'S NUCLEAR DETERRENCE POLICY

Pakistan has relied on nuclear weapons to deter Indian aggression for over 2 decades, but a thoroughly considered and planned nuclear deterrence strategy

took shape only after the country conducted its first nuclear explosive tests in May 1998—a development that was prompted suddenly and unexpectedly by India’s surprise nuclear test series earlier that month. Before then, nuclear weapons had not been integrated into Pakistani military plans, the armed forces had no nuclear employment doctrine to speak of, and command and control over the nuclear arsenal and delivery systems was only vaguely defined and loosely organized.¹ Even after the 1998 nuclear tests, Pakistani defense planners gradually recognized that premising national security on nuclear weapons required a multitude of new undertakings related to doctrine, command and control, force structure, delivery systems, and the vetting and training of specialized personnel assigned to various strategic force responsibilities.

Pakistan’s efforts to establish an effective nuclear force posture, strategic organization, use doctrine, deterrence strategy, and command and control system were severely complicated, but also ultimately facilitated, by three serious crises that occurred in the past 5 years: (1) the forced reorientation of Pakistan’s foreign and defense policies after the September 11, 2001 (9/11) terrorist attacks against the United States and the subsequent U.S.-led war on terrorism; (2) the 2001-02 military standoff that nearly produced a major war with India; and (3) the revelations in early 2003 of the A. Q. Khan network’s illicit transfers of nuclear weapons technology and materials to Iran, Libya, and North Korea. Because of the sweeping changes Pakistan has made in its nuclear programs, strategic organizations, and force posture in the wake of these traumatic events, Pakistani security planners now have a much more effective—and “normal”—nuclear deterrence posture. However, the emergence of new

political and military challenges arising from the U.S.-India strategic partnership—particularly, the U.S.-India initiative for civilian nuclear cooperation and possible defense technology and military equipment transfers—will further test the ability of Pakistan’s military leadership to maintain a robust, credible, and secure nuclear deterrent.

Today, Pakistan’s strategic deterrence strategy consists of five major elements: (1) an effective conventional fighting force and the demonstrated resolve to employ it against a wide range of conventional and sub-conventional threats; (2) a minimum nuclear deterrence doctrine and force posture; (3) an adequate stockpile of nuclear weapons and delivery systems to provide for an assured second strike; (4) a survivable strategic force capable of withstanding sabotage, conventional military attacks, and at least one enemy nuclear strike; and (5) a robust strategic command and control apparatus designed to ensure tight negative use control during peacetime and prompt operational readiness (positive control) at times of crisis and war. Each of these features is described below.

Conventional-Military Components of Deterrence.

Pakistan’s nuclear weapons are considered to be absolutely essential to deter India from undertaking a wide range of coercive political-military behavior that could undermine Pakistan’s territorial integrity and political sovereignty. However, it is important to recognize that Pakistani defense planners still consider their conventional armed forces to be the first line of defense against Indian conventional military attack and the backbone of the country’s overall deterrence posture. It could be said that 95 percent of Pakistan’s

strategic deterrent relies on a robust conventional military capability and deliberate and repeated demonstrations of the Pakistani leadership's readiness to employ it decisively if attacked – or even seriously threatened with military attack.

Pakistan's military conduct during the 2001-02 crisis with India revealed this orientation. When India mobilized its armed forces for attack shortly after the December 13, 2001, terrorist strike against the Indian Parliament, Pakistan responded by immediately putting its own armed forces on a war footing. Pakistani military leaders were very satisfied that their ground forces were able to reach their designated strike positions more quickly than their opposite numbers, thus eliminating the element of surprise and nullifying any advantage that India might have by striking across the border first. It is widely speculated that Indian Prime Minister Atal Bihari Vajpayee decided against a military attack when his troops had moved into their strike positions by the middle of January because Pakistani troop deployments indicated that Islamabad was well-prepared to counterstrike at locations of its choosing, thus eliminating any advantage India would have gained by attacking first. As President Pervez Musharraf wrote in his memoir, "We went through a period of extreme tension throughout 2002, when Indian troops amassed on our borders during a hair-trigger, eyeball-to-eyeball confrontation. We responded by moving all our forces forward. The standoff lasted 10 months. Then the Indians blinked and quite ignominiously agreed to a mutual withdrawal of forces."²

A similar experience in coercive diplomacy occurred a few months later, when Indian and Pakistani troops were still fully deployed along the international border

and the Kashmir line of control. When the Pakistani leadership received tactical intelligence that India once again was preparing to attack in early June 2002, the Pakistani military command's response was to instruct its soldiers to counterattack immediately after the first Indian violation of the international border. Not only that, but following the traditional approach of Pakistani deterrence strategy, orders were given for at least one additional counterattack to take place in reaction to the Indian strike.³ By demonstrating its readiness to use conventional military force in response to any Indian provocation, Pakistan hoped then, and still hopes today, to compensate for its disadvantage relative to India in conventional troop numbers and equipment quality with greater resolve and the willingness to run greater military risks.⁴

If an Indo-Pakistani military crisis were to deepen, the weight of deterrence would shift more to nuclear weapons. Pakistan's nuclear posture, which during peacetime is recessed and structured mainly for secrecy and safety, would reflect a much greater emphasis on usability and operational readiness. Of course, this is what senior Pakistani defense planners have referred to when they express concern about the degradation of Pakistan's conventional military capability lowering the threshold for nuclear weapons use: The shorter the period of time that Pakistan's conventional military (notably the Pakistan Army and Air Force) could hold out in a war, the quicker the National Command Authority (NCA) would be to order the deployment—and possibly the employment—of nuclear weapons.

A key point that emerges from this understanding of the close connection of conventional military force and nuclear force in Pakistan's deterrence strategy is the realization that escalation dominance at all rungs

of the military ladder—from low-intensity conflict to conventional war and all the way to nuclear war—is deemed absolutely essential for the weaker power to survive. Pakistani defense planners firmly believe that if they allow India to seize the advantage at any level of violence—from subconventional through conventional to nuclear warfare—then India is sure to exploit it, and all will be lost.

Minimum Nuclear Deterrence Doctrine.

Pakistan has not formally declared a nuclear employment doctrine, but this does not mean there is no doctrine. On the contrary, Pakistan has operational plans and requirements for nuclear use integrated within its military warfighting plans. In contrast to India, which has stated the basic parameters of its nuclear use doctrine but remains quiet about its strategic command and control structure, Pakistan has disclosed the basic features of its nuclear command and control organization,⁵ but no official has discussed how the government plans to employ its nuclear weapons. In fact, Lieutenant General Khalid Kidwai, director of Pakistan's Strategic Plans Division (SPD)—the military organization created in 1999 to oversee the development, custody, and employment of nuclear weapons—affirmed to a pair of Italian physicists in 2002 that Pakistan would not make its nuclear doctrine public, as India did in August 1999.⁶

The primary purpose of Pakistan's nuclear arsenal, a purpose which Pakistani officials have openly stated, is to deter an Indian conventional military attack. As noted above, Pakistan prioritizes conventional military readiness for deterrence and warfighting. If this fails, Pakistani officials plan to be the first to use nuclear

weapons as a last resort to prevent the loss of Pakistan's territory, or the military defeat of the Pakistani armed forces. In the most authoritative statement on the subject, Pakistani Foreign Minister Abdul Sattar indicated in June 2001 that the government had adopted "minimum credible deterrence as the guide to [its] nuclear program."⁷

Planning for how and under what circumstances Pakistan's nuclear weapons would be employed has been only broadly outlined over the years. As early as December 1974, Prime Minister Zulfikar Ali Bhutto declared for the first time the basic principle of Pakistan's nuclear weapons use policy. He stated: "Ultimately, if our backs are to the wall and we have absolutely no option, in that event, this decision about going nuclear will have to be taken."⁸

Three decades later, at the peak of the 2002 crisis, when Indian and Pakistani forces were deployed against each other in a military standoff unprecedented in duration and intensity, President Pervez Musharraf repeated Bhutto's policy formulation. Musharraf stated in an interview published in April 2002 in the German magazine, *Der Spiegel*: "Nuclear weapons are the last resort. I am optimistic and confident that we can defend ourselves with conventional means, even though the Indians are buying up the most modern weapons in a megalomaniac frenzy." Nuclear weapons could be used, Musharraf said. "If Pakistan is threatened with extinction, then the pressure of our countrymen would be so big that this option, too, would have to be considered." In a crisis, he said, nuclear weapons also have to be part of the calculation.⁹

In a rare departure from established procedure, Lieutenant General Khalid Kidwai selectively removed some of the traditional ambiguity over the

circumstances in which Pakistani defense planners have thought about the employment of nuclear weapons. As the military crisis deepened with India in January 2002, Kidwai told a pair of Italian physicists that Pakistani nuclear weapons would be used only “if the very existence of Pakistan as a state is at stake.” Kidwai elaborated: “Nuclear weapons are aimed solely at India. In case that deterrence fails, they will be used if:

- a. India attacks Pakistan and conquers a large part of its territory (space threshold);
- b. India destroys a large part either of its land or air forces (military threshold);
- c. India proceeds to the economic strangling of Pakistan (economic strangling);
- d. India pushes Pakistan into political destabilization or creates a large-scale internal subversion in Pakistan (domestic destabilization).”¹⁰

The last two elements of the four nuclear use triggers are fuzzy and should not be considered in isolation. They are offshoots or preludes to a conventional war that India might undertake. In this respect, “economic strangulation” chiefly implies an Indian naval blockade or possibly also the placement of Indian dams on rivers flowing from Kashmir that could be used either to dry up or flood Pakistan’s Punjab plains, depending on how India’s military operations were to unfold. Similarly, “ethnic conflict” is a redline peculiar to South Asia. In Pakistan, this is seen as a threat to national survival reminiscent of India’s assistance to the *Mukti Bahini* guerrillas that led to the breakdown of Pakistan’s control over East Pakistan in 1971 and subsequently resulted in the creation of Bangladesh. Pakistani apprehension over Indian-abetted ethnic conflict also derives

from memories of Indian machinations in Pakistan's Sindh province in the 1980s, which were believed to have been conducted as a quid pro quo for Pakistan's alleged support to the Sikh insurgency in Indian Punjab. This concern is exacerbated today by Pakistani allegations of Indian complicity (via Afghanistan) in the ongoing ethnic crises in the two states of Pakistan that border Afghanistan: Baluchistan and the Northwest Frontier Province. Pakistan is unlikely to bring nuclear weapons directly into play in such a scenario (though a naval blockade is an act of war), as they could not play any credible role in resolving the crisis. But any conventional force posturing in conjunction with this will certainly up the ante.

Pakistan's official position is that the main function of its nuclear arsenal is to prevent India from destroying or otherwise overwhelming the country. However, the precise Indian actions that are interpreted as posing an existential threat have not been articulated. Kidwai's four existential threats for possible use are credible, but also vague. The statement was almost certainly intended to be imprecise so as to enhance Pakistani deterrence. If Pakistan were more explicit about nuclear red lines, this might enable India to adjust the scope of its strategic plans and military operations accordingly. By not specifying the precise Indian actions that would trigger Pakistan's use of nuclear weapons, Pakistani defense planners hope to create uncertainty in the minds of Indian policymakers as to how far they can press Pakistan on the battlefield.

The second objective of Pakistan's nuclear weapons policy is to deter an overwhelming Indian conventional military attack against Pakistan's armed forces. Islamabad considers that India's advantages in geography and nearly all categories of conventional

military capability make nuclear force indispensable for Pakistan's defense. Pakistani military officials believe that clearly communicated resolve to use nuclear weapons and a robust conventional military posture are the key requirements for effective deterrence. In their view, one would not work without the other. According to this logic, if India attacks, Pakistan would counterattack with conventional forces; each side would inflict significant damage on the other; and India would be forced to refrain from escalating the conflict out of a fear of Pakistan's nuclear response.

The conviction that nuclear force is required to augment Pakistan's conventional military deterrence of a possible Indian conventional attack is reinforced by the common perception among Pakistani elites that Pakistan successfully deterred attacks by India on at least six occasions – during the military crises of 1984-85, 1986-87, 1990, 1998, 1999, and 2001-2002.¹¹ This interpretation gained even more credibility in light of President Musharraf's December 2002 statement that war with India was averted because of his repeated warnings that if Indian forces crossed the border, Pakistan would not restrict its response to conventional warfare.¹² Despite the fact that war was only narrowly averted in 2002, Pakistani military planners now appear to have even greater confidence in their ability to manage the risks of strategic deterrence.

The Pakistani government's approach to employing nuclear weapons thus rests on a calculation of its vulnerability to India's conventional and nuclear forces, and even to India's possible use of nonmilitary instruments to threaten Pakistan's territorial integrity, political stability, and economic viability (as per Kidwai's reference to economic strangling and domestic destabilization). Armed with few viable defense

options apart from its expanding nuclear arsenal, and ever concerned about such wide-ranging threats, Pakistan is likely to continue to embrace a flexible and nonspecified doctrine for using nuclear weapons.

If at all possible, Pakistan does not intend to fight India with nuclear weapons. Pakistani civilian and military policymakers recognize that their government and perhaps even their country are not likely to survive a nuclear exchange with India. But operational military plans must include all contingencies. Pakistan's targeting policy probably includes a mix of countervalue and counterforce targets. At present, Pakistan has nuclear-capable F-16 and *Mirage 5* aircraft, which have limited range and penetration capability. Pakistani ballistic missiles, both liquid and solid fuel, can reach key strategic points in India. Cruise missiles also have been tested and gradually will be integrated into operational plans. Pakistan's strategic development strategy includes continuous research experiments and flight-tests to improve the accuracy and penetrability of existing nuclear delivery systems. Pakistan's nuclear use doctrine probably calls for holding multiple Indian industrial centers, military-industrial complexes, defense facilities, and military bases and formations at risk. Should India push Pakistan to the brink—whether by attacking, occupying, destroying, or strangling—Pakistan's NCA could very well decide to use nuclear weapons.

Nuclear Weapons Stockpile and Delivery Systems.

Pakistan's nuclear force requirement is a tightly held national secret. Islamabad's stated goal is to maintain a credible minimum deterrent, defined primarily around Pakistan's assessment of India's nuclear force

inventory, penetrability and targeting requirements, and unspecified future adversaries and contingencies. In addition, Pakistani decisionmaking for its strategic force structure is based on the requirements of survivability, which include a sufficiently large weapons stockpile to ensure dispersal to multiple launch sites and a second-strike capability. A key strategic consideration thus is the maintenance of "sufficient" fissile stock material as well as the creation and operation of fissile material production facilities with adequate capacity to meet both short-term and long-term requirements.

According to public estimates of Pakistan's fissile material stockpile at the end of 2006, Islamabad probably had amassed between 30 and 85 kilograms of weapons-grade plutonium from its Khushab research reactor and between 1,300 and 1,700 kilograms of weapons-grade highly enriched uranium (HEU) from the Kahuta gas centrifuge facility. The Khushab reactor probably can produce between 10 and 15 kilograms of plutonium per year. Kahuta may be able to produce 100 kilograms of HEU each year. Assuming that Pakistani scientists require 5 to 7 kilograms of plutonium to make one warhead and 20 to 25 kilograms of HEU to produce a bomb, then Pakistan would have accumulated enough fissile material to be able to manufacture between 70 and 115 nuclear weapons by the end of 2006.¹³ A medium estimate based on these figures would mean that Pakistan could have an arsenal of about 90 weapons, as indicated in Table 1.

Pakistani Fissile Material & Nuclear Weapons (end of 2006)			
	Low	Medium	High
Weapon-Grade Plutonium (kg)	30	55	85
Weapon-Grade Uranium (kg)	1300	1,500	1,700
Weapon Capability	70	90	115

Table 1. Pakistani Fissile Material and Nuclear Weapons.

In Pakistan’s normal peacetime force posture, nuclear weapons are believed not to be deployed. That is, they are not mated with their delivery systems. Nuclear warheads and missile delivery systems probably are stored in secure locations that are separate from one another—but not too far apart. Delivery aircraft, of course, are located at one or more of the country’s 10 major air bases or 10 forward operating air bases. In the past 5 years, Pakistan has started to set up strategic forces in all three services, two of which (land and air), are presently functional.

Pakistan relies on a combination of aircraft and ballistic missiles for nuclear delivery missions. Two aircraft in its inventory, the U.S.-supplied F-16 *Fighting Falcon* multirole fighter and the French *Mirage 5PA*, are particularly well-suited to this role. At present, Pakistan has about 50 *Mirage 5s* and 35 1980s-vintage F-16s, although at the end of 2006, the United States agreed to provide mid-life upgrades for Pakistan’s existing F-16s and to transfer another 18 models to the Pakistan Air Force.¹⁴

With nonproliferation sanctions severely curtailing Pakistan’s ability to modernize its air force during the

1990s, Islamabad went on a major campaign to procure technology and parts for a variety of ballistic missiles for nuclear delivery roles. Today, Pakistan possesses a missile force comprising road and rail mobile solid-fuel missiles (*Abdali*, *Ghaznavi*, *Shaheen 1* and *2*), as its mainstay, and the less accurate liquid-fuel missiles (*Ghauri 1* and *2*) for long-range strikes against deep population centers in India. Pakistan is also working on a ground-launched cruise missile (GLCM), called the *Babur*, which was tested first in August 2005 and again in March 2006. Table 2 lists the main air and missile delivery systems in Pakistan's inventory.

Aircraft / Missile	Range	Source	Status
F-16 A/B	925 km	United States	35 planes in inventory
Mirage 5 PA	1,300 km	France	50 planes in inventory
Haf 1	80—100 km	Indigenous	In service since mid-1990s
Haf 2 (Abdali)	180 km	Indigenous/China	Tested in May 2002, in service
Haf 3 (Ghaznavi)	300 km	Indigenous/China	M-11, tested May 2002, in service
Haf 4 (Shaheen 1)	600—800 km	Indigenous /China	First tested October 2002, in service
Haf 5 (Ghauri 1)	1,300—1,500 km	Indigenous/DPRK	No Dong, tested May 2002, in service
Haf 5 (Ghauri 2)	2,000 km	Indigenous/DPRK	No Dong, tested April 2002, in development
Haf 6 (Shaheen 2)	2,000—2,500 km	Indigenous/China	First tested March 2004, in development
Haf 7 (Babur)	500 km GLCM	Indigenous/China?	First tested August 2005, in development

Table 2. Pakistani Nuclear Delivery Systems.¹⁵

Survivable Strategic Force.

Since the advent of Pakistan's nuclear program, Pakistani officials have worried about preventative strikes against their nuclear production facilities and later against their concealed weapons arsenal. Concerns about the survivability of the nuclear program arose in the mid and late 1970s, when (following India's first nuclear explosive test in May 1974) the U.S. Government aggressively blocked Pakistan's attempt to acquire nuclear technology from Europe. Pakistanis believed that Washington established the Nuclear Suppliers Group (NSG) primarily to prevent them from going nuclear; meanwhile India's nuclear status was accepted after the minor opprobrium it received following its surprise nuclear detonation. Even today, Pakistanis cite as evidence of international discrimination against their nuclear effort the visit to Islamabad by U.S. Secretary of State Henry Kissinger in August 1976 to pressure President Zulfikar Ali Bhutto to abandon the nuclear bomb development program, which was then at a very early stage. Kissinger offered 110 A-7 attack aircraft as compensation to reverse Pakistan's nuclear ambitions. Although Kissinger evidently did not issue a direct threat, to this date the Pakistani narrative consistently has maintained that Bhutto was threatened with severe consequences if he did not change the country's nuclear policy.¹⁶

Three years later, after U.S. President Jimmy Carter levied nuclear nonproliferation sanctions against Islamabad, Pakistani officials feared that the United States might conduct sabotage or air strikes against Pakistan's uranium enrichment plant at Kahuta. In response, Pakistan tightened perimeter security and air defenses around the sensitive fissile material

production facility. These fears were rekindled after Israel's successful attacks on Iraq's Osirak nuclear reactor in June 1981. Reportedly, in the same month, the Indian air force established contingency plans for attacking Kahuta, which the Indian government consistently has denied.¹⁷

Alarm bells sounded once again in the mid-1980s over the prospect of Indian air attacks against Kahuta. Islamabad's threat perceptions escalated in the summer of 1984 when the Indian army mounted military operations inside the sacred Golden Temple in Amritsar to suppress the Sikh crisis in Indian Punjab and also occupied the contested Siachen Glacier in the same month. A few years later, during the 1986-87 Brasstacks military crisis, Pakistani fears of a preventive strike against Kahuta triggered even more serious concerns. By then, sufficient evidence had convinced the Pakistan leadership that Indian Army Chief General Sundarji was planning a preventive war against Pakistan in the shadow of military exercises along the border with the ultimate objectives of neutralizing Pakistan's alleged support for the Sikh separation movement and dismantling Pakistan's nuclear weapons program.¹⁸ This crisis, which led to the partial mobilization of troops on both sides of the border, finally subsided after President Zia ul-Haq met with Prime Minister Rajiv Gandhi at a cricket match in Jaipur, India.

During the Kashmir uprising in the early 1990s, Pakistani policymakers once again became concerned about the security of their nuclear facilities, this time suspecting a joint Israeli-Indian preventive military attack. On this occasion, the Pakistani leadership of President Ghulam Ishaq Khan, Prime Minister Benazir Bhutto, and Army Chief General Aslam Beg decided

to convey a clear threat to India that Pakistan would attack India's key nuclear facilities outside of Bombay (the Bhabha Atomic Research Center and the Tarapur power reactors) if Kahuta were struck. Soon thereafter, the military crisis ended, although the violence in Kashmir persisted for well over a decade. Partly as a consequence of Pakistan's nuclear policy reorientation during the 1990 crisis, the U.S. Government invoked nonproliferation sanctions under the Pressler Amendment, which terminated all arms transfers and nearly all economic assistance to Pakistan throughout the decade of the 1990s.

Immediately after India conducted its surprise nuclear tests on May 11 and 13, 1998, Pakistani policymakers became concerned about the possibility of an Indian or joint Indian-Israeli attack on Pakistan's nuclear production and storage facilities and its test site in Baluchistan. This threat perception was stimulated on a general level by the aggressive rhetoric of the new ruling party in India, the Bharatiya Janata Party (BJP), and more specifically by Pakistani intelligence reports of at least one Israeli aircraft that was observed operating on Indian territory during the period when Pakistan was preparing for its own nuclear test series.

According to Pakistani defense analyst, Hasan-Askari Rizvi, "two intelligence reports appeared that caused much panic among Pakistan's policymakers. First, intelligence service and Army authorities reported the sighting of an unidentified F-16 aircraft in Pakistan's airspace on May 27 (it should be noted here that India does not have F-16 aircraft; Pakistani military authorities were suggesting the presence of an Israeli aircraft in the area). The country's *Ghauri* missiles were deployed that same day. The second report came shortly after midnight of May 27-28. The Pakistani military was

put on maximum alert when the country's intelligence agencies reported an unusual movement of aircraft in India just across the border, hinting at a possible preventive air strike against nuclear installations. The Pakistani press began to talk about the possibility of an Indian air strike on Pakistan's nuclear installations a couple of days before the security alert."¹⁹ Ultimately, nothing came of these reports – except for the Pakistan government's rush to demonstrate its nuclear weapons capability before something came up to prevent it from doing so.

A few years later, in the immediate aftermath of the 9/11 terrorist attacks against the United States, Washington's urgent response to take down al-Qaeda and the Taliban regime in Afghanistan created new worries in Islamabad about preventive strikes against Pakistan's nuclear arsenal. In a statement to the nation announcing Pakistan's full cooperation with the U.S. war on terrorism and its sudden withdrawal of support for the Taliban, President Musharraf cited the protection of the country's strategic assets as one of the main reasons for this policy reversal. As Musharraf has written in his memoir,

The security of our strategic assets would be jeopardized. We did not want to lose or damage the military parity that we had achieved with India by becoming a nuclear weapons state. It is no secret that the United States has never been comfortable with a Muslim country acquiring nuclear weapons, and the Americans undoubtedly would have taken the opportunity of an invasion to destroy such weapons. And India, needless to say, would have loved to assist the United States to the hilt.²⁰

U.S. and Indian reactions to the events of 9-11 put Pakistan in a very precarious position in which its

strategic assets and undoubtedly its overall sovereign integrity would have been threatened if it did not immediately and completely reverse its position toward the Taliban—even though sacrificing the Taliban out of geopolitical exigencies created enormous domestic problems for the Musharraf government, and still complicates its ability to rule in the northwestern part of the country.²¹

Fears of an Indian attack against Pakistan's nuclear assets resurfaced once again during the military standoff with India following the December 13, 2001, terrorist attack against the Indian parliament building. This time, however, Pakistan mobilized its conventional forces and went into full operational alert. Nuclear weapons reportedly already had been dispersed after the post-9/11 crisis; but although the entire national security apparatus was placed on high alert, there were no reports of Pakistan mating nuclear weapons to delivery systems during this 2001-02 military standoff.

Since the 1998 tests, various pronouncements, publications in the Western press, and events in the region, have eroded the credibility of Pakistan's nuclear command and control, overshadowing the efforts that have been made since 1999 to harness a coherent command system to ensure management of its nuclear capabilities. The revelation of A. Q. Khan's reckless secondary proliferation activities and information that two Pakistani atomic scientists met members of al-Qaeda in Afghanistan created further concerns over Pakistan's nuclear security. Also, U.S. intelligence reportedly believed that Pakistan readied its nuclear arsenals to threaten India during the Kargil conflict. These actions have created an overall impression of an irresponsible nuclear power.²²

Pakistani officials admit that many mistakes had been made which allowed the A. Q. Khan saga to take place. But continuing criticism of its nuclear custodianship within Western government and think tank circles feeds Pakistani fears of being targeted and labeled as an irresponsible state, not primarily due to its nuclear policy and custody shortcomings, which it believes it has corrected, but more as a conspiracy to keep the Pakistani nuclear program on the defensive. This “conspiracy” is viewed in Islamabad as an attempt to establish the grounds for rollback of its nuclear weapons program, harkening back to the U.S. position from the 1970s through the mid-1990s. These fears are further reinforced with Washington’s renewed global partnership with India, making Pakistan’s nuclear weapons arsenal an exceptionally – perhaps even uniquely – “illegitimate” capability.

Today, the expanding U.S.-India strategic partnership, which goes well beyond the civilian nuclear cooperation deal, has rekindled concerns about a possible Indian preventive military attack, this time perhaps in collaboration with the United States. In response to the U.S.-India announcement of civilian nuclear cooperation during President George Bush’s visit to India in March 2006, Pakistan’s NCA publicly resolved that any deal that would shift the nuclear balance in South Asia would force Pakistan to reevaluate its minimum nuclear deterrence requirements. One effect of Pakistan’s decades-old fears of preventive strikes against its nuclear complex has been a very high priority placed on the survivability of all nuclear production facilities, weapons and missile storage complexes, and potential launch facilities. Because of operational security concerns, no details have been revealed about the measures taken to ensure

survivability, but presumably they involve an emphasis on mobile systems; camouflage; hardened and deeply buried facilities; and strict compartmentalization of information about the plans, locations, and standard operating procedures governing the movement, deployment, and possible employment of strategic forces.

Responsive Strategic Command and Control System.

President Pervez Musharraf announced the formal creation of Pakistan's NCA on February 2, 2000. Prior to this announcement, a de facto nuclear command and control arrangement existed as part of the national military command structure, which had provided—and continues to provide—guidance over conventional military operations. The new NCA operates much like the structure that preceded it, although its membership is more formally (and publicly) articulated, and at least one dedicated communications system reportedly has been created to enable the NCA to issue guidance to operational strategic forces during serious military crises and war.

The secretariat of the NCA is the Strategic Plans Division (SPD), located at the Joint Services Headquarters. SPD supports each of the two main elements of the NCA. The apex body is the Employment Control Committee (ECC), a senior leadership group comprising both military and civilian policymakers. This decisionmaking group provides policy direction and is the authority over strategic forces. This body is chaired by the President and also includes the Prime Minister (who is Vice Chairman), Foreign Minister (Deputy Chair), Ministers for Defense, Interior, and

Finance, the three service chiefs, the chairman of the Joint Chiefs of Staff Committee (JCSC), and of course the Director General of SPD (who serves as the organization's secretary). The Finance Minister was not on the original ECC approved by Prime Minister Nawaz Sharif. He was added shortly after Musharraf assumed control of the government in October 1999.

The membership of the ECC has undergone some change even after the Pakistan Government announced it publicly in February 2000. When Musharraf first talked openly about the NCA, he was then Chief Executive of the country and indicated that the chair of the NCA would be the head of the government. Then after the October 2002 elections, when Zafarullah Khan Jamali became Prime Minister, Musharraf announced that the chair of the NCA would become the President, a post he then occupied, and that the vice-chair would be the Prime Minister.

The subordinate body of the NCA is the Developmental Control Committee (DCC), which is comprised of military and scientific elements and is tasked to optimize the technical and financial efficiency of the entire program to implement the strategic force goals set by the Employment Control Committee. This group is also chaired by the President and includes the Prime Minister (Vice Chairman), the chairman of the Joint Chiefs of Staff Committee (Deputy Chair), the three service chiefs, the heads of the concerned strategic-scientific organizations, and the Director General of SPD (Secretary). In practice, the DCC is chaired by the DG-SPD, and the operational directors of each of the military services attend in place of the service chiefs.

The organizational diagram of the NCA appears in Figure 1.

National Command Authority

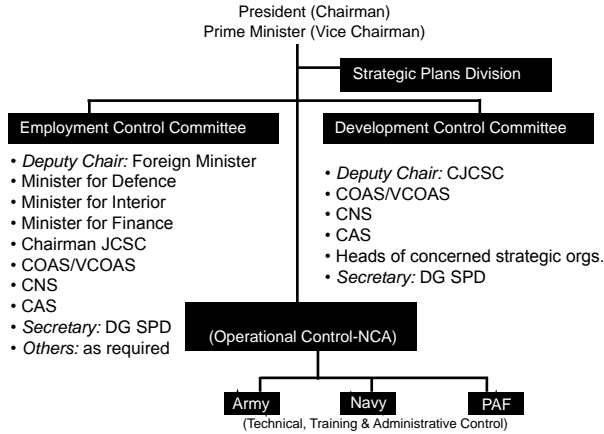


Figure 1. Pakistan National Command Authority.

The A.Q. Khan crisis has galvanized the Pakistani command and control system in ways Pakistani policymakers could not have predicted. In this instance, it was indeed true that a crisis contained both grave danger and tremendous opportunity. Out of a strange combination of necessity and desire, the military moved very quickly to tighten its grip on all of the country's strategic and scientific organizations in a professional manner—bringing about more coherence among the military planners, operators, and scientific bodies. Meanwhile, the three armed services continue to build and train strategic forces with a great deal of secrecy and compartmentalization. However, Pakistan has continued with the same personnel under the leadership of SPD Director General, Lieutenant General Khalid Kidwai, who remains the focal point of all nuclear matters in Pakistan.

Since the A. Q. Khan affair, the SPD has gone to great lengths to improve the country's command and control infrastructure. One of the greatest flaws in

the system was the lack of formal oversight over the strategic scientific organizations. The security setup arranged since the beginning of the program was designed to protect it from outside interference, spying, and physical threats (including sabotage). There was no formal reporting channel of the security apparatus that could have the ability to account for shipments (in and out), personal travels, etc. Also, there was no formalized procedure of nuclear material protection, control, and accounting (MPC&A).²³ The nuclear security and safety aspect was always believed to be a highly classified national secret because it revealed the capacity and capability of the country. This was a fatal flaw in the system, which SPD had grappled with since its formation.²⁴

SPD placed particular emphasis on enhancement of its security division. Lieutenant General Kidwai appointed a dedicated two-star general to head this vital part of the organization and expanded it to include approximately 8,000 military personnel. A separate security directorate for counterintelligence was formulated, headed by a one-star brigadier general. This organization essentially coordinates with all intelligence agencies about any external threats. The Inter-Services Intelligence Directorate (ISID) forms the outermost ring of security and works closely with the security division. Prior to this, there was no formal role for the ISID in nuclear matters. Even now, the ISID director general is not a formal member of the NCA. (Reportedly, he is a regularly invited member.) Since the whole SPD organization falls under the Joint Services Headquarters, the overall responsibility of nuclear safety and security rests with the Chairman of the Joint Chief of Staff Committee. The chairman represents the highest level of joint military integration

for national security intelligence and articulation of the nuclear command authority. See Figure 2 for an organizational diagram of SPD.



Figure 2. Strategic Plans Division.

IMPACT OF U.S.-INDIA STRATEGIC COOPERATION ON PAKISTAN

The growing strategic cooperation between the United States and India has caused some consternation in Islamabad, even though Pakistani policymakers have not made a public hue and cry over the issue. Three potential implications of expanded nuclear and defense cooperation between Washington and New Delhi are particularly troubling—not as immediate concerns, but more as long-term threats that need to be monitored and countered.

1. **India may be able to out race Pakistan by rapidly expanding its production of fissile material.**

The most widely discussed implication for Pakistani security of the U.S.-India civil nuclear cooperation accord is the potential it provides for India to divert more of its indigenously produced nuclear fuel to the weapons program because of the likely boost in international supplies of fuel for India's civil nuclear power program. Both the Indian government and the Bush administration deny that this will be the case. For example, U.S. Under Secretary of State Nicholas Burns told reporters on March 2, 2006, that the agreement would not have an impact on India's strategic program.²⁵ However, Pakistanis may believe that unless India stops production of fissile material for weapons purposes—which it shows no interest in doing—nuclear safeguards will do little to ensure that outside assistance is not diverted.

The problem as viewed in Islamabad is exacerbated by the tendency of Pakistan's military and political leaders to view everything related to India in zero-sum terms—a particularly dangerous state of affairs considering India's growing economic and military might and its significantly enhanced political capital in the United States, Europe, China, and elsewhere. Pakistani defense planners have shown little willingness to accommodate India's growing regional preeminence. They say that what is required are firm assurances that India will respect Pakistan's independence and territorial integrity—or, to put it more colorfully, to prevent the transformation of Pakistan into a weak, subservient "West Bangladesh." However, the main "dilemma" of Pakistan's security predicament is that no Pakistani leader has ever been able to articulate what kind of assurances are required of India to reassure Pakistan that India accepts its existence as a permanent nation-state.

Although Indian government officials deny that they have any interest in significantly expanding their fissile material production capabilities, because of Pakistan's intense insecurity complex, there is a tendency in Islamabad to listen to and accept as true the aggressive and sometimes hegemonic claims of India's defense hawks such as Brahma Chellaney and Bharat Karnad – the latter of whom has been a particularly vocal critic of India's minimum deterrent posture, arguing for a force of at least four fleet ballistic missile submarines (SSBNs) armed with 48 sea launched ballistic missiles (SLBMs), 25 nuclear-armed intercontinental ballistic missiles (ICBMs), 40 nuclear intermediate range ballistic missiles (IRBMs), and 70 manned nuclear-delivery aircraft, all to be complemented by another 70 nuclear-equipped air-to-surface missiles and 25 demolition munitions.²⁶ While all objective evidence would suggest that the Indian government does not pay very close attention to Chellaney, Karnad, and other hawks, at least on the issue of nuclear force levels, inside the Pakistani strategic community these views are taken as a rough blueprint for India's force development. In the absence of reliable intelligence on many crucial strategic matters, worst-case analysis usually guides policymaking.

Compounding the problem is the tendency of Pakistani military officials to also pay close attention to the debate in the United States over strategic matters in South Asia. The incredible publicity over the U.S.-India initiative for civilian nuclear cooperation has provided an abundance of grist for the worst-case analysis mill in Islamabad and Rawalpindi. In 2006, for example, Robert Einhorn has stated, "the deal appears to give India complete freedom not just to continue but to expand its production of fissile material for

nuclear weapons.” Joe Cirincione has been even more blunt: “President Bush has now given away the store. He did everything but actually sell nuclear weapons to India.” Cirincione added: “If the deal stands, India will use foreign fuel for its power reactors, freeing up Indian uranium for its military reactors. India will be able to double or triple the number of weapons it can make annually. They could go from the 6-10 they can currently produce to 30 a year.”²⁷

Regardless if this prediction is merited or not, Pakistani strategic planners almost certainly put a great deal of stock in this calculation when they reviewed the implications of the U.S.-India nuclear deal for their own strategic requirements in a combined NCA meeting on April 12, 2006. During this meeting, Pakistan’s strategic leadership probably concluded that Pakistan’s own fissile material production plan required some adjustment—possibly to include the acquisition of an additional fissile material production facility to compensate for India’s presumed expansion of fissile material production. Recent public reports about the expansion of Pakistan’s plutonium production and reprocessing capabilities, if true, would seem to be further evidence of this development.²⁸

2. India may be able to identify and target Pakistan’s strategic assets with its enhanced intelligence, surveillance, and reconnaissance (ISR) capabilities and it may be able to reach and destroy Pakistani strategic assets using its improved precision-strike aircraft and missile capabilities. As discussed above, Pakistani defense planners have long been concerned about the survivability of their nuclear weapons production facilities and weapons arsenal. Although there were many scares about possible Indian preventive strikes—either alone or in combination

with some outside power – Pakistani officials probably recognized that India’s ability to locate key strategic targets and then mount precision attacks against them was relatively limited. India simply did not possess either the intelligence, surveillance, and reconnaissance systems or precision strike capabilities to perform this kind of mission with a high confidence of success. However, because of India’s expanding international defense relationships, especially with the United States, this situation is changing.

India is placing a real priority on developing and acquiring foreign weapons systems to deter aggressive actions from both China and Pakistan. To improve its intelligence, surveillance, and reconnaissance (ISR) capabilities, India has purchased or is in negotiation for the *Phalcon* Airborne Warning and Control System (AWACS), surveillance radars, weapon locating radars, maritime surveillance aircraft, unmanned aerial vehicles (UAVs), and satellites. In the area of precision strike, India’s priorities have been on acquiring the new models of the Su-30MKI and *Mirage* 2000-5 aircraft, upgrading the *Jaguar* and the MiG-27 jets, acquiring and developing anti-tank guided-weapons systems, guided artillery weapons, multipurpose guided weapons, and the *Rafael* listening targeting pod.²⁹

The ISR and precision strike systems mentioned above are expected to provide India with the ability to dissuade and deter its potential attackers by helping achieve a military edge over Pakistan and by helping bridge a quality gap between the Chinese military and the Indian military. The modern technology is expected to improve the ability of the Indian armed forces to survey potential threats to Indian security and to respond to them in a timely and effective manner. The ISR systems will provide an improved

capability to detect and track enemy infiltration, and will also provide improved queuing for patrolling assets to engage the enemy. Having precision strike capability will then allow Indian forces to effectively engage and neutralize the enemy with a high degree of success. Having an improved ISR, precision strike, and missile defense capability is expected to dissuade and deter a potential enemy by ensuring its detection and punishment, and a successful defense against a missile attack is expected to deter the enemy from launching an attack in the first place.

This pattern of arms acquisition by India has been a serious concern for Pakistan. Predictably, Islamabad is likely to view India's recent modernization efforts as a significant threat to its security. India's military modernization program has led to a growing disparity between the Indian and Pakistani conventional military capabilities. A particularly grave concern is that if India pursues its policy to achieve technical superiority in ISR and precision targeting, this will provide India the capability to effectively locate and efficiently destroy strategically important targets in Pakistan. India's new-found ISR capability, through its acquisition of the *Phalcon* AWACS, will provide India with the ability to locate targets deep inside Pakistan's territory, and direct India's superior aircraft, such as the Su-30 and the *Mirage* 2000-5, with their air-to-air and precision strike capabilities, onto those targets. Possessing advanced precision strike capability will ensure high probability of kill, and put Pakistan at a significant disadvantage. The result of this growing divergence in the two states' conventional capabilities will be either a regional arms race—as Pakistan desperately attempts to keep pace with India so as to deter a preventive strike from India—and/or a lowering of the nuclear threshold for

Pakistan—if it fails to keep up the conventional arms race with an economically powerful India and therefore needs to rely on its nuclear arsenal for a deterrent.

How this issue will play out in the coming years remains to be seen, but suffice it to say that Pakistani defense planners have considerable cause for concern as they project the evolving security environment over the next 1 to 2 decades. This concern is not particularly evident from the rhetoric of the government. For example, President Musharraf remarked in December 2006:

If we look at the unconventional mode then Pakistan is a nuclear power. We have tested our whole missile power, and the security and safety of our missile system is that much strong that if any nuclear attack is done on Pakistan, it will not be affected. So I am sure that there is no threat against Pakistan and the Pakistani nation is fully prepared to face any threat.³⁰

Despite the positive spin, it seems likely that Pakistani officials are growing increasingly concerned about the long-term survivability of their strategic deterrent owing to India's improving ISR and precision-strike capabilities.

3. The U.S. Government, which seemingly places more value on its strategic, economic, and political relations with India than with Pakistan, may be more inclined to side with India in future regional disputes, continuing a trend that began with the Kargil conflict in the summer of 1999. The final implication of the expanding U.S. strategic relationship with India for Pakistan's security is the most difficult to define with any precision. It is a more general apprehension held by many Pakistani defense decisionmakers that Washington's views on South Asian affairs increasingly

will be shaped by India's perceptions and arguments, rather than by a cool, objective determination by U.S. policymakers.

The Pakistani commentators who have expressed this concern have pointed to different causal dynamics. These range from the benign – a shift in U.S. perceptions that could result from the greater degree of Indian inputs coming into the U.S. system due to the heightened strategic interaction between U.S. and Indian policymakers and military officers – to the sinister – the possible tendency of U.S. officials to take a pro-Indian line because of the growing economic interaction between the two countries and the much higher money and rewards at stake than ever was the case in South Asia.

No matter what the driving force is – or is thought to be – and notwithstanding Washington's repeated reminders that the U.S. strategic relationship with Pakistan continues to be of vital importance to U.S. security interests, Pakistan's concern about becoming strategically isolated – as it was in the late 1970s and throughout the 1990s – is likely to intensify as the U.S.-India strategic relationship continues to grow. How this plays out in Islamabad's general foreign policy orientation and in its strategic policies remains to be seen.

ENDNOTES - CHAPTER 5

1. Zafar Iqbal Cheema, "Pakistan's Nuclear Use Doctrine and Command and Control," in *Planning the Unthinkable: How New Powers Will Use Nuclear, Biological, and Chemical Weapons*, Ithaca, NY: Cornell University Press, 2000, p. 159.

2. Pervez Musharraf, *In the Line of Fire*, New York: Free Press, 2006, p. 301.

3. Personal conversations with senior Pakistani military officers.

4. This is an intuitive element of Pakistan's strategic culture, but it conforms to the findings of much theoretical research by Thomas Schelling and other scholars on the nature of strategic interaction between nuclear-armed powers during military crises.

5. See "National Command Authority Established," Associated Press of Pakistan, February 3, 2000, available at www.fas.org/news/pakistan/2000/000203-pak-app1.htm.

6. See Paolo Cotta-Ramusino and Maurizio Martellini, "Nuclear Safety, Nuclear Stability and Nuclear Strategy in Pakistan," *Concise Report of a Visit by Landau Network-Centro Volta*, January 21, 2002, lxmi.mi.infn.it/~landnet. Kidwai reiterated this point in a October 27, 2007, address to the Center for Contemporary Conflict at the Naval Postgraduate School in Monterey, California. For a summary of the talk, see www.ccc.nps.navy.mil/news/kidwaiNov06.asp.

7. Pakistani Foreign Minister Abdul Sattar, keynote address at Carnegie International Non-proliferation conference, June 18, 2001, www.ceip.org/files/projects/npp/resources/Conference%202001/sattar.htm.

8. Reported in *The Pakistan Times*, December 27, 1974, p. 1.

9. Roger Boyes, "Musharraf Warns India He May Use Nuclear Weapons," *Times Online*, April 8, 2002, available at www.nci.org/02/04f/08-06.htm.

10. Pakistani military officials subsequently informed the authors of the Landau report that General Kidwai's remarks on what would trigger a Pakistani nuclear reaction were "purely academic." The officials stated:

These are matters which as elsewhere, are primarily the responsibility of the political leadership of the day.

. . . The elaborate command and control mechanisms introduced with the establishment of the National Command Authority which is Chaired by the Head of State and assisted by political and civilian leaders . . . ensure the highest level of responsibility and due deliberation on all matters of strategic importance.

See Cotta-Ramusino and Martellini.

11. Agha Shahi, Zulfiqar Ali Khan, and Abdul Sattar, "Securing Nuclear Peace," *The News International*, October 5, 1999; "Are Pakistani Nukes More Effective Than Indian?" *Daily Times*, Lahore, www.dailytimes.com.pk/default.asp?page=story_13-12-2002_pg1_11.

12. Musharraf did not specify the nuclear threat in his speech to an army corps reunion in Karachi, but he did state that he was prepared to act decisively at the height of the 2002 crisis: "In my meetings with various world leaders, I conveyed my personal message to Indian Prime Minister Vajpayee that the moment Indian forces cross the Line of Control and the international border, then they should not expect a conventional war from Pakistan. I believe my message was effectively conveyed to Mr. Vajpayee." "India Was Warned of Unconventional War," *The News International*, December 31, 2002, available at www.nti.org/d_newswire/issues/2002/12/30/5s.html.

13. Institute for Science and International Security, "Global Stocks of Nuclear Explosive Materials," July 12, 2005, revised September 7, 2005, www.isis-online.org/global_stocks/end2003/tableofcontents.html. A separate study by a team of Indian and Pakistani analysts puts Pakistan's plutonium inventory slightly higher (90 kilograms), and its HEU holding slightly lower (1,300 kilograms). Zia Mian, A. H. Nayyar, R. Rajaraman, and M. V. Ramana, "Fissile Materials in South Asia: The Implications of the U.S.-India Nuclear Deal," *International Panel on Fissile Materials Research Report No. 1*, September 2006, p. 3, www.fissilematerials.org/ipfm/site_down/ipfmresearchreport01.pdf.

14. John Grevatt, "USAF Awards Lockheed Martin Pakistan's F-16 Upgrade," *Jane's Defence Industry*, January 1, 2007.

15. Information contained in the table is from various sources, including "Pakistan: Air Force," *Jane's World Air Forces*, November 28, 2006, and "Pakistan: Armed Forces," *Jane's Sentinel Security Assessment: South Asia*, November 22, 2006, both subscription websites.

16. Dennis Kux, *United States and Pakistan, 1947-2000: Disenchanted Allies*, Washington, DC: Woodrow Wilson Center, 2001, p. 222.

17. Milton R. Benjamin, "India Said to Eye Raid on Pakistan's A-plants," *The Washington Post*, December 20, 1982.

18. Proliferation analyst George Perkovich has written that consideration of an attack on Pakistani nuclear facilities went all the way up to the most senior Indian policymakers in January 1987:

[Prime Minister] Rajiv [Gandhi] now considered the possibility that Pakistan might initiate war with India. In a meeting with a handful of senior bureaucrats and General Sundarji, he contemplated beating Pakistan to the draw by launching a preemptive attack on the Army Reserve South. This also would have included automatically an attack on Pakistan's nuclear facilities to remove the potential for a Pakistani nuclear riposte to India's attack. Relevant government agencies were not asked to contribute analysis or views to the discussion. Sundarji argued that India's cities could be protected from a Pakistani counterattack, perhaps a nuclear one, but, upon being probed, could not say how. One important advisor from the Ministry of Defense argued eloquently that "India and Pakistan have already fought their last war, and there is too much to lose in contemplating another one." This view ultimately prevailed.

George Perkovich, *India's Nuclear Bomb: The Impact on Global Proliferation*, Berkeley, CA: University of California Press, 1999, p. 280. See also Scott D. Sagan and Kenneth N. Waltz, *The Spread of Nuclear Weapons: A Debate Renewed*, New York: W. W. Norton, 2003, pp. 92-95.

19. Hasan-Askari Rizvi, "Pakistan's Nuclear Testing," *Asian Survey*, Vol. 41, No. 6, November-December 2001, pp. 943-955.

20. Musharraf, p. 202.

21. For background, see Khawar Hussain, *Pakistan's Afghanistan Policy*, Master's thesis, Naval Postgraduate School, June 2005, www.ccc.nps.navy.mil/research/theses/Hussain05.pdf.

22. See Scott D. Sagan, "Keeping the Bomb Away from Tehran," *Foreign Affairs*, Vol. 85, No. 5, September-October 2006, pp. 51-54; Strobe Talbott, *Engaging India: Diplomacy Democracy and the Bomb*, Washington DC: The Brookings Institutions Press, 2004, pp. 166-7; and Bruce Riedel, "American Diplomacy and the 1999 Kargil Summit at Blair House," Philadelphia, PA: Center for the Advanced Study of India, University of Pennsylvania, *Policy Paper Series*, 2002.

23. For background, see Nathan E. Busch, *No End in Sight: The Continuing Menace of Nuclear Proliferation*, Lexington, KY: University of Kentucky Press, 2004.

24. For background, see Peter R. Lavoy and Feroz Hassan Khan, "Rogue or Responsible Nuclear Power? Making Sense of Pakistan's Nuclear Practices," *Strategic Insights*, Vol. 3, No. 2, February 2004, www.ccc.nps.navy.mil/si/2004/feb/lavoyFeb04.asp.

25. White House, Office of the Press Secretary, "Press Briefing by Under Secretary of State for Political Affairs Nick Burns," Maurya Sheraton Hotel and Towers, New Delhi, India, March 2, 2006.

26. Bharat Karnad, "A Thermonuclear Deterrent," in *India's Nuclear Deterrent*, Amitabh Matoo, ed., New Delhi: Har-Anand Publications, 1999.

27. Joseph Cirincione, "Oh Canada!" *The Globe and Mail*, March 11, 2006, available at www.carnegieendowment.org/npp/publications/index.cfm?fa=view&id=18116.

28. For example, see David Albright and Paul Brannan, "Chashma Nuclear Site in Pakistan with Possible Reprocessing

Plant," Institute for Science and International Security report, January 18, 2007, www.isis-online.org/publications/southasia/chashma.pdf.

29. *Indian Defense Yearbook 2004*, Lieutenant General R. K. Jasbir Singh, PVSM, ed., Dehra Dun, India: Natraj Publishers, 2004.

30. President Pervez Musharraf, "Address on Birth Anniversary of Quaid-e-Azam at Mazari-Quaid," December 25, 2006, www.presidentofpakistan.gov.pk/Files/Speeches/SpecialDays/117200733854AMPresidents%20Speech%20on%20Dec%2025.pdf.

CHAPTER 6

FISSILE MATERIALS IN SOUTH ASIA AND THE IMPLICATIONS OF THE U.S.-INDIA NUCLEAR DEAL

**Zia Mian, A.H. Nayyar, R. Rajaraman,
and M.V. Ramana**

It is easy to see that in certain circumstances aid given by the [International Atomic Energy] Agency with its full safeguards system in operation could help in accelerating a military programme. Let us assume that the country receiving aid received from the Agency heavy water or fissile material for a reactor for peaceful purposes. If the country concerned already has heavy water or fissile material, the loan of the Agency's heavy water or fissile material to that extent liberates the country's own materials for use in military programmes.

Homi Bhabha,
Founder of the Indian
Nuclear Program, 1964.¹

INTRODUCTION

On July 18, 2005, U.S. President George Bush and Indian Prime Minister Manmohan Singh issued a joint statement in Washington, DC, laying the grounds for the resumption of U.S. and international nuclear trade with India.² This trade has been suspended for about 3 decades because India is neither a signatory to the Nuclear Non-Proliferation Treaty (NPT) nor allows International Atomic Energy Agency (IAEA) safeguards on all its nuclear facilities. The July agreement has generated domestic political debate in the United States and India, and concern on the part

of a number of other countries.³ Among the issues is the fear that the agreement serves to normalize India's status as a nuclear weapons state and so weakens the NPT and the larger nonproliferation regime. Another important concern is that it may serve to expand India's potential nuclear weapons production capabilities, and thus hinder international efforts to end the production of fissile materials for nuclear weapons.

As part of the July 2005 deal, the Bush Administration offered both to amend U.S. laws and policies on nuclear technology transfer and to seek the necessary exemptions in the international controls on the supply of nuclear fuel and technology managed by the Nuclear Suppliers Group (NSG) of states so as to allow nuclear trade with India. In exchange for the lifting of these restrictions, India's government offered to identify and separate civilian nuclear facilities and programs from its nuclear weapons complex, and volunteer these civilian facilities for IAEA safeguarding. However, the final shape and status of the deal is still unclear since it will require the U.S. Congress to amend existing laws, and a consensus among the NSG countries, both of which may attach conditions that India may not accept.⁴

At the March 2006 summit in New Delhi between President Bush and Prime Minister Singh, it was announced that the Bush administration was satisfied with the proposed Indian plan to separate its program into a civilian and a military component.⁵ The separation plan offers to subject to IAEA safeguards eight Indian power reactors that are either operating or under construction, in addition to the six reactors that are already subject to safeguards because they were purchased from abroad (see Appendix I for a list of India's operating and under construction reactors).

These “civilian” facilities will be put under safeguards “in a phased manner” by 2014 and thereafter will remain open to inspections in perpetuity. India’s remaining eight power reactors, all its research reactors, and the plutonium-fuelled fast breeder reactor program are to be part of the military program. India also offered to shut down by 2010 a reactor supplied by Canada, used for peaceful purposes, but whose plutonium was used in the 1974 nuclear weapon test. India also claimed the right to classify as either civilian or military any future reactors it might build.

The nuclear agreement has elicited great concern from Pakistan, which has demanded from the United States (and been refused) the same deal as is being offered to India.⁶ China has called for any exemptions for international nuclear cooperation and trade agreed to by the NSG to be open to Pakistan as well.⁷ The United States has refused.⁸

Pakistan’s Prime Minister, Shaukat Aziz, observed that “nuclear nonproliferation and strategic stability in South Asia will be possible when the United States fulfills the needs of both Pakistan and India for civil nuclear technology on an equal basis,” and warned that “a selective and discriminatory approach will have serious implications for the security environment in South Asia.”⁹ Pakistan’s National Command Authority (NCA), chaired by President Pervez Musharraf and responsible for its nuclear weapons policy and production, declared that, “In view of the fact the [U.S.-India] agreement would enable India to produce a significant quantity of fissile material and nuclear weapons from unsafeguarded nuclear reactors, the NCA expressed firm resolve that our credible minimum deterrence requirements will be met.”¹⁰ However, at the same time, Pakistani ambassador

to the United States and former Army chief General Jahangir Karamat offered that “if bilaterally, the United States can facilitate a moratorium on fissile material production or on testing; we are very happy to be part of that.”¹¹

Technical issues related to fissile materials that are involved in these concerns about the agreement are discussed.¹² First the estimated fissile material production and stockpiles in South Asia are reviewed. Then the significance of the line India has drawn between its civilian and military facilities for India’s future weapons-useable fissile material production capabilities is assessed.

SOUTH ASIAN NUCLEAR PROGRAMS

India and Pakistan have long-standing nuclear weapons programs that are linked to their civilian nuclear infrastructure. International support was crucial in the development of these complexes in both states. Most of this support followed the 1953 launch of the U.S. Atoms for Peace program, which sought to encourage third world countries to become U.S. allies by offering nuclear technology, but had unfortunate consequences in facilitating proliferation in South Asia and elsewhere.¹³

India.

Established in 1948, India’s Atomic Energy Commission turned to the United Kingdom for the design and enriched uranium fuel for its first nuclear reactor, Apsara. Similarly, the CIRUS reactor was supplied by Canada, while the heavy water used in it came from the United States. India’s first power

reactors at Tarapur and Rawatbhata were supplied by the United States and Canada, respectively. A U.S. design was used for India's first reprocessing plant in Trombay. Some of these technologies and materials contributed to the production and separation of the plutonium used in India's 1974 nuclear weapons test. Due to this test and its subsequent refusal to give up its nuclear weapons and sign the NPT, India has been kept largely outside the system of trade of nuclear technology that has developed over the past 3 decades.

India has over the years built a nuclear power program with 15 reactors (Appendix I) providing today an installed capacity of 3,310 megawatts electric (MWe), which accounts for about 3 percent of India's installed electricity generation capacity. Thirteen of the reactors are Pressurized Heavy Water Reactors (PHWRs), the first two of which were supplied by Canada. The other PHWR reactors are Indian built but largely based on the Canadian design. The latest evolution of the design has increased the capacity from 220 to 540 MWe. The other two power reactors are first-generation Boiling Water Reactors supplied by the United States.

Only the four foreign supplied reactors are currently under IAEA safeguards. Two 1,000 MWe reactors being built by Russia under a 1988 deal will also be safeguarded. These two large reactors will increase India's nuclear capacity by over 50 percent in the next few years.

For decades, India's Department of Atomic Energy (DAE) has pursued an ambitious fast-breeder reactor development program. This involves separating plutonium from the spent fuel produced in natural uranium reactors and using it to fuel fast-neutron breeder reactors, which in turn could be used to produce

U-233 that would eventually serve to fuel heavy-water reactors operating on a Th-U-233 closed fuel cycle.¹⁴ These efforts have made slow progress: The first breeder reactor to be built, the Fast Breeder Test Reactor, was due to become operational in 1976 but started only in 1985 and has been plagued with problems.¹⁵ The 500-MWe Prototype Fast Breeder Reactor is not expected to be completed until 2010, if all goes according to plan. India has also begun work on a prototype plutonium-thorium-uranium-233 fuelled Advanced Heavy Water Reactor (AHWR) to gain experience with the thorium and U-233 fuel cycle.¹⁶

India conducted its first nuclear weapon test in May 1974. There were another five tests in 1998 involving fission weapons and a thermonuclear weapon. There are reports that at least one test used plutonium that was less than weapons grade.¹⁷ India is believed to have a stockpile of perhaps 40-50 nuclear weapons. One report cites plans for 300-400 weapons within a decade.¹⁸

Pakistan.

Pakistan obtained its first research reactor from the United States as part of the Atoms for Peace Program. Its first power reactor, a 137 MWe PHWR built by Canada, began operating in 1972. Since 2001, a 325 MWe Pressurized (Light) Water Reactor (PWR), designed and built by China, has been operating at Chashma. A second reactor of the same type is under construction at the same site. All of these foreign-supplied reactors are under IAEA safeguards (Appendix 1).

After India's 1974 nuclear test, Pakistan sought technology both to separate plutonium and to enrich uranium for its nuclear weapons program. A 1974

deal with France for a reprocessing plant was canceled in 1978 amid growing concerns about a possible Pakistani nuclear weapons program.¹⁹ But A. Q. Khan, a Pakistani metallurgist working for a subsidiary of the European enrichment company, URENCO, was able to acquire centrifuge technology, and Pakistan succeeded in enriching uranium at its Kahuta centrifuge uranium enrichment facility in 1982.²⁰ In 1998, Pakistan also began operating a plutonium-production reactor at Khushab.²¹ A second reactor is now under construction at the same site, with work apparently having begun on it in 2000.²²

In 1998, Pakistan followed India in testing nuclear weapons. A 2001 estimate suggested Pakistan may by then have had an arsenal of 24-48 nuclear weapons.²³

CURRENT STOCKS OF FISSILE MATERIAL IN INDIA AND PAKISTAN

India and Pakistan are producing fissile materials for their nuclear-weapons programs. Along with Israel and perhaps North Korea, they may be the only states currently doing so. The five NPT nuclear weapons states, the United States, Russia, the United Kingdom, France and (informally) China, have all announced an end to fissile material production for weapons.

Weapons Grade Plutonium.

As far as is known, India's weapons-grade plutonium comes from the 40 megawatt thermal (MWt) CIRUS and 100 MWt Dhruva reactors (see Figure 1).



Figure 1. The Dhruva (left) and CIRUS (right) Reactors (IKONOS Satellite Imagery Courtesy of GeoEye).

Public details of the operating histories for CIRUS and Dhruva are sparse. CIRUS became critical in 1960 and fully operational in 1963. An extended refurbishment of CIRUS started in October 1997, and it resumed operation in October 2003.²⁴ Dhruva was commissioned in 1985 but began normal operation in 1988.²⁵ One figure that has been published is the availability factor, which is the fraction of time that the reactor is operable. CIRUS is reported to have an “availability factor of over 70 percent.”²⁶ In 2000, Dhruva was claimed to have “achieved an availability factor of over 68 percent during the year which is the highest so far.”²⁷

Assuming that the reactors operate at full power when they are available allows an upper-bound estimate of plutonium production. At full power and

an availability factor of 70 percent, each year CIRUS would produce about 10.2 tons of spent fuel, containing about 9.2 kg of weapons grade plutonium, and Dhruva would produce about 25.6 tons of spent fuel containing 23 kg of weapons grade plutonium.²⁸

Pakistan has a smaller plutonium production potential from its 50 MWt Khushab reactor (see Figure 2).²⁹ It is a natural uranium-fuelled heavy water reactor and appears to be similar to India's CIRUS reactor.



**Figure 2. The Khushab Reactor
(IKONOS Satellite Imagery Courtesy of GeoEye).**

There is little information available about the history and operating experience of the Khushab reactor other than that construction started in 1985 and it started operating in early 1998.³⁰ Assuming that the Khushab reactor has been operated in a fashion similar to India's CIRUS reactor, it could produce almost 12 kg of plutonium per year.³¹

The capacity of the second reactor being built at Khushab (see Figure 3) is still uncertain. One estimate suggests it may be as high as 1,000 MWt, which would allow it to produce as much as 200 kg of weapons grade plutonium a year.³² However, government officials from the United States and Pakistan, as well as some independent analysts, have disputed this; a U.S. official claimed that the reactor under construction may be “over 10 times less capable” than had been reported, i.e., it may have about the same capacity as the existing one.³³



Figure 3. The Reactor under Construction at Khushab
(August 12, 2006; IKONOS Satellite Imagery
Courtesy of GeoEye).

The estimated cumulative weapons grade plutonium production for India and Pakistan is given in Table 1.³⁴ It does not include the possibility of a few tens of kilograms of plutonium from the lower burn-up initial discharges of India's unsafeguarded PHWRs having been added to this stockpile.³⁵ For both India and Pakistan, it is hard to know how much of the plutonium that has been recovered from spent fuel has been incorporated into weapons.

	India		Pakistan
Reactor	CIRUS	Dhruva	Khushab
Cumulative Plutonium production (kg)	234	414	92

Table 1. Estimated Cumulative Weapons Grade Plutonium Production (kg) Up to 2006.

Spent fuel from CIRUS and Dhruva is reprocessed at the Trombay reprocessing plant. This plant started functioning in 1964 with a capacity of 30 tons/year, but was shut down for renovation and a capacity increase after the first Indian nuclear test in 1974. When it restarted operation in 1985, its capacity had increased to 50 tons/year.³⁶ India also has two much larger reprocessing plants at Tarapur (commissioned in 1975-82) and Kalpakkam (commissioned in 1998) to recover plutonium from spent power reactor fuel (see Table 2).³⁷

	India	Pakistan
Trombay	50	
PREFRE (Tarapur)	100	
KARP (Kalpakkam)	100	
New Labs (Rawalpindi)		10-20

**Table 2. Reprocessing Plant Capacities in India and Pakistan
(Tons of Heavy Metal in Spent Fuel Per Year).**

India plans to increase its annual reprocessing capacity to 550 tons by 2010 and to 850 tons by 2014 to meet the needs of its fast breeder reactor program and AHWR.³⁸

The spent fuel from Pakistan's Khushab reactor is believed to be reprocessed at the New Labs facility near Islamabad, which has a capacity of 10-20 tons/year of heavy metal.³⁹ In March 2000, it was reported that "recent air samples" which had been "taken secretly" showed that "Pakistanis have begun reprocessing."⁴⁰ This report seems to be consistent with estimates of the detectability of *krypton-85* released by reprocessing at the New Labs facility.⁴¹

Some of India's weapons grade plutonium has been consumed over the years in nuclear weapons tests as reactor fuel and in processing losses. We estimate about 6 kg for India's 1974 nuclear weapons test.⁴² We assume that another 25 kg may have been used in the five presumably more advanced weapons tests in 1998. As for reactor fuel, we assume India used 20 kg for the core of the Purnima I research reactor, and 60 kg for the first (*Mark I*) core of the Fast Breeder Test

Reactor.⁴³ We estimate about 20 kg to have been lost in processing. Taken together, this suggests a total of 131 kg of weapons grade plutonium was consumed. This would leave India with a current stockpile of about 500 kg of weapons grade plutonium, sufficient for about 100 nuclear weapons.⁴⁴

Civil Plutonium.

India's power reactors produce plutonium in their fuel as a normal by product of energy generation. Since the chosen way of dealing with the spent fuel is through reprocessing, the result is a large additional stockpile of separated plutonium. This plutonium could be used to make nuclear weapons.⁴⁵

As of May 2006, India's unsafeguarded reactors had produced about 149 trillion watt hours or terrawatt hours (TWh) of electricity. Their spent fuel would contain about 11.5 tons of plutonium.⁴⁶ They are producing about 1.45 tons of plutonium per year. This spent fuel has to be cooled for some years before reprocessing, but this does not greatly change the total plutonium content.⁴⁷ Assuming fuel is cooled on average for 3 years, only spent fuel generated before 2003 would have been reprocessed by 2006, in which case, no more than about 9 tons of plutonium could have been separated. It is not clear how much has actually been extracted.⁴⁸ PREFRE, the only reprocessing plant dedicated to dealing with power reactor spent fuel before 1998, has apparently operated at very low capacity factors.⁴⁹

India's safeguarded power reactors have produced 108 TWh of electricity and 1266 tons of spent fuel, containing about 6.8 tons of plutonium.⁵⁰ Little of this spent fuel has been reprocessed; it is stored in spent fuel pools and then moved to dry cask storage.⁵¹

Pakistan has no unsafeguarded civil plutonium stocks. Both its power reactors, Kanupp (137 MWe PHWR) and Chashma (325 MWe PWR), are under safeguards. As of May 2006, they had generated cumulatively about 22 TWh of electricity and discharged spent fuel containing roughly 1.2 tons of unseparated plutonium (see Table 3 and Figure 4).⁵²

	Plutonium Content in Spent Fuel (kg)	
	Unsafeguarded	Safeguarded
India	11,500	6800
Pakistan	—	1200

Table 3. Estimated Cumulative Civilian Reactor Grade Plutonium Production (May 2006).

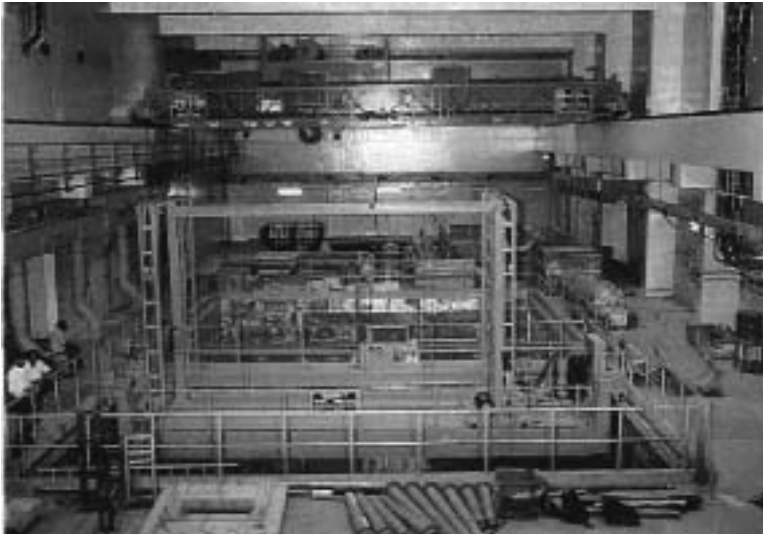


Figure 4. Spent Fuel Pool and Fuel Handling Area, Kalpakkam Reprocessing Plant.⁵³

Enriched Uranium.

India has two gas-centrifuge uranium enrichment facilities. The Bhabha Atomic Research Center complex has had a pilot scale plant operating since 1985, and there is a larger production scale plant at Rattehalli, near Mysore, Karnataka, that has been working since 1990 (see Figure 5).



Figure 5. The Centrifuge Enrichment Plant at Rattehalli, Mysore.⁵⁴

Rattehalli is believed to enrich uranium to fuel the land-prototype reactor for India's nuclear-powered submarine project, the Advanced Technology Vessel (ATV).⁵⁵ Assuming that the ATV prototype core contained 90 kg U-235 when the core was tested in 2000-01, a 2004 estimate suggested the enrichment capacity

of the Rattehalli plant was about 4,000 SWU/y.⁵⁶ This corresponds to the facility producing about 40-70 kg/year of 45 percent to 30 percent enriched uranium respectively. This enrichment capacity could yield 20 kg/year of weapons grade uranium (93 percent U-235).

For Pakistan, it has been suggested that the enrichment capacity at Kahuta (see Figure 6) may have increased over the past 2 decades.⁵⁷ In this case, it could have produced a stockpile of 1,100 kg of highly enriched uranium by the end of 2003.⁵⁸ If production continued at 100 kg/year, Kahuta would have produced about 1,400 kg of weapons grade uranium by the end of 2006.⁵⁹



Figure 6. The Centrifuge Halls at Kahuta (IKONOS Satellite Imagery Courtesy of GeoEye).⁶⁰

These estimates do not take into account the possibility that Pakistan may have other enrichment facilities. In 1999, the U.S. Department of Commerce listed centrifuge facilities at Golra, Sihala, and Gadwal as also subject to export restrictions.⁶¹ There is no public indication of their capacity.

Pakistan claims to have tested six nuclear weapons in 1998. Assuming that each weapon used 20 kg in its core, the tests would have consumed 120 kg of HEU. This would give Pakistan a weapons HEU stockpile now of about 1,300 kg, sufficient for about 65 weapons.⁶² It is not known how much of this fissile material is actually in the form of weapon cores. (See Table 4).

	Assumed SWU Capacity (2005)	Highly Enriched Uranium (kg)
India	4100	460-700 (45-30 percent enrichment)
Pakistan	20,000	1400 (90 percent enrichment)

Table 4. Estimated Cumulative Enriched Uranium Production (kg) in South Asia.

DRAWING THE LINE

A central feature of the U.S.-India agreement is the separation of India's nuclear facilities into civil and military, with the former category being made available for IAEA monitoring. At the time of writing, the U.S. Administration had accepted a separation plan presented by Prime Minister Manmohan Singh to the Indian Parliament on March 7, 2006.⁶³

According to this proposal, civilian facilities "after separation, will no longer be engaged in activities of

strategic significance” and “a facility will be excluded from the civilian list if it is located in a larger hub of strategic significance, notwithstanding the fact that it may not be normally engaged in activities of strategic significance.” Further, the separation would be conditioned “on the basis of reciprocal actions by the U.S.”

From the 22 power reactors in operation or currently under construction, India has offered to place eight additional reactors under safeguards between 2006 and 2014, each with a capacity of 220 MWe. These are:

- Two Rajasthan reactors still under construction, RAPS 5 and 6, which would be made available for IAEA monitoring when they commence operation in 2007 and 2008 respectively,
- RAPS 3 and 4, which are already operating but would only be available for safeguards in 2010,
- The two Kakrapar reactors, which would be made available for safeguards in 2012, and
- The two reactors at Narora would become available for safeguards in 2014.⁶⁴

Currently, India has four reactors under IAEA safeguards, the U.S.-built Tarapur 1 and 2, and the Canadian-built Rajasthan 1 and 2. The two Koodankulam reactors that are under construction by Russia will also be subject to safeguards under the associated India-Russian contract.

Some of the facilities at the Nuclear Fuel Complex, Hyderabad, have been identified as civilian and are to be offered for safeguards by 2008.⁶⁵ Other facilities to be declared civilian include three heavy water plants (leaving at least two out of safeguards), and the two Away-from-Reactor spent fuel storage facilities that contain spent fuel from the safeguarded Tarapur and Rajasthan reactors.

India would permanently shut down the Canadian-built CIRUS reactor in 2010, which has been used to make weapons grade plutonium. It would also shift the spent fuel from the APSARA reactor to a site outside the Bhabha Atomic Research Centre and make it available for safeguarding in 2010.

A significant proportion of India's nuclear complex would remain outside IAEA safeguards and could have a "strategic" function. This unsafeguarded nuclear complex would include the Tarapur 3 and 4 reactors, each of 540 MWe capacity, the Madras 1 and 2 reactors, and the four power reactors at Kaiga.⁶⁶ Together, these unsafeguarded reactors have 2,350 MWe of electricity generation capacity. India also will not accept safeguards on the Prototype Fast Breeder Reactor (PFBR) and the Fast Breeder Test Reactor (FBTR), both located at Kalpakkam. Facilities associated with the nuclear submarine propulsion program would not be offered for safeguards. Reprocessing and enrichment facilities also are to remain outside safeguards.⁶⁷

Finally, under the deal, India retains the right to determine which future nuclear facilities it builds would be civilian and open to safeguards and which would not.

The Uranium Constraint.

One important reason for the DAE's willingness to agree to have more of its nuclear facilities placed under safeguards is India's severe and growing shortage of domestic uranium. Nuclear Power Corporation of India data shows that most of its reactors have had lower capacity factors in the last few years.⁶⁸ The Indian Planning Commission noted that these reduced load factors were "primarily due to nonavailability

of nuclear fuel because the development of domestic mines has not kept pace with addition of generating capacity.”⁶⁹ An Indian official told the BBC soon after the U.S.-India deal was announced, “The truth is we were desperate. We have nuclear fuel to last only till the end of 2006. If this agreement had not come through we might have as well closed down our nuclear reactors and by extension our nuclear program.”⁷⁰ The former head of the Atomic Energy Regulatory Board has reported that “uranium shortage” has been “a major problem . . . for some time.”⁷¹

We analyze here the extent to which this uranium constraint will be eased if the nuclear deal goes through and the ways in which the uranium supply so liberated could be used to increase India’s rate of production of plutonium for weapons. As background, recall that apart from imported low-enriched uranium for two very old imported U.S. reactors, India relies on its domestic uranium reserves to fuel its nuclear reactors. As of May 2006, the total electric capacity of India’s power reactors that were domestically fuelled was 2,990 MWe. This includes the Rajasthan 1 and 2 reactors, which are under safeguards but have to be fuelled by domestic uranium. At 80 percent capacity, these reactors would require about 430 tons of natural uranium fuel per year. The weapons grade plutonium production reactors, CIRUS and Dhruva, consume about another 35 tons of uranium annually. The uranium enrichment facility would require about 10 tons of natural uranium feed a year. Thus, the total current requirements are about 475 tons of domestic natural uranium per year.⁷²

In comparison, we estimate that current uranium production within India is less than 300 tons of uranium a year, well short of these requirements,

but is being expanded rapidly.⁷³ DAE has been able to continue to operate its reactors by using uranium stockpiled during the period when India's nuclear generating capacity was much smaller. Our estimates are that, in the absence of uranium imports or cutbacks in India's nuclear power generation, this stockpile will be exhausted by 2007.

India is estimated to have total conventional uranium resources of about 95,500 tons of uranium, sufficient to supply about 10 GWe installed capacity of PHWRs for 40 years or so.⁷⁴ However, the Department of Atomic Energy's efforts to open new uranium mines in the country have met with stiff resistance, primarily because of concerns in the communities around existing mines about the health impacts of uranium mining and milling.⁷⁵ State governments in Andhra Pradesh and Meghalaya, where DAE has found significant uranium deposits, have yet to approve new licenses for uranium mining and milling activities.⁷⁶ It is possible however, that DAE may be able to overcome this resistance. The most likely new sites are in the district of Nalgonda, in Andhra Pradesh, with a potential capacity of about 150-200 tons of uranium a year.⁷⁷ If these mines are developed, then India could meet its current domestic uranium needs for both its nuclear power reactors and weapons program. In the meantime, old mines are being re-opened and existing mines expanded, including at Jaduguda.⁷⁸

In the next few years, the domestic uranium demand for India's unsafeguarded reactors will increase further by about 140 tons/year, to 575 tons per year, as the 540 MWe Tarapur-3 and the 220 MWe Kaiga-3 & Kaiga-4 reactors are completed and begin operation in 2007. However, the total domestic uranium requirement will begin to decrease as some of the currently unsafeguarded reactors are opened for inspection

in 2010, 2012 and 2014; additionally the Rajasthan-1 and 2 reactors can be fuelled with imported uranium (Figure 7). Consequently, if India is able to meet the additional demand for domestic uranium until 2010, the availability of uranium imports allowed by the U.S.-India deal thereafter will give it a growing excess uranium production capacity that could be used for weapons purpose.

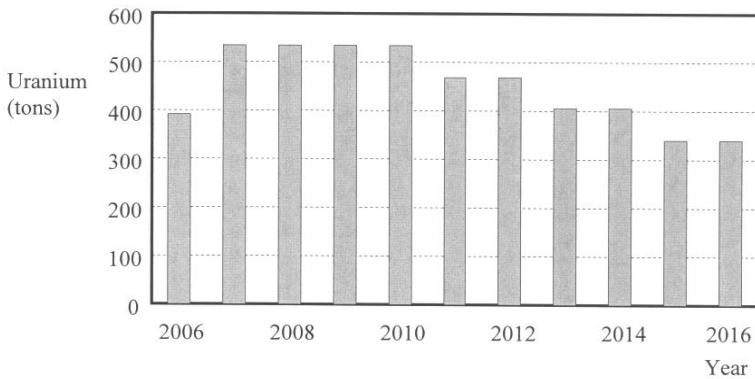


Figure 7. Estimated Annual Domestic Uranium Requirements for Unsafeguarded Heavy Water Power Reactors.⁷⁹

India has offered to put 1760 MWe of PHWRs under safeguards (including two reactors under construction) in addition to the two Rajasthan PHWRs with a combined capacity of 300 MWe that are already under safeguards. Without access to international uranium, all these reactors would have to be fueled using domestic uranium. At an 80% capacity factor, they would require about 300 tons of uranium annually. If the deal goes through, the DAE will be able to purchase these 300 tons of uranium from the international market, in effect freeing up the equivalent of India’s entire current uranium production for possible use in

military facilities. With Nalgonda on line, the uranium available for the unsafeguarded power and weapons grade plutonium production reactors, along with the enrichment program, increases to 450-500 tons/year. This would yield a uranium surplus of 75-125 tons a year after 2014.

There are several ways in which India could use its freed-up domestic uranium. In particular, concern has been raised about the possibility that it might be used to increase India's production of weapons-grade plutonium. This option has been suggested by, among others, K. Subrahmanyam, former head of the National Security Advisory Board, who has argued that "Given India's uranium ore crunch and the need to build up our minimum credible nuclear deterrent arsenal as fast as possible, it is to India's advantage to categorize as many power reactors as possible as civilian ones to be refueled by imported uranium and conserve our native uranium fuel for weapons grade plutonium production."⁸⁰

There are different ways in which this could be accomplished. One is that India could choose to build a third reactor dedicated to making plutonium for its nuclear weapons. There have been proposals for many years to build another plutonium production reactor at the Bhabha Atomic Research Centre in Bombay.⁸¹ The proposed reactor would be similar to the 100 MWt Dhruva that has been operating at BARC since 1985. A decision on whether to go ahead is expected early in 2007.⁸² If a reactor of the same power rating as Dhruva is built, it could yield an additional 20-30 kg of plutonium, i.e. several bombs worth, each year.

India also could choose to use some of its domestic uranium to make weapons grade plutonium in one of its unsafeguarded PHWRs. This can be done by

limiting the time the fuel is irradiated, through more frequent refueling.⁸³ This is beyond the normal design requirement of PHWR refueling machines, but might be possible. Assuming that such high refueling rates are sustainable, a typical 220 MWe pressurized heavy water reactor could produce between 150-200 kg/year of weapons grade plutonium when operated at 60-80 per cent capacity.⁸⁴ Even one such reactor, if run on a production mode, could increase India's current rate of plutonium production by a factor of six to eight.⁸⁵ The net requirement of extra uranium for running one 220 MWe reactor in production mode is 190 tons of natural uranium.⁸⁶

To see if this option can be sustained given India's supply of domestic uranium, we summarize in Table 5 various possibilities. The table shows estimates for the uranium requirements for Dhruva, and of running an unsafeguarded 220 MWe power reactor at very low burn-up to optimize weapons grade plutonium production. The table also gives the aggregate uranium demand of the eight unsafeguarded power reactors if they operate normally.

Rows 1 and 3 of Table 5 show that if one power reactor were to be run to produce weapons grade plutonium, and with normal operation of the other unsafeguarded power reactors, plus Dhruva, India would require almost 560 tons of uranium per year, for which additional domestic sources would have to be found. To offset the additional 190 tons/year of uranium required if India were to operate a single 220 MWe PHWR in weapons grade plutonium production mode, it could recycle some of the depleted uranium recovered from the spent fuel from this reactor into the other seven unsafeguarded power reactors. This

scheme involves fuelling 25% of the core with depleted uranium (containing 0.61% U-235) and ends up saving 20% of the normal natural uranium requirement, with the average burn up reduced to 5400 MWd/tHM.⁸⁸

	Burn Up (MWd/tHM)	Uranium Demand (tons/year)	Reactor-Grade Plutonium (kg/y)	Weapons Grade Plutonium (kg/y)
Dhruva	1000	29		26
One 220 MWe reactor run for weapons grade plutonium	1000	222		200
Seven reactors in power mode and one 220 MWe reactor in production mode ⁸⁷		528	1147	200
Seven reactors in power mode with partial depleted uranium cores and one 220 MWe reactor in production mode		467		200
All eight reactors in power mode	7000	338	1265	—
All eight reactors in power mode with partial depleted uranium cores		270		—

Note: All reactors are assumed to run at 80 percent capacity factor.

Table 5. Uranium Requirements for India's Unsafeguarded Reactors in Various Operating Modes.

The resulting 20% saving on the roughly 306 tons/year of natural uranium the seven power reactors require is equivalent to 61 tons/year of natural uranium. The net penalty of running one reactor in production mode is reduced from 190 tons/year to about 130/tons per year.⁸⁹ This implies that India could operate

an unsafeguarded 220 MWe heavy water reactor in production mode, provided the Nalgonda and other mines can yield an additional 200 tons/year of uranium, and that India has sufficient reprocessing capacity to maintain the necessary flow of depleted uranium.

India has already fuelled some PHWRs – including the Rajasthan-3 & 4, Kaiga-2 and Madras-2 reactors – using natural uranium and depleted uranium recovered as a byproduct of weapons grade plutonium production.⁹⁰ It has used depleted uranium recovered from low burn-up fuel from CIRUS and Dhruva.⁹¹ These reactors generate only about 30 tons/year of spent fuel. However, there is a stock of about 750 tons of such spent fuel.⁹² This would suffice for roughly four to five years if all the power reactors ran on a mixed natural and depleted uranium core.

Power Reactor Spent Fuel.

The nuclear deal does not constrain India's use of the plutonium from the spent fuel discharged by any of its currently unsafeguarded reactors. The six currently operating reactors to be placed under safeguards will add to the current stock of 11.5 tons of reactor grade plutonium before they are opened to inspection. Operating at 80% capacity, each reactor would add about 120 kg/year of plutonium during its remaining unsafeguarded operation. The total contribution from these six reactors will be about 4300 kg before they are all finally under safeguards (Table 6).

Reactor	Proposed Date of Safeguarding	Plutonium Production (kg) Before Reactor is Safeguarded
Rajasthan-3	2010	475
Rajasthan-4	2010	475
Kakrapar-1	2012	712
Kakrapar-2	2012	712
Narora-1	2014	950
Narora-2	2014	950
Total		4274

Table 6. Projected Plutonium Production from 2007 Until Reactors Are Safeguarded.

The total annual unsafeguarded plutonium production will increase from the current 1450 kg/year as reactors under construction come into operation next year and then decline in coming years as reactors are opened for inspection. Plutonium production will be reduced from about 2000 kg/year in 2007 to about 1250kg/year after 2014, when it will stabilize (Figure 8) unless additional unsafeguarded reactors are built. Thus, the separation plan will serve to reduce India's annual production of unsafeguarded plutonium by about one-third.

The "reactor-grade" plutonium in the high burn up spent fuel being discharged by these reactors has a different mix of isotopes from weapons grade plutonium. However, reactor-grade plutonium can be used to make a nuclear explosive and, as mentioned earlier, one of India's May 1998 nuclear tests is reported to have involved such material.⁹³

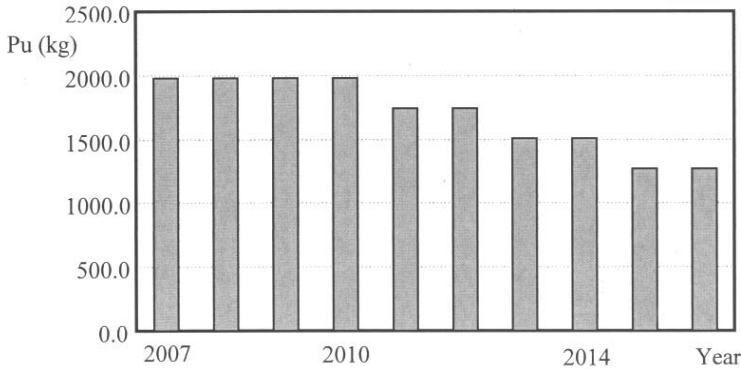


Figure 8. Annual Production of Unsafeguarded Plutonium from All Indian Power Reactors from 2007 until 2016, as Reactors Are Progressively Placed Under Safeguards.

An estimated 8 kg of reactor grade plutonium would be required to make a simple nuclear weapon.⁹⁴ If this plutonium is not put under safeguards, it could provide an arsenal of over 1300 weapons.

A commonly cited problem with the use of reactor grade plutonium is the increased risk of a “fizzle yield”, where a premature initiation of the fission chain reaction by neutrons emitted by fissioning of plutonium-240 leads to pre-detonation of the weapon and an explosive yield only a few percent of the design value. In Indian PHWR spent fuel, plutonium-240 is over 22 percent of the total plutonium (compared to about 5 percent in weapons grade plutonium).⁹⁵ The greater abundance of plutonium isotopes other than Pu-239 in reactor grade plutonium also leads to increased heat generation and radiation from a mass of this material. However, these are not insuperable engineering difficulties.

The U.S. Department of Energy has noted that “At the lowest level of sophistication, a potential

proliferating state or sub-national group using designs and technologies no more sophisticated than those used in first-generation nuclear weapons could build a nuclear weapon from reactor grade plutonium that would have an assured, reliable yield of one or a few kilotons (and a probable yield significantly higher than that). At the other end of the spectrum, advanced nuclear weapons states such as the United States and Russia, using modern designs, could produce weapons from reactor grade plutonium having reliable explosive yields, weight, and other characteristics generally comparable to those of weapons made from weapons-grade plutonium."⁹⁶ India presumably falls somewhere in this spectrum.

One "modern design" feature that allows reactor grade plutonium to be used for weapons is "boosting," in which a gas mixture of deuterium and tritium is introduced into the hollow core of an implosion weapon just before it detonates.⁹⁷ The fusion reaction that is triggered releases a large quantity of neutrons, which are able in turn to initiate fission more quickly in a larger mass of the fissile material than the normal chain reaction. This serves to greatly increase the yield. Indian weapons designers claim to have tested a thermonuclear weapon with a boosted fission primary in 1998.⁹⁸ One history of India's nuclear weapons program notes explicitly the use of boosting in a reactor grade plutonium device test in 1998 and observes that "if validated it would increase India's stock of fissile material dramatically."⁹⁹

The Fast Breeder Reactor Program.

India's DAE has consistently offered the potential shortage of domestic uranium and India's abundant

thorium reserves as the justification for its plutonium fuelled fast breeder reactor program. India would gain access to the international uranium market as part of the agreement with the United States and so end the prospect of future uranium shortages.

An important concern is that the DAE has chosen to keep the breeder program out of IAEA safeguards as part of the nuclear deal. In support of this, DAE has raised concerns that safeguards would unduly constrain reactor research and development programs.¹⁰⁰ But IAEA safeguards do not seem to have compromised or limited the development of commercial breeder programs in Germany and Japan, or that of new generations of PHWRs in Canada. The many technical and safety problems that breeder programs in various countries have experienced have been for other reasons.

DAE chairman Anil Kakodkar has also declared that, "Both from the point of view of maintaining long-term energy security and for maintaining the minimum credible deterrent, the Fast Breeder Programme just cannot be put on the civilian list."¹⁰¹ This suggests that the breeder may be used to produce weapons grade plutonium.

India's first large breeder reactor, the 500 MWe PFBR, is located at Kalpakkam, near Madras. It is part of a larger complex that includes the Madras PHWR reactors and a reprocessing plant. This entire complex is being kept outside safeguards.¹⁰² The PFBR is expected to be completed in 2010 (see Figure 9).

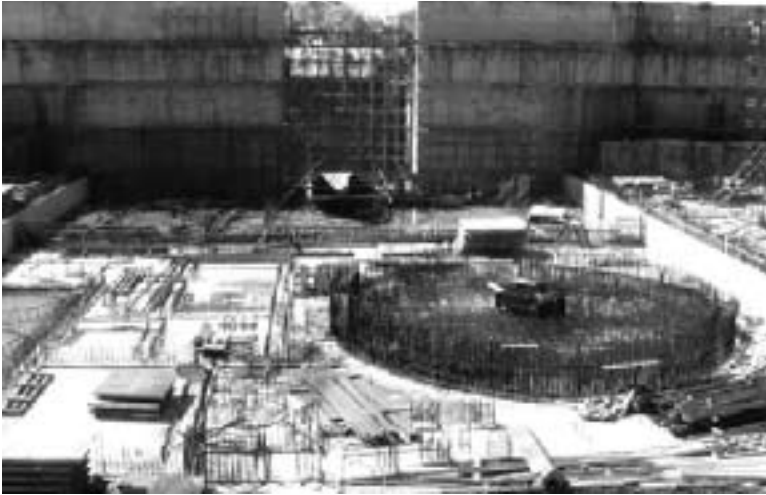


Figure 9. Construction Activity at Prototype Fast Breeder Reactor, Kalpakkam, April 2006.¹⁰³

Fueled initially by reactor grade plutonium separated from PHWR spent fuel, the PFBR would produce weapons grade plutonium in both its radial and axial blankets of depleted uranium while plutonium recovered from the core could be recycled for use again as fuel. To recover the weapons grade plutonium, the core and blanket fuel assemblies would have to be reprocessed separately. This would include separating the axial blanket from the part of the fuel assembly that lies within the core, which can be done by using shearing machines to cut the fuel assemblies prior to reprocessing.¹⁰⁴ Plans for a dedicated reprocessing plant for FBR fuel have been developed.¹⁰⁵

The PFBR is designed to have a thermal power of 1,250 MW and an initial inventory of 1,910 kg of plutonium in its core.¹⁰⁶ The current design is reported to have an overall, equilibrium cycle breeding ratio

of almost 1.05.¹⁰⁷ Applying the neutron balance in a generic breeder reactor with a homogeneous core permits a first order estimate of plutonium production in the PFBR core and its radial and axial blankets.¹⁰⁸ With these uncertainties in mind, we find that at 80 percent capacity, the PFBR could produce on the order of 135 kg of weapons grade plutonium every year in its blanket.¹⁰⁹ This would amount to about 25-30 weapons worth of plutonium a year, a four to five-fold increase over India's current weapons grade plutonium production capacity.

India plans to build four additional breeder reactors by 2020, and then move to larger 1,000 MWe breeders and eventually install 500 GWe of breeder capacity.¹¹⁰ Each of the four planned 500 MWe breeder reactors would need two initial cores before they would be able to begin recycling their own plutonium, a total of about 16 tons.¹¹¹ India would appear to have more than sufficient unsafeguarded plutonium for placing all four of the planned breeders in the military sector. If these five breeders are built and all are kept military, then in about 15 years, India would be able to produce about 500-800 kg per year of weapons grade plutonium from them.

CONCLUSIONS

The July 2005 U.S.-India joint statement represents a fundamental transformation of U.S.-India relations and at the same time a challenge to the disarmament and nonproliferation regime. The U.S. Congress and the Nuclear Suppliers Group of countries will have to take that into account as they consider whether or not to approve the deal. The March 2006 separation plan proposed by India as the basis for demarcating its

military and civilian nuclear facilities lays the basis for a potentially rapid expansion of its capacity for fissile material production for weapons.

In this chapter, the fissile material production capabilities in India and how they might change as a result of the U.S.-India deal have been assessed. India's current stockpile of weapons grade plutonium from its CIRUS and Dhruva reactors have been estimated and found to be about 500 kg. Assuming a typical figure of 5 kg of plutonium for each nuclear warhead, this stockpile would be sufficient for roughly 100 weapons.

Under the deal, India will be able to produce another 45 kg of weapons grade plutonium from its CIRUS reactor before it is shut down in 2010. The Dhruva reactor will continue to operate and add about 20-25 kg/year. A second Dhruva-sized reactor that is being considered would add a similar amount each year.

The most important potential increase in India's weapons grade plutonium production will come from its unsafeguarded fast breeder reactor, the PFBR, to be completed in 2010. It could produce an estimated 130 kg of weapons grade plutonium each year, a four-fold increase in India's current production capability. Note that even in the absence of the U.S.-India deal, the breeder would have remained unsafeguarded and could have produced the same amount of plutonium.

India has plans for four more breeder reactors by 2020, which could produce over 500 kg a year of weapons grade plutonium. The safeguards status of these reactors has not yet been announced.

These breeders would be fuelled by India's stockpile of about 11 tons of unsafeguarded reactor-grade plutonium. This stockpile is currently increasing at about two tons/year. As part of the U.S.-India deal,

India will place six of its reactors under safeguards between now and 2014—these will be in addition to the six imported reactors that are required to be under safeguards. The reactors newly assigned to be safeguarded are estimated to contribute in total another four tons of unsafeguarded plutonium before they are opened for inspection. Meanwhile, the eight reactors that are designated as military and will remain unsafeguarded will contribute 1250 kg of reactor grade plutonium per year.

Without the deal, India would have 16 unsafeguarded nuclear reactors (including five under construction and expected to begin operating in 2007-08). They would have produced altogether 2,200 kg/year of reactor-grade plutonium. India's proposed nuclear facilities separation plan will serve to reduce its annual unsafeguarded plutonium production by about 40 percent, to roughly 1,250 kg/year. All this reactor-grade plutonium is also potentially weapon-useable.

India currently fuels 13 heavy water reactors, with a total capacity of 2,990 MWe from domestic uranium. Under the deal, it will be able to fuel the eight of them that are to be safeguarded using imported uranium. Of the five heavy water reactors under construction, two are to be safeguarded, while three will be military and not open to inspection. This will give India 2,350 MWe of unsafeguarded heavy water reactor capacity that it will have to fuel using domestic uranium.

We find that India's current domestic production of natural uranium of about 300 tons/year is insufficient to fuel its unsafeguarded reactors and sustain its current weapons grade plutonium and enriched uranium production, which altogether require about 475 tons a year. India has been able to escape this constraint so

far by using stocks of previously mined and processed uranium. As new unsafeguarded reactors come online in 2007-08, India would need altogether about 615 tons of domestic uranium per year. However, this requirement will decline from 615 tons/year to about 380 tons, since India will be able to import uranium for reactors when they come under safeguards in 2010, 2012, and 2014.

To meet the increased demand, India expects to expand uranium mining. It is hoped that the proposed Nalgonda mines could produce about 150-200 tons per year, increasing the total available to about 450-500 tons a year. Assuming this happens, and as the requirement falls to 380 tons of uranium per year, India may be able to divert the additional 70-120 tons/year towards producing 60-100 kg/year of weapons grade plutonium by partially running one of its unsafeguarded power reactors at low burn up. This will require operating the reactor refueling machines at much higher rates than normal, which may limit the extent to which this is possible.

It would require an extra 190 tons of natural uranium a year if an entire 200 MWe heavy water reactor were to be shifted from power production to weapons grade plutonium production. The possibility of India offsetting some of this natural uranium demand by using recycled depleted uranium (containing 0.61 percent uranium-235) as part of the fuel for its other unsafeguarded power reactors would reduce the natural uranium requirement to 130 tons per year, not very far from the additional 70-120 tons that may be available. A key constraint on the recycling of depleted uranium on this scale may be the operational capacity of India's reprocessing plants.

It should be noted that only the weapons grade plutonium that could be produced by the unsafeguarded power reactors (because of the availability of imported uranium) is a direct consequence of the U.S.-India deal that has been negotiated. The breeder and production reactors would have remained unsafeguarded even if there had been no deal. Only a deal that would have brought the PFBR and all the power reactors under safeguards would have ensured that Indian fissile material production for weapons remained at about the current levels.

An expansion of fissile material stockpiles in South Asia would be at odds with the stated doctrine of both India and Pakistan of pursuing a “minimum deterrence.” It has been shown that half a dozen modest Hiroshima-yield weapons, if dropped on major cities in South Asia, could kill over a million people.¹¹² This suggests that several dozen weapons would more than suffice to meet any reasonable criteria for “minimum deterrence.”¹¹³ This number would permit a nuclear attack with a dozen warheads and provide for sufficient redundancy to deal with any concerns about survivability, reliability, and interception.¹¹⁴

Both India and Pakistan have already achieved the fissile material requirements for a “minimal” arsenal, and it has been argued for some time that they should end production of fissile material for weapons.¹¹⁵ Rather than pursue the option of a large expansion of their nuclear arsenals, they should choose to suspend all further production of fissile materials for weapons purposes pending the negotiation and entry into force of a Fissile Material Cutoff Treaty. This is also a necessary step in progress towards nuclear disarmament.

ENDNOTES - CHAPTER 6

1. Homi Bhabha, address to Twelfth Pugwash Conference, Udaipur, India, January 27–February 1, 1964, cited in George Perkovich, *India's Nuclear Bomb: The Impact on Global Proliferation*, Berkeley, CA: University of California Press, 1999, pp. 61-62.

2. The U.S.-India nuclear agreement is at www.whitehouse.gov/news/releases/2005/07/20050718-6.html.

3. The politics and broader policy issues of the deal are discussed in Zia Mian and M. V. Ramana, "Wrong Ends, Means, and Needs: Behind the U.S. Nuclear Deal with India," *Arms Control Today*, January/February 2006, www.armscontrol.org/act/2006_01-02/JANFEB-IndiaFeature.asp.

4. The Nuclear Suppliers Group member states are Argentina, Australia, Austria, Belarus, Belgium, Brazil, Bulgaria, Canada, China, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Kazakhstan, Latvia, Lithuania, Luxembourg, Malta, Holland, New Zealand, Norway, Poland, Portugal, South Korea, Romania, Russia, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom, and the United States, www.nuclearsuppliersgroup.org.

5. President Bush and Prime Minister Singh Press Conference, New Delhi, March 2, 2006, www.whitehouse.gov/news/releases/2006/03/20060302-9.html.

6. "Pakistan Seeks Nuclear Deal on Par with India," *Dawn*, November 8, 2005; Khalid Hasan, "No Indian-Style Nuclear Deal for Pakistan," *Daily Times*, November 7, 2005.

7. Mark Hibbs, "China Favors NSG Solution on India That Facilitates Trade with Pakistan," *Nuclear Fuel*, November 7, 2005.

8. Mark Hibbs and Shahid-ur-Rehman, "NSG, U.S. Won't Accommodate New Pakistan-China Commerce," *Nucleonics Week*, March 2, 2006.

9. "Aziz Pleads for Pak-U.S. N-Deal," *Daily Times*, April 6, 2006.

10. Shakil Sheikh, "Pakistan Vows to Maintain Credible N-deterrence," *The News*, April 13, 2006.

11. "Pakistan Totally Committed to Non-Proliferation, Restraint Regime," *Associated Press of Pakistan*, April 9, 2006, www.app.com.pk/n87.htm.

12. Some of these issues are also discussed in a recent report by Ashley Tellis, *Atoms for War*, Washington, DC: Carnegie Endowment, 2006, www.carnegieendowment.org/files/atomsforwarrevised1.pdf.

13. Leonard Weiss, "Atoms for Peace," *Bulletin of the Atomic Scientists*, November/December 2003.

14. R. Chidambaram and C. Ganguly, "Plutonium and Thorium in the Indian Nuclear Programme," *Current Science*, Vol. 70, No. 1, 1996.

15. K. V. Suresh Kumar, R. P. Kapoor, P. V. Ramalingam, B. Rajendran, G. Srinivasan, K. V. Kasiviswanathan, "Fast Breeder Test Reactor. 15 Years of Operating Experience," Paper presented at the Technical Meeting on Operational and Decommissioning Experience with Fast Reactors, IAEA-TM-25332, Vienna, Austria: International Atomic Energy Agency, 2002, pp. 15-27.

16. B. Battacherjee, "An Overview of R&D in Fuel Cycle Activities of AHWR," Paper presented at the 14th Indian Nuclear Society Conference, Kalpakkam, December 17-19, 2003, www.indian-nuclear-society.org.in/conf/2003/1.pdf.

17. Perkovich, p. 428.

18. Nuclear Notebook, "India's Nuclear Forces, 2005," *Bulletin of the Atomic Scientists*, September/October 2005. Indian Defense ministry sources have mentioned plans for 300-400 weapons, Vivek Raghuvanshi, "India to Stay the Course on Nuke Doctrine," *Defense News*, November 1, 2004.

19. Leonard Spector, *Nuclear Proliferation Today*, Vancouver, Canada: Vintage Books, 1984, pp. 78-81.

20. A. Q. Khan, "Dr A. Q. Khan Laboratories, Kahuta, Twenty Years of Excellence and National Service," *Friday Times*, September 5-11, 1996.

21. "Pakistan's Indigenous Nuclear Reactor Starts Up," *The Nation*, April 13, 1998.

22. The first images of construction activity at the reactor site were released by Institute for Science and International Security, July 24, 2006, www.isis-online.org/publications/southasia/newkhushab.pdf.

23. Nuclear Notebook, "Pakistan's Nuclear Forces, 2001," *Bulletin of the Atomic Scientists*, January/February 2001.

24. After start up, reactor power was raised to 30 MWt in February 2004 and then to 40 MWt in November 2004, "Barc's Refurbished Reactor Attains Full Power Operation," *The Hindu News Update Service*, November 19, 2004.

25. Mark Hibbs, "Dhruva Operating Smoothly within Refueling, Availability Limits," *Nucleonics Week*, Vol. 33, No. 13, 1992; Brahma Chellaney, "Indian Scientists Exploring U Enrichment, Advanced Technologies," *Nucleonics Week*, Vol. 28, No. 10, 1987.

26. R. C. Sharma and S. K. Agarwal, "Research Reactor: Its Refurbishment and Future Utilisation," *BARC Newsletter*, June 2004.

27. *Annual Report 2000*, Trombay, Mumbai, India: Bhabha Atomic Research Centre, 2001.

28. This assumes a burn-up of 1,000 megawatt-days per ton of heavy metal (MWd/tHM) and a plutonium content of 0.9 kg/t in the spent fuel.

29. Mark Hibbs, "After 30 Years, PAEC Fulfills Munir Khan's Plutonium Ambition," *Nucleonics Week*, Vol. 41, No. 24, June 15, 2000.

30. "Pakistan's Indigenous Nuclear Reactor Starts Up," *The Nation*, April 13, 1998.

31. Assuming a burn-up of 1,000 MWd/tHM, with 0.9 g of weapons grade plutonium produced per megawatt (thermal) day of output and that the reactor operates at 70 percent of its capacity.

32. Joby Warrick, "Pakistan Builds Plutonium Reactor. Massive Plant Underway Would Generate Material for 40-50 Nuclear Bombs a Year," *The Washington Post*, July 24, 2006.

33. William J. Broad and David Sanger, "U.S. Disputes Report on New Pakistan Reactor," *The New York Times*, August 3, 2006; Joby Warrick, "Pakistani Reactor not as Significant as was Reported," *The Washington Post*, August 5, 2006.

34. We assume that both CIRUS and Dhruva (since 1988) have had an average annual availability factor of 70 percent, except for CIRUS between 1991-97, when we assume a 60 percent availability factor because of reported problems with aging. Sharma and Agarwal. Khushab has been assumed to be operating with a 70 percent availability factor since 1998.

35. About 35 kg of low burn-up PHWR plutonium may have been produced by the end of 2004; *India's Military Plutonium Inventory End 2004*, Washington, DC: Institute for Science and International Security, www.isis-online.org/global_stocks/end2003/india_military_plutonium.pdf.

36. "Third Reprocessing Plant Opened at Kalpakkam," *Nuclear News*, May 1996.

37. Z. Mian and A. H. Nayyar, "An Initial Analysis of 85-Krypton Production and Dispersion from Reprocessing in India and Pakistan," *Science & Global Security*, Vol. 10, No. 3, 2002.

38. *Ibid.*

39. Milton Benjamin, "Pakistan Building Secret Nuclear Plant," *Washington Post*, September 23, 1980.

40. "Pakistan is Reprocessing Fuel Rods to Create Plutonium Nuclear Weapons," *CBS News Transcripts*, March 16, 2000.

41. Mian and Nayyar.

42. This device is described as "the Indian version of the Fat Man," the U.S. weapon used against Nagasaki, that contained about 6 kg of plutonium; Raj Chengappa, *Weapons of Peace: The Secret Story of India's Quest to be a Nuclear Power*, New Delhi: Harper Collins, 2000, p. 195. For a description of the Indian device, see pp. 175-195.

43. According to Bhabha Atomic Research Centre, the total weight of fuel in the Purnima I reactor is 21.6 kg of plutonium oxide. There is a claim that this plutonium was recovered and used in the 1974 nuclear test because of a dearth of plutonium. See Chengappa, p. 185. We do not take that possibility into account in our estimate of plutonium consumption. By 1970, spent fuel from CIRUS containing over 60 kg of plutonium would have been cool enough to be reprocessed. The amount of plutonium in the Fast Breeder Test Reactor core is from Mark Hibbs, "Kalpakkam FBR to Double Core, Load First Thorium-232 Blanket," *Nucleonics Week*, Vol. 38, No. 48, 1997.

44. We emphasize that all of this plutonium may not have been separated. ISIS estimates India may have accumulated 575 kg of weapons grade plutonium as of the end of 2004. See ISIS, "India's Military Plutonium Inventory, End 2004," www.isis-online.org/global_stocks/end2003/india_military_plutonium.pdf.

45. J. Carson Mark, "Explosive Properties of Reactor-Grade Plutonium," *Science & Global Security*, Vol. 4, No. 1, 1993.

46. Assuming a 7,000 MWd/tHM burn-up, thermal efficiency of 0.29, MCNP calculations by Alexander Glaser and Jungmin Kang show the fresh spent fuel contains about 3.8 kg of plutonium per ton of heavy metal (tHM). As the spent fuel cools, its Pu-241 decays with a 14-year half-life and the overall plutonium content therefore decreases by about 1 percent over 5 years to 3.75 kg per

ton of spent fuel. Indian PHWRs now have an average burn-up of 7,000 MWd/tHM. See K. C. Sahoo and S. A. Bhardwaj, "Fuel Performance In Water Cooled Nuclear Reactors," 14th Indian Nuclear Society Annual Conference, Kalpakkam, December 17-19, 2003, www.indian-nuclear-society.org.in/conf/2003/12.pdf.

47. Indian PHWR spent fuel is reported to be cooled for a minimum of 430 days before being sent to a reprocessing facility. See P. K. Dey, "An Indian Perspective for Transportation and Storage of Spent Fuel," 26th International Meeting on Reduced Enrichment for Research and Test Reactors, Vienna, November 7-12, 2004. It may be stored for 5 to 10 years before being reprocessed. See V. K. Chaturvedi, "Economics of Fuel Cycles of PHWRs, VVERs and TAPS BWRs," Paper presented at the 14th Indian Nuclear Society Annual Conference, Kalpakkam, December 17-19, 2003, www.indian-nuclear-society.org.in/conf/2003/2.pdf.

48. Theoretically, all this spent fuel could have been reprocessed since, until the past few years, the total reprocessing plant design capacity has been greater than spent fuel produced. But for a reasonable capacity factor, it seems unlikely that all of the spent fuel could have been reprocessed.

49. Mark Hibbs, "PREFRE Plant Used Sparingly, BARC Reprocessing Director Says," *Nuclear Fuel*, Vol. 17, No. 7, 1992; Mark Hibbs, "Tarapur-2 to Join Twin BWR in Burning PHWR Plutonium," *Nuclear Fuel*, Vol. 20, No. 20, 1995.

50. Currently safeguarded reactors are Tarapur 1 and 2 and Rajasthan 1 and 2. The Tarapur reactors have a thermal efficiency of 31.2 percent, an average fuel burn-up of 19,500 MWd/tHM, and produce 8 kg/tHM of plutonium.

51. K. C. Sahoo and S. A. Bhardwaj, "Fuel Performance in Water Cooled Nuclear Reactors," Paper presented at the 14th Indian Nuclear Society Annual Conference, Kalpakkam, December 17-19, 2003, www.indian-nuclear-society.org.in/conf/2003/12.pdf.

52. Electricity production data for Kanupp and Chashnupp are not yet available for May 2006. We assume that the output in May 2006 was the same as in the previous month.

53. P. K. Dey, "Spent Fuel Reprocessing: an Overview," 14th Indian Nuclear Society Annual Conference, Kalpakkam, December 17-19, 2003, www.indian-nuclear-society.org.in/conf/2003/14.pdf.

54. Image from David Albright and Susan Basu, *India's Gas Centrifuge Program: Stopping Illicit Procurement and the Leakage of Technical Centrifuge Know-How*, Washington, DC: Institute for Science and International Studies, March 10, 2006, www.isis-online.org/publications/southasia/indianprocurement.pdf.

55. The "spark plug" in the fusion stage of a thermonuclear weapon can use highly enriched uranium or plutonium.

56. This assumes 0.3 grams of uranium-235 per shaft-horse power year and a 10-year life time for the ATV reactor. See M. V. Ramana, "An Estimate of India's Uranium Enrichment Capacity," *Science & Global Security*, Vol. 12, 2004, pp. 115-124. The growth in enrichment capacity over time is assumed to be linear.

57. From 3,000-5,000 SWU/year in 1986 to 9,000-15,000 SWU/year in 1990-1991 and 13,000-22,000 SWU/year by the late 1990s. See David Albright, Frans Berkout, and William Walker, *Plutonium and Highly Enriched Uranium 1996*, New York: Oxford University Press, 1997, p. 278.

58. *ISIS Estimates of Unirradiated Fissile Material in De Facto Nuclear Weapon States, Produced in Nuclear Weapon Programs*, June 30, 2005, www.isis-online.org/global_stocks/end2003/de_facto_nws.pdf.

59. A capacity of about 20,000 SWU/year would produce 100 kg/year of weapons grade uranium.

60. The enrichment halls were identified in a September 2005 U.S. State Department briefing, "Iran's Nuclear Fuel Cycle Facilities: A Pattern of Peaceful Intent?" www.globalsecurity.org/wmd/library/report/2005/iran-fuel-cycle-brief_dos_2005.pdf.

61. U.S. Department of Commerce, Bureau of Export Administration, 15 CFR Part 742 and 744, *Federal Register*, Vol. 63, No. 223, November 19, 1998, www.chaos.fedworld.gov/bxa/whatsnew.cgi/in-pak.pdf.

62. This is consistent with estimates of Pakistan possibly having 24-48 weapons in 2001, given the additional enriched uranium produced since then. Nuclear Notebook, "Pakistan's Nuclear Forces, 2001," *Bulletin of The Atomic Scientists*, January/February 2001.

63. "Suo Moto Statement by Prime Minister Dr. Manmohan Singh on Discussions on Civil Nuclear Energy Cooperation with the US: Implementation of India's Separation Plan," www.indianembassy.org/newsite/press_release/2006/Mar/24.asp.

64. "Implementation of the India-United States Joint Statement of July 18, 2005: India's Separation Plan," www.mea.gov.in/treatiesagreement/2006/11ta1105200601.pdf.

65. Fuel cycle facilities to be safeguarded are Uranium Oxide Plant (Block A), Ceramic Fuel Fabrication Plant (Pelletizing) (Block A), Ceramic Fuel Fabrication Plant (Assembly) (Block A), Enriched Uranium Oxide Plant, Enriched Fuel Fabrication Plant, and Gadolinia Facility. There seem to be other fuel production facilities at the Nuclear Fuel Complex that will remain unsafeguarded, such as the New Uranium Oxide Fuel Plant, www.aerb.gov.in/t/annrpt/anr99/srnp.htm; and T. S. Subramanian, "Fuelling Power," *Frontline*, March 16-29, 2002, www.frontlineonnet.com/fl1906/19060840.htm.

66. "Implementation of the India-United States Joint Statement of July 18, 2005: India's Separation Plan," www.mea.gov.in/treatiesagreement/2006/11ta1105200601.pdf.

67. The PREFRE reprocessing plant has had safeguards in place when running spent fuel from Rajasthan 1 and 2.

68. Nuclear Power Corporation of India, www.npcil.nic.in/PlantsInOperation.asp.

69. Planning Commission, Government of India, *Mid-Term Appraisal of the Tenth Five-Year Plan (2002-07)*, Chapter 10, pp. 229-230, www.planningcommission.nic.in/midterm/cont_eng1.htm.

70. Sanjeev Srivastava, "Indian P.M. Feels Political Heat," *British Broadcasting Corporation*, July 26, 2005, at www.news.bbc.co.uk/go/pr/fr/-/2/hi/south_asia/4715797.stm.

71. A. Gopalakrishnan, "Indo-US Nuclear Cooperation: A Nonstarter?" *Economic and Political Weekly*, July 2, 2005.

72. "The Nuclear Fuel Complex Chairman, R. Kalidas, Has Said That India's Current Annual Uranium Requirement Is on the Order of 400-500 Tons of Uranium Oxide (340-424 t/U)." *RWE Nukem*, December 2004, p. 24.

73. We assume that India mines and mills 2,000 tons of uranium ore per day, 300 days per year, at an average ore grade of 0.05 percent uranium. The actual ore grade being mined may be only 0.03 percent, since the better quality ore has already been used. The Jaduguda mill has a processing capacity of about 2,100 tons ore/day and may only have been producing 230 tons per year. *RWE Nukem*, December 2004, p. 24. An official report notes that one mill is under construction at Banduhurang, Jharkhand, and was expected to be completed in mid-2006. Work is underway on another mill at Turamdih, reported to have a capacity of 3,000 tons per day of ore (about 450 tons/year of uranium). *Project Implementation Status Report of Central Sector Projects Costing Rs. 20 Crore and Above*, October-December 2005, Infrastructure and Project Monitoring Division, Government of India, April 2006, www.mospi.nic.in/pi_status_report_oct_dec2005.pdf. The Turamdih plant is expected to be commissioned by December 2006. See "UCIL Exploring Uranium Ore in Chattisgarh, Rajasthan, Karnataka," *PTI*, June 5, 2006.

74. "Interview with R. Kalidas," *RWE Nukem*, December 2004.

75. Xavier Dias, "DAE's Gambit," *Economic and Political Weekly*, August 6, 2005.

76. T. S. Subramanian, "Uranium Crisis," *Frontline*, January 13, 2006.

77. The Uranium Corporation of India claims it expects to mine 1250 tons of uranium ore per day. See "Environmental Clearance for Uranium Mining," *Hindustan Times*, December 12, 2005. Assuming an average grade of 0.04-0.05 percent, this implies 150-187.5 tons/year of uranium. As noted in footnote 72, India expects a large increase in ore processing capacity in 2006 that can more than handle this increased demand.

78. T. S. Subramanian and Suhrid Sankar Chattopadhyay, "Back To Singhbhum," *Frontline*, January 13, 2006.

79. This includes under construction PHWRs as they come into operation and excludes PHWRs once they come under safeguards and can be fuelled by imported uranium. It also excludes CIRUS and Dhruva and uranium demand from the enrichment program, which adds up to about 45 tons per year.

80. K. Subrahmanyam, "India and the Nuclear Deal," *Times of India*, December 12, 2005.

81. "BARC Planning New Dhruva-Type Reactor," *Hindustan Times*, April 28, 1999.

82. Mark Hibbs, "Replication of Dhruva Reactor Proposed for Next Indian Economic Plan," *Nuclear Fuel*, May 8, 2006.

83. This possibility is suggested by Albright, Berkhout, and Walker, p. 267. In normal operation, a 220 MWe PHWR refueling machine would need to change eight fuel bundles a day. A typical refueling machine apparently requires 2-3 hours to change 4-8 fuel bundles. See, for example, *CANDU Fundamentals*, www.canteach.candu.org/library/20040700.pdf, p. 179. For 1,000 MWd/tHM burn-up, such refueling would have to be repeated seven times a day.

84. A. H. Nayyar, A. H. Toor, and Z. Mian, "Fissile Material Production in South Asia," *Science & Global Security*, Vol. 6, No. 2, 1997, pp. 189-203.

85. A 220 MWe power reactor operating at 1,000 MWd/tHM burn-up would require a seven times higher refueling rate than at its normal 7,000 MWd/tHM operation. This appears to be possible given the on-line refueling capabilities of these reactors.

86. Uranium consumption is about 222 tons/year in production mode versus 32 tons in power mode.

87. If the 170 MWe Madras 1 reactor was used to produce weapons plutonium, its annual uranium requirement would be 170 tons, and consequently the total uranium requirement for that

and the other seven unsafeguarded PHWRs would be reduced to 485 tons, instead of 528.

88. Baltej Singh, P. D. Krishnani and R. Srivenkatesan, "Use of Depleted Uranium in Equilibrium Core of Standard PHWRs: A Complete Study," Paper presented at the 16th Annual Conference of the Indian Nuclear Society, 2005, www.indian-nuclear-society.org.in/conf/2005/pdf_3/topic_1/T1_CP5_Baltej_Singh.pdf. The depleted uranium requirement is twice that of the natural uranium it replaces, in order to maintain reactor performance.

89. These 130 tons are the difference between the 467 tons in Row 4 and the 338 tons in Row 5 of the Table.

90. Singh, Krishnani, and Srivenkatesan, "Use of Depleted Uranium in Equilibrium Core of Standard PHWRs: A Complete Study." It has been studied for Tarapur 3 and 4. See V. K. Chaturvedi, "Economics of Fuel Cycles of PHWRs, VVERs and TAPS BWRs," Paper presented at the 14th Indian Nuclear Society Annual Conference, Kalpakkam, December 17-19, 2003, www.indian-nuclear-society.org.in/conf/2003/2.pdf.

91. Depleted uranium fuel is manufactured at the Nuclear Fuel Complex using uranium recovered by the reprocessing plant which handles spent fuel from CIRUS and Dhruva; C. Ganguly, "Manufacturing Experience Of PHWR and LWR Fuels," Paper presented at the 14th Indian Nuclear Society Conference, Kalpakkam, December 17-19, 2003, www.indian-nuclear-society.org.in/conf/2003/8.pdf. In a PHWR at a burn-up of 1,000 MWd/tHM, the 0.7 percent U-235 in natural uranium fuel is reduced to 0.6 percent U-235, while fuel with a burn up of 7,000 MWd/tHM contains 0.2 percent uranium-235.

92. As of 2003, the Nuclear Fuel Complex at Hyderabad had produced about 76 tons of depleted uranium fuel. *Ibid.*

93. Perkovich, pp. 428-430, claims "knowledgeable Indian sources confirmed" use of non-weapons grade plutonium in one of the 1998 tests. Raj Chengappa, pp. 41-418, claims "one of the devices . . . used reactor grade or dirty plutonium."

94. J. Carson Mark, "Explosive Properties of Reactor-Grade Plutonium," *Science & Global Security*, Vol. 4, No. 1, 1993, pp. 111-124.

95. The plutonium produced by an Indian PHWR at a burn-up of 7,000 MWd/tHM, typical of power generation, is about 72 percent Pu-239 and over 22 percent Pu-240. At a burn-up used for weapons plutonium production of 1,000 MWd/tHM, the plutonium produced is almost 95 percent Pu-239 and about 5 percent Pu-240.

96. *Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Material Storage and Excess Plutonium Disposition Alternatives*, DOE/NN-0007, Washington, DC: U.S. Department of Energy, January 1997, pp. 37-39, www.ccnr.org/plute.html.

97. India's CIRUS and Dhruva and its heavy water power reactors produce tritium as a normal byproduct of their operation.

98. Perkovich, p. 427.

99. Chengappa, pp. 416-418.

100. Pallava Bagla, "On the Record: Anil Kakodkar," *Indian Express*, February 8, 2006.

101. *Ibid.*

102. The four reactors at Kaiga have also all been designated as military. This suggests that this site could eventually host a reprocessing plant and unsafeguarded breeder reactor similar to the arrangement at Madras.

103. Baldev Raj, "A Perspective on Science and Technology of Fast Breeder Reactors," Kalpakkam, India: Indira Gandhi Centre for Atomic Research, [www.igcar.ernet.in/igc2004/manuscript.ppt#376,90,Slide 90](http://www.igcar.ernet.in/igc2004/manuscript.ppt#376,90,Slide%2090).

104. India already cuts fuel assemblies into large sections prior to the chopping into small pieces that accompany reprocessing. This is done, for instance, with spent fuel assemblies from Dhruva. See M. S. Rajkumar, "Remote Technologies for Handling Spent Fuel," in *Remote Technology in Spent Fuel Management*, Proceedings of an Advisory Group meeting, Vienna, September 22-25, 1997, IAEA TECDOC-1061, 1999, pp. 35-48.

105. India plans a series of "FBR parks," each of which will have two to four FBRs, a dedicated reprocessing plant, and a fuel fabrication plant, including one at Kalpakkam. See T. S. Subramanian, "A Milestone at Kalpakkam," *Frontline*, November 6, 2004.

106. *Design of Prototype Fast Breeder Reactor*, Kalpakkam, India: Indira Gandhi Centre for Atomic Research, December 2003, www.igcar.ernet.in/broucher/design.pdf. The plutonium content of the fuel is reported to be 20.7 percent in the inner core and 27.7 percent in the outer core, with approximately 91 percent of the total power generated in the core. See D. G. Roychowdhury, P. P. Vinayagam, S. C. Ravichandar, and M. V. Sridhar Rao, "Thermal Hydraulic Design of PFBR Core," *LMFR Core Thermohydraulics: Status and Prospects*, IAEA-TECDOC-1157, June 2000, www.iaea.org/inis/aws/fnss/fulltext/1157_3.pdf.

107. "National Presentations: India," in *Primary Coolant Pipe Rupture Event in Liquid Metal Cooled Reactors*, IEA TECDOC-1406, August 2004, www.iaea.org/inis/aws/fnss/fulltext/te_1406_web.pdf. The breeding ratio is the mass of fissile isotopes produced by the reactor divided by the amount of fissile material consumed. It appears the PFBR breeding ratio was reduced to 1.049 after a redesign of the radial blanket. It had previously been given as 1.07. See S. M. Lee, S. Govindarajan, R. Indira, T. M. John, P. Mohanakrishnan, R. Shankar Singh and S. B. Bhoje, "Conceptual Design of PFBR Core," *Conceptual Designs of Advanced Fast Reactors*, IAEA-TECDOC-907, 1996, www.iaea.org/inis/aws/fnss/fulltext/28014311.pdf.

108. We assume roughly two-thirds of all fissions in the inner and outer cores are from Pu-239 nuclei, 13.5 percent are of Pu-241, and 1.5 percent are of U-235. For the inner and outer cores, we assume generic capture to fission ratios for Pu-239, Pu-241, and U-235 of 0.25, 0.1, and 0.25 respectively. See Alan E. Waltar and Albert B. Reynolds, *Fast Breeder Reactors*, New York: Pergamon Press, 1981, pp. 123-134. The actual values for the PFBR may be somewhat different.

109. We assume a core breeding ratio of 0.68 and an overall breeding ratio of 1.05. Note that Japan's Monju and the cancelled

U.S. Clinch River fast breeder reactors had core breeding ratios of 0.6-0.75. See S. Usami *et al.*, *Reaction Rate Distribution Measurement and the Core Performance Evaluation in the Prototype FBR Monju*, last updated July 5, 2005, aec.jst.go.jp/jicst/NC/tyoki/sakutei2004/sakutei17/siryu41.pdf. For this range of core breeding ratios, the PFBR would produce about 109-164 kg of weapons grade plutonium. Preliminary results from MCNP calculations on PFBR plutonium production support this range of plutonium production. Alexander Glaser private communication.

110. T. S. Subramanian, "A Milestone at Kalpakkam," *Frontline*, November 6-19, 2004, www.hinduonnet.com/frontline/fl2123/stories/20041119003210200.htm.

111. The spent fuel from the breeder would need to cool before it could be reprocessed and the plutonium recycled. Thus an initial plutonium stock for two cores, about four tons in total, is required for each breeder.

112. Matthew McKinzie, Zia Mian, A. H. Nayyar, and M. V. Ramana, "The Risks and Consequences of Nuclear War in South Asia," in Smitu Kothari and Zia Mian, eds., *Out of the Nuclear Shadow*, Delhi: Lokayan and Rainbow Publishers, and London: Zed Books, 2001.

113. R. Rajaraman, "Save the Indo-U.S. Agreement," *Hindustan Times*, November 5, 2005.

114. R. Rajaraman, "Cap the Nuclear Arsenal Now," *The Hindu*, January 25, 2005; R. Rajaraman, "Towards De-Nuclearisation of South Asia," paper presented at the 2nd Pugwash Workshop on South Asian Security, Geneva, Switzerland, May 16-18, 2003).

115. Zia Mian and M. V. Ramana, "Beyond Lahore: From Transparency to Arms Control," *Economic and Political Weekly*, April 17-24, 1999; Zia Mian, A. H. Nayyar, and M. V. Ramana, "Making Weapons, Talking Peace: Resolving The Dilemma of Nuclear Negotiations," *Economic and Political Weekly*, July 17, 2004; R. Rajaraman, "India-U.S. Deal and the Nuclear Ceiling," *The Hindu*, September 10, 2005; R. Rajaraman, "Nurturing the Indo-U.S. Agreement," in *The Debate on the Indo-US Nuclear Cooperation*, Delhi: Delhi Policy Group and Bibliophile South Asia, 2006.

APPENDIX I POWER REACTORS IN INDIA AND PAKISTAN

India. (Note: Military reactors will not be open for safeguards.)

Power reactor	Type	Gross Power (MWe)	Start-up date	Safeguards (June 2006)	Open for Safeguards
In Operation					
Kaiga-1	PHWR	220	16-Nov-00	Unsafeguarded	Military
Kaiga-2	PHWR	220	16-Mar-00	Unsafeguarded	Military
Kakrapar-1	PHWR	220	6-May-93	Unsafeguarded	2012
Kakrapar-2	PHWR	220	1-Sep-95	Unsafeguarded	2012
Madras-1	PHWR	170	27-Jan-84	Unsafeguarded	Military
Madras-2	PHWR	220	21-Mar-86	Unsafeguarded	Military
Narora-1	PHWR	220	1-Jan-91	Unsafeguarded	2014
Narora-2	PHWR	220	1-Jul-92	Unsafeguarded	2014
Rajasthan-1	PHWR	100	16-Dec-73	Safeguarded	Safeguarded
Rajasthan-2	PHWR	200	1-Apr-81	Safeguarded	Safeguarded
Rajasthan-3	PHWR	220	1-Jun-00	Unsafeguarded	2010
Rajasthan-4	PHWR	220	23-Dec-00	Unsafeguarded	2010
Tarapur-1	BWR	160	28-Oct-69	Safeguarded	Safeguarded
Tarapur-2	BWR	160	28-Oct-69	Safeguarded	Safeguarded
Tarapur-4	PHWR	540	12-Sep-05	Unsafeguarded	Military
Under Construction					
Kaiga-3	PHWR	220	2007 (planned)	Unsafeguarded	Military
Kaiga-4	PHWR	220	2007 (planned)	Unsafeguarded	Military
Kudankulam-1	VVER	1000	2007 (planned)	Safeguarded	Safeguarded
Kudankulam-2	VVER	1000	2008 (planned)	Safeguarded	Safeguarded
Rajasthan-5	PHWR	220	2007 (planned)	Unsafeguarded	2007
Rajasthan-6	PHWR	220	2008 (planned)	Unsafeguarded	2008
Tarapur-3	PHWR	540	2007 (planned)	Unsafeguarded	Military
PFBR	Fast Breeder	500	2010	Unsafeguarded	Military

Pakistan.

Power reactor	Type	Gross Power (MWe)	Start-up date	Safeguards (June 2006)
In Operation				
Chashma-1	PWR	325	13-Jun-00	Safeguarded
Karachi	PHWR	137	28-Nov-72	Safeguarded
Under Construction				
Chashma-2	PWR	325	2011 (planned)	Safeguarded

PART III:
**PAKISTAN'S NEXT SET OF NUCLEAR
HEADACHES**

CHAPTER 7

PREVENTING NUCLEAR TERRORISM IN PAKISTAN: SABOTAGE OF A SPENT FUEL CASK OR A COMMERCIAL IRRADIATION SOURCE IN TRANSPORT

Abdul Mannan

INTRODUCTION

The human desire to attain a better standard of living in terms of comfort of life has led to a concurrent demand for more energy. With conventional sources of energy fast depleting, several countries embarked upon nuclear energy programs, constructing nuclear power plants (NPPs). As of December 2005, 443 NPPs with generating capacities of 370 gigawatts (Gwe) are operating in 31 countries. In addition, 27 NPPs with total generating capacities of 22 GWe are under construction in 11 countries.¹ The reactors discharge irradiated fuel no longer able to economically sustain a chain reaction. The spent fuel contains fission products generating huge activity and producing heat energy initially after discharge. Except for possible reprocessing, this fuel must eventually be removed from its temporary storage location at the reactor site and be placed in a permanent repository. In addition to NPPs, many more have research reactors (of which there are approximately 550 in the world) and a very large number use other nuclear technologies, in particular, sealed radiation sources.

The nuclear and radioactive sources, the facilities housing such materials including spent fuel storage and fuel cycle facilities, have become an urgent source

of global concern from the nuclear and radiological terrorism perspective since the tragedy of September 11, 2001 (9/11). These concerns vary on the basis of the risk of nuclear terror acts. According to *The Four Faces of Terrorism*, a risk reduction strategy must consider the consequence and probability factors of nuclear terrorism. This stems from two assumptions in nuclear terrorism. First, modes of attack with the gravest consequences (e.g., NPPs and associated facilities) are the most difficult to execute because of robust physical protection measures and thus are less likely to occur. Second, attacks with the least consequences are the most likely to occur because of less stringent security measures compared to nuclear installations (e.g., industrial radiography sources in transportation). An Improvised Nuclear Device (IND), while clearly more effective in terms of destruction than a Radiological Dispersion Device (RDD), is more complex and therefore a less likely approach. However, most of the nuclear facilities around the world, including in the United States, would not be able to provide a reliable defense against attacks as large as terrorists have already proved that they can mount.² According to the Lugar Survey, the possibility of a weapons of mass destruction (WMD) attack against a city or other target somewhere in the world is real and increasing over time. The median estimate of the probability of a radiological attack over 10 years was twice (40 percent) as high as the estimate for a nuclear or biological attack during the same period.³ Thus a strategy should reduce the consequences of those nuclear attacks that are the most likely and limit the probability of attacks with the highest consequences.⁴

Given the above considerations, Pakistan's vulner-

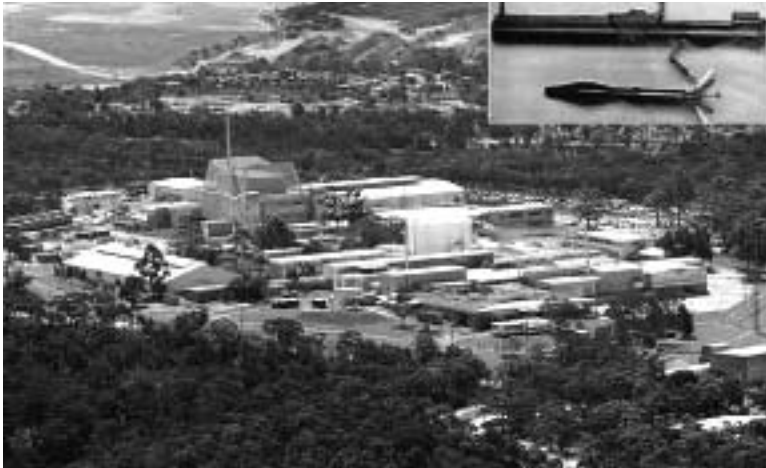
ability to nuclear terrorism and the consequences during movement of radioactive materials through two possible hypothetical case studies are reviewed. The first is a successful terrorist attack on Spent Nuclear Fuel (SNF) during transportation and shipment. This scenario is less probable because of expected physical protection measures, and SNF shipments are not anticipated in the near future in Pakistan. The second is the more likely of the two, a terrorist attack on high activity radioactive sources being transported within Pakistan.

NUCLEAR TERRORISM AND PAKISTAN'S VULNERABILITY

The threat of terrorism and possible use of nuclear, biological, and chemical (NBC) Weapons by terrorists was not ignored by many experts. On March 20, 1995, the unimaginable Tokyo subway attack made the threat real. Five coordinated attacks released sarin gas on several lines of the Tokyo subway, killing 12 people and injuring nearly 1,000 others.⁵ The attack caused massive disruption and widespread fear in a society that was previously perceived to be virtually free of crime. Considering such risk, the security levels of nuclear power plants and facilities housing nuclear and other radioactive materials were augmented. Still, Americans found the idea of large scale terrorist attacks inconceivable prior to 9/11.⁶

Richard Falkenrath, in his book *America's Achilles' Heel*, recognized U.S. vulnerability to NBC terrorism. He elaborated the consequences of an NBC attack as massive casualties, contamination, panic, degraded response capabilities, economic damage, loss of strategic position, social-psychological damage, and

political change.⁷ A recent report prepared by Nuclear Consultants of Large & Associates cited an October 16, 2005, news report entitled “Nuke Bomb Plot,” revealing that a group of terrorists acquired detailed plans of Britain’s most sensitive nuclear sites and was planning a terror attack on a major nuclear target in the United Kingdom (UK).⁸ In another event on March 22, 2006, *BBC News* reported a “List of Terror targets Revealed” where a suspected terrorist was allegedly involved in a plot to buy a “radio-isotope bomb.” The *Sunday Morning Herald* on January 6, 2007, reported, “Stolen Australian Army rocket launchers are in the hands of a home-grown terrorist group which planned to use them to attack Sydney’s Lucas Heights nuclear reactor, police allege.” (See Figure 1.)



Source: *Sunday Morning Herald*.⁹

Figure 1. Lucas Heights Nuclear Reactor.

Dr. Charles D. Ferguson commented, “The good

news is that the rockets would not have done much, if any, significant damage to the reactor. The bad news is that the emerging details of the case point to the harm that insiders can perpetrate. If Australia moves forward with ambitious plans—as proposed in the controversial Switkowski report—to build 25 nuclear power reactors by 2050, it should take adequate precautions to guard against external and internal security threats.”¹⁰ He further argued that the Australian Defense Forces have dozens of shoulder-fired *Javelin* “fire-and-forget” missiles that have lock-on targeting and infra-red (night-time) guidance, and such a long-range and high penetration that a missile fired more than a kilometer away could have penetrated the relatively thin shell of the nuclear shipping casks.

Getting hold of a nuclear weapon or successful acquisition of nuclear material and detonation of an IND by terrorists could turn a modern civilization into a smoking ruin.¹¹ Dr. Charles Ferguson outlines nuclear terrorism in four approaches:

1. Theft and detonation of an intact nuclear weapon (NW).
2. Theft or purchase of fissile material leading to the fabrication and detonation of a crude NW—an improvised nuclear device.
3. Attacks against and sabotage of nuclear facilities, in particular NPPs, causing the release of large amounts of radioactivity.
4. Unauthorized acquisition of radioactive materials contributing to the fabrication and detonation of a Radiological Dispersion Device (RDD)—a “dirty bomb”—or radiation emission device (RED).¹²

Any successful attack based on the above

possibilities would have catastrophic and far reaching consequences. The damage that can be done by a large release of fission products was demonstrated by the April 1986 Chernobyl accident. More than 100,000 residents from 187 settlements were permanently evacuated because of contamination by Cs-137. Strict radiation-dose control measures were imposed in areas contaminated to levels greater than 15 Ci/km² (555 kBq/m²) of Cs-137. The total area of this radiation-control zone was huge: 10,000 km², equal to half the area of the State of New Jersey. During the following decade, the population of this area declined by almost half because of migration to areas of lower contamination.¹³ Beyond contamination, Graham Allison cited in his article that researchers at RAND, a U.S. Government-funded think-tank, estimate that a nuclear explosion at the port of Long Beach in California would cause immediate indirect costs worldwide of more than \$3 trillion, and that shutting down all U.S. ports would cut world trade by 10 percent.¹⁴

United Nations (UN) Secretary General Kofi Annan said:

Perhaps the thing that it is most vital is to deny terrorists access to nuclear materials. Nuclear terrorism is still often treated as science fiction. I wish it were. But, unfortunately, we live in a world of excess hazardous materials and abundant technological know-how, in which some terrorists clearly state their intention to inflict catastrophic casualties. Were such an attack to occur, it would not only cause widespread death and destruction, but would stagger the world economy and thrust tens of millions of people into dire poverty. Given what we know of the relationship between poverty and infant mortality, any nuclear terrorist attack would have a second death toll throughout the developing world.¹⁵

Nuclear terrorism can be a real threat to Pakistan. Pakistan has dealt with terrorism for some time, with much of the root cause from the Soviet invasion of Afghanistan in 1979. The Soviet Union's departure in 1989 promoted further unrest as it left behind an enormous arsenal of heavy weapons and an internal conflict in Afghanistan that followed. Pakistan's renewed alliance with the United States after 9/11 has increased the threat of terrorism. General Pervez Musharraf, President of Pakistan, describes the current situation starkly in his recent book:

A deadly al-Qaeda terrorist network entrenched itself in our major cities and the mountains of tribal agencies on our western border with Afghanistan. A culture of targeted killing, explosives, car bombs, and suicide attacks took root.¹⁶

Major attacks continue in Pakistan, including the recent suicide bomber who killed at least 42 soldiers in Dargai.¹⁷ However, Pakistan had previously experienced such incidents of terrorism but these were very target specific and mostly in retaliation for some action taken domestically or outside our country. None of the terrorist actions were designed to kill populations *en masse* or to cause panic on a large scale. No such terrorist action was ever directed towards any nuclear installation, radiation facility, or other hazardous industry. However, a change in strategy of terrorists cannot be totally ignored.

As the threat of global terrorism has grown, so too has the Government of Pakistan's nuclear power program. Today it envisages an expansion in its nuclear power program from its current production capacity of 437MWe to 8,800 MWe by 2030.¹⁸ Besides nuclear power plants, two research reactors, and one

commercial irradiation plant (PARAS) at Lahore, numerous high activity radioactive sources are being used for research and development (R&D), commercial, industrial, and medical purposes. The vulnerability of these facilities to nuclear terrorism cannot be ignored, especially in the current context of Pakistan's active participation with U.S. and Western Allies in the War on Terror.

AVAILABILITY OF NUCLEAR MATERIAL AND RADIOACTIVE SOURCES

Today, there are hundreds of tons of nuclear material, not just in the former Soviet Union, but in dozen of countries around the world that remain dangerously vulnerable to theft. As a part of Nunn-Lugar and other initiatives, the United States has secured 54 percent of the buildings housing such materials, leaving still substantial work needed to be done before the target completion year 2008.¹⁹ Stocks of fissile material in the United States, in spite of higher security measures compared to other states, may be vulnerable to attack because of flaws in protective measures.²⁰ In a subcommittee hearing on April 27, 2004, an official of the National Nuclear Security Agency (NNSA) of the U.S. Department of Energy (DOE) admitted that Y-12, where the United States manufactures and maintains the world's largest repository of 400 MT of highly enriched uranium (HEU), has "some of the most difficult security problems in the complex. Its facilities were built in the early days of the cold war with no thought of the kind of threat we have now."²¹ Richard Levernier, a security specialist with the DOE, in an interview in 2003 said "in more than 50 percent of our tests at the Los Alamos facility, we got in, captured the

plutonium, got out again, and in some cases didn't fire a shot because we didn't encounter any guards."²²

Several incidents of theft involving radioactive materials have been reported. One of the most dangerous occurred in 2003 with the theft of three of the world's most potent radioactive sources—Russian “nuclear batteries”—each with the radioactive potential to make an urban area the size of the District of Columbia uninhabitable. Fortunately, thieves discarded the radioactive materials, retaining their pure metal container housing, which they planned to sell as scrap.²³ Nineteen individuals were arrested in August 2003 in Ontario, Canada, on charges of conspiring to destroy a NPP on the shore of Lake Ontario. This reflects the interest of terrorist organizations in exploiting nuclear facilities to cause grievous harm to the United States and its friends.²⁴

According to the International Atomic Energy Agency (IAEA) database on Illicit Trafficking, there have been 827 confirmed incidents of illicit trafficking through December 31, 2005.²⁵ Of the 827 confirmed incidents, 224 incidents involved nuclear materials, 516 incidents involved other radioactive materials (mainly radioactive sources), 26 incidents involved both nuclear and other radioactive materials, 50 incidents involved radioactively contaminated materials, and 11 incidents involved other materials. Of the 224 nuclear incidents, 16 confirmed incidents involved trafficking in highly enriched uranium (HEU) and plutonium (Pu). A few of these incidents involved seizures of kilogram quantities of weapons usable nuclear material, but the majority involved very small quantities.

The nuclear proliferation by A. Q. Khan was the most serious case in recent years. President Musharraf wrote, “I can say with confidence that neither the

Pakistan Army nor any of the past governments of Pakistan was ever involved or had any knowledge of A. Q.'s proliferation activities." He further wrote, "There is little doubt that A. Q. was the central figure in the proliferation network, but he was assisted over the years by a number of money-seeking freelancers from other countries, mostly in Europe, in manufacturing, procuring and distributing, to countries like Iran and Libya materials and components related to centrifuge technology."²⁶

Radioactive sources are widely used in almost every country in various applications (industrial, commercial, medical, research and development, etc.).²⁷ The facilities housing radioactive materials have lighter physical protection measures as compared to nuclear facilities, and therefore the probability of terrorist hauling away such sources cannot be ignored. Besides half-life, the activity content of a source and its relative dispersability determine its relative security risk. High activity sources which have been classified as high risks include radioisotope thermoelectric generators (RTGs), commercial irradiators, medical radiotherapy sources, and industrial radiography sources.²⁸

SPENT NUCLEAR FUEL AND RADIOACTIVE SOURCES

Among these various options and given the tight security around nuclear power plants, terrorists can target spent nuclear fuel and high activity radioactive sources in transit as they can be rich and easy radiological dispersion devices (RDD). Consequences of such an attack could be disastrous. The 400 power reactors located worldwide produced around 255,000 tons of spent nuclear fuel (SNF) by 2003, which will increase

to about 340,000 tons by 2010 and to about 457,000 by 2020. The bulk of SNF (in tons) has been generated by the United States (42,710), the United Kingdom (41,430), Canada (27,860), France (30,480), Russia (17,860), Japan (17,450), and Germany (9,660). Pakistan had generated around 240 tons through 2000. This figure will swell with the operation of two nuclear power plants to 1,180 tons by 2020.²⁹ Spent fuel from a nuclear reactor is the most radioactive type of material and constitutes most of the high level waste produced by a reactor. It is very hazardous, highly radioactive, and hot from the energy released by radioactive decay.

Of the millions of radioactive sources used worldwide in various applications, perhaps only several tens of thousands of these sources are classified as high risk sources because of their high activity, portability, and dispersibility.³⁰ Among various radioisotopes, Co-60, Cs-137, Ir-192, Sr-90, Am-241, Cf-252, Pu-238, and Ra-226 are sources of greatest security concern.³¹ Besides NPPs and two research reactors, numerous high activity radioactive sources are being used for R&D, commercial, industrial, and medical purposes in Pakistan. Appropriate steps have been taken for the last 20 years to ensure proper tracking of all radioactive sources imported into Pakistan (see Figure 4.1).³² Less than 6 percent of these sources fall within the radioactive sources classifications of IAEA categories 1 and 2 (see Figure 4.2). The sources imported into Pakistan have found applications in cancer treatments, R&D, industrial applications, etc. (see Figure 4.3). All the radioactive sources are under strict regulatory control right from import until their disposal.

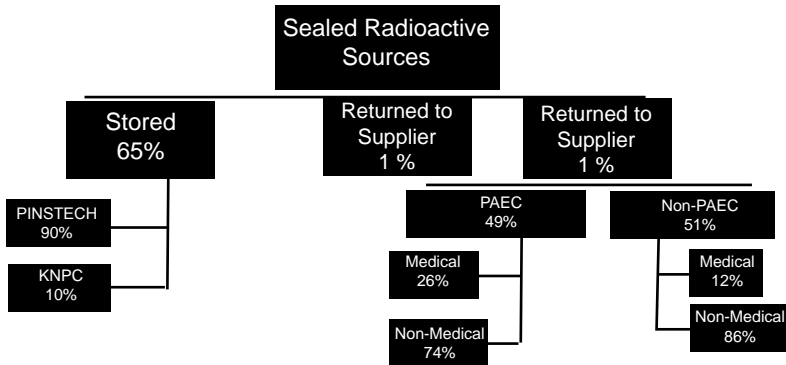
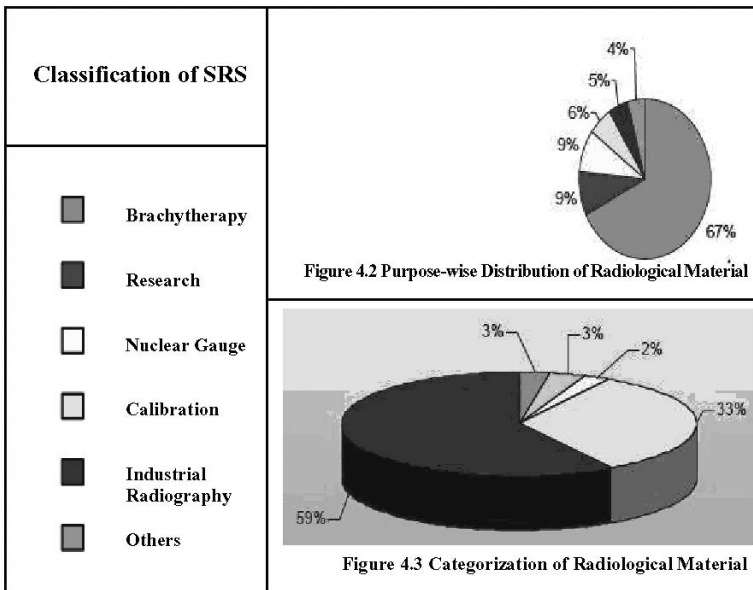


Figure 4.1 Volume of Sources in Pakistan, (Up to 2005)



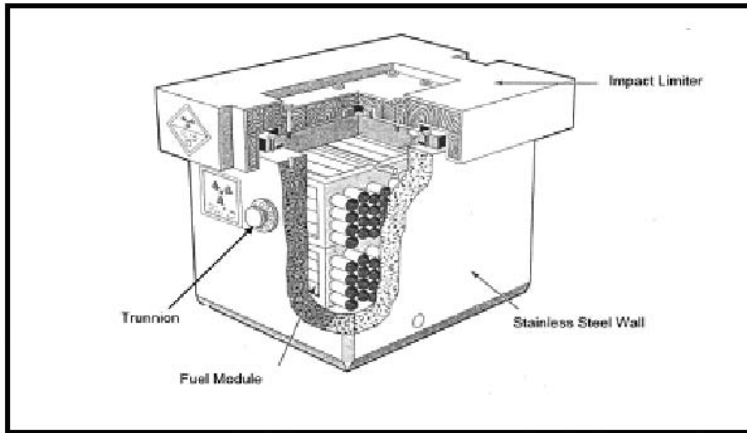
Source: From author's training courses/seminars.

The Pakistan Nuclear Regulatory Authority (PNRA) has been applying stringent measures for administrative and engineering controls over such radioactive sources from cradle to grave by the

licensees. The security of radioactive sources is ensured through periodic physical verifications and regulatory inspections.

SHIPPING CONTAINER DESIGN

IAEA transport regulations require that spent fuel transportation casks be evaluated for a series of hypothetical accident conditions.³³ These include a 30 ft (9 m) drop test, a 40 in (1 m) pin puncture drop test, and a fully engulfing fire with an average flame temperature of 1475°F (800°C) for a period of 30 minutes. In addition, the undamaged containment system of a cask must be designed to withstand an external water pressure of 290 psi (2 MPa) for a period of no less than 1 hour without collapse. Casks must maintain shielding and criticality control functions throughout the sequence of hypothetical accident conditions.³⁴ In the United States, the NRC-approved spent fuel transportation cask includes the HOLTECH HI-STAR 100 and the TransNuclear TN-68 rail transportation cask.³⁵ In Canada, transportation casks have been designed for truck and rail transport. These include two designs for transporting Canadian used fuel, the DSC, and the Irradiated Fuel Transportation Container (IFTC) (see Figure 5.1). The IFTC is a rectangular cask made of stainless steel with dimensions of 1566 mm x 1881 mm x 1697 mm. The wall thickness is 267mm and can hold 2 modules (196 fuel bundles) for road transportation.³⁶ IFTC has been designed for transportation of 2 modules (192 fuel bundles) for road transportation and each bundle contains 19kg of U.³⁷



Courtesy NWMO August 2003 by Amair Hussain & Kwansik Choi.

Figure 5.1 Ontario Power Generation's Irradiated Fuel Transportation Container.

British Nuclear Fuels (BNFL) designed, licensed, and currently owns and operates a fleet of Excellox casks. BNFL ships SNF for the United Kingdom, continental Europe, and Japan for reprocessing.³⁸

Design features such as cask materials, its thickness, cavity, and overall diameter are especially important for assessing the vulnerability of SNF and high level waste (HLW) shipments to terrorist attacks. Different shipping container designs could perform very differently in response to an attack.³⁹ Russia is working to develop a next-generation SNF storage, transport, and disposal cask system that meets modern-day requirements. Their requirements for the casks are nearly identical. The leading candidate material is DUO2-steel cermet. Bench-scale laboratory studies of this new radiation shielding material are nearing completion, and the fabrication and testing of one-quarter scale demonstration casks is planned. This new

material in the cask offers increased protection against rocket and missile attack. Thus, these new casks have the potential for superior resistance to terrorist assault compared with conventional SNF pool storage.⁴⁰

CONCERN OVER SPENT FUEL TRANSPORTATION

Materials like spent nuclear fuel and high activity sources under movement are much more difficult to defend from adversaries than materials in fixed locations. Terrorist attacks against the transportation of radioactive material can occur almost anywhere in any industrialized country. Transporting thousands of shipments of nuclear waste across a country would provide thousands of targets for terrorists, putting millions of people at risk along the transportation routes. Spent fuel is highly vulnerable, and there are several tactics terrorists can use with a higher-than-anticipated probability of breaching a shipping cask.⁴¹

Many are confident that the casks offer sufficient protection. Gail Marcus, former president of the American Nuclear Society, testified that the same features that render casks highly resistant to highway and rail accidents tend to make them difficult targets for an attack.⁴² The National Research Council also assessed the vulnerability of spent fuel in transit and concluded that "spent fuel transport containers are very robust and appear to offer similar protection against terrorist attack. Studies on the vulnerability of spent fuel transport containers to sabotage suggest that relatively little or no radioactivity would be released in the event of a terrorist attack."⁴³ The United States General Accounting Office also made an assessment:

The likelihood of widespread harm from a terrorist attack or a severe accident involving commercial spent nuclear fuel is low, according to studies conducted by DOE and NRC. Largely because spent fuel is hard to disperse and is stored in protective containers, these studies found that most terrorist or accident scenarios would cause little or no release of spent fuel, with little harm to human health. Some assessments found widespread harm is possible under certain severe but extremely unlikely conditions involving spent fuel stored in storage pools. As part of its ongoing research program and to respond to increased security concerns, NRC has ongoing and planned studies of the safety and security of spent fuel, including the potential effects of more extreme attack scenarios, including deliberate aircraft crashes.⁴⁴

Such a scenario involving Castor V/19 (PWR) and V/52 (BWR) were theoretically studied, based on a scenario in which a large commercial airliner crashed into a storage facility housing 135 SNF casks containing 170 MCi of Cs-137. A fire ensued and burned for 3 to 5 hours at 1000°C. It was estimated that about 0.04 MCi of Cs-137 would be released.⁴⁵ A still larger release could occur if a cask were attacked in such a way as to initiate and sustain combustion of the zirconium cladding of the fuel.⁴⁶

Since the 1970s, DOE and NRC have conducted several studies of the effect of an attack during the transportation of SNF. These studies found that a successful attack would have a limited effect on human health.⁴⁷ A study published by the Department of Energy's (DOE) Sandia National Laboratory in 1999 confirmed earlier studies that, under certain worst-case scenarios, NRC-certified transportation containers could be penetrated by armor-piercing weapons and release small quantities of radioactive materials.⁴⁸ NRC and DOE sponsored studies of the

1970s and 1980s were criticized by the Nevada State Nuclear Waste Project Office (NWPO). They observed that the previous analyses were inadequate as the full-scale test conducted by the DOE did not use weaponry equivalent to the currently best available armor-piercing weapons and that the NRC underestimated the health and economic impact resulting from a terrorist attack.⁴⁹ Guerilla armies around the world are known to be equipped with older anti-armor missiles such as the Soviet RPG-7 and American M72. Such weapons have the ability to penetrate up to 10-14 inches of armor plate and pose a considerable threat to a nuclear waste shipping cask.⁵⁰

Terrorists could conceivably obtain one of the 12 or more anti-tank weapons currently capable of penetrating 12 to 30 inches of tank armor. More advanced missiles like the *MILAN* (see Figure 6.1) and *Javelin* could be effective weapons to penetrate or even perforate a large transport cask containing SNF. Conceivably, the Ontario Power Generation shipping container (ITFC) with wall thickness of 26.7 cm or the HOLTEC HI-STAR 100 and the TransNuclear TN-68 rail transportation cask cannot provide any extraordinary defense against these anti-tank missiles with armor penetration capabilities exceeding 100 cm. It therefore determines the type of weapon that needs to be evaluated in a terrorism risk assessment for spent nuclear fuel and high-level radioactive waste transportation. See Table 6.1 for current portable anti-tank weapons.

Testifying for NWPO, Robert J. Halstead stated:

An attack on the GA-4/9 truck cask would likely cause complete perforation and release more than one percent of cask contents, resulting in a release of about 8,000 curies, with fission products such as Sr-90, Cs-134, and

Milan Missile

- Armor penetration capability:>1000 mm;
- Man-portability: total system weight is about 33 kg; Long range capability: maximum effective range of 2,000 meters (travel time 12.5 seconds);
- Relative ease of use: sight-on-target, semi-automatic, wire guidance;
- Relative availability: several tens of thousands have been produced and are used by a number of European, Middle Eastern, and Asian armies



Source: www.militaryfactory.com/smallarms/detail.asp?smallarms_id=44.

Figure 6.1.

Weapon	Country	Weight	Range	Warhead Ø/Kg	Arm or Penetration
Milan Anti-Tank Missile	France	32 kg	2000m	133 mm/3.12 kg	>1000 mm
Eryx Anti-Tank Missile	France	21 kg	600m	160 mm/3.8 kg	900 mm
Panzerfaust 3 Anti-Tank Launcher	Germany	13 kg	300m	110 mm/NA	>700 mm
Folgore Anti-Tank System	Italy	21 kg	4500m	80 mm/3 kg	>450 mm
Apilas	South Africa	9 kg	330m	112 mm/NA	>720 mm
RPG-7 Anti-Tank Launcher	Soviet Union	11 kg	300m	85 mm/NA	330 mm
C-90-C Weapon System	Spain	5 kg	200m	90 mm/NA	500 mm
AT-4 Anti-Tank Launcher	Sweden	7 kg	300m	84 mm/NA	>400mm
Carl Gustav M2 Recoilless Gun	Sweden	15 kg	700m	84mm/NA	>400mm
LAW 80 Anti-tank Launcher	U.K.	9 kg	500m	94 mm/NA	700mm
M72 66mm Anti-tank Launcher	USA	4 kg	220m	66mm/NA	350mm
SMAW	USA	14 kg	500m	83mm/NA	>600mm
AT-8 Bunker Buster	USA	8 kg	250m	84mm/NA	NA
Superdragon Anti-tank Missile	USA	17 kg	1500m	140mm/10.07kg	>500mm
TOW 2 Anti-tank Missile	USA	116 kg	3750m	127mm/28kg	>700mm
Javelin AAWS/M	USA	16 kg	2000m	127mm/NA	>400mm

Source: Large and Associates

Table 6.1. Current Portable Anti-tank Weapons.

Cs-137 constituting over one-third of the total curies, and Pu-241 20 percent or more. The consequences could be much greater if the attack involved more than one missile or explosive device, or if the attack included use of an incendiary device, or if the attack were accompanied by a fire from combustion of the vehicle fuel supply or another fuel source. Such exacerbating factors could result in (1) a potentially larger percentage release of cask contents, possibly as great as 10 percent; (2) a potentially higher percentage of respirable particulates and/or vaporized radionuclides; and (3) potentially more widespread dispersal and deposition.⁵¹

In another testimony on April 25, 2002, Dr. James D. Ballard stated that the transportation effort, as it was proposed, would ensure a target rich environment wherein a terrorist could plan, pick, and chose the time and place for an attack. He argued that:

If the transportation vehicle were to be captured, placed in an immobile state by any number of means, or once acquired it was able to be moved at will by the terrorists, it would be susceptible to the application of explosives and/or a human engineered breach. Thus, the cargo could become a radiological dispersion device if the attackers where to breach the cargo shielding and release the radioactive contents into the environment.⁵²

In the aftermath of a July 2001 incident in the Howard Street Tunnel in Baltimore, Radioactive Waste Management Associates prepared a study that concluded that, had SNF casks been part of the train involved in that accident, the fire in the tunnel would have resulted in a release of contaminating radiation throughout a section of the city.⁵³ In March 2003, the NRC released a similar report on the Baltimore tunnel incident and the hypothetical consequences if a SNF cask had been involved.⁵⁴ It concluded that an SNF

transportation cask, approved under NRC rules for packaging and transportation of radioactive materials (10 CFR 71), subjected to the conditions encountered in the Howard Street tunnel fire would not release radioactive materials. In addition, the health and safety of the public would have been maintained.⁵⁵

INVENTORY OF RADIONUCLIDES IN SPENT-FUEL

Although a number of isotopes are of concern, we focus here on the fission products namely Kr-85, Sr-90, Pu-241, Cs-134, and Cs-137, which constitute around 90 percent of activity in 10-year-old SNF. Of these, Cs-137 has a 30-year half-life, is relatively volatile, and along with its short-lived decay product, Ba-37 (2.55 minute half-life), accounts for about half of the fission-product activity in 10-year-old spent fuel.⁵⁶ The activities of Kr-85, Sr-90, Pu-241, Cs-134, and Cs-137 contained per cask of PWR spent fuel after 10 years from the discharge from the core with average burnup have been estimated from the reported values of activities per ton of spent fuel (Table 6.2).⁵⁷ Similarly, the activities of the above radionuclides contained in PHWR Cask have been estimated and presented in Table 6.3. Cs-137 content has been estimated per ITFC Cask as $7.09\text{E}+4$ Ci which is lower by a factor of more than 2.5 as compared to PWR Truck Cask activity of $1.89\text{E}+5$ Ci, owing to lower burnup and enrichment factors.⁵⁸

DISPERSION MODEL

Several computer codes have been used to model the dispersion of radionuclides into the atmosphere. For the simple scenarios as modeled in this chapter, the most commonly used is the HOTSPOT computer code

Radionuclides	Activity after 10 Years	
	Ci/tU	Per Truck Cask (Ci) (1.604tU/cask)
Kr-85	6.76E+03	1.08E+4
Sr-90	8.11E+04	1.30E+5
Cs-134	8.11E+04	1.62E+4
Cs-137	1.18E+05	1.89E+5
Pu-241	9.89E+04	1.60E+5
Total	3.51E+05	5.62E+5

Table 6.2. Estimated Inventory, by major radionuclide, of reference PWR Spent Fuel Medium Burnup, 10 years cooling period.

Radionuclides	Activity after 10 Years	
	Ci/tU	Per Truck Cask (Ci) (3.648tU/cask)
Kr-85	1.15E+03	4.20E+03
Sr-90	1.30E+04	4.73E+04
Cs-134	6.95E+02	2.53E+03
Cs-137	1.94E+04	7.09E+04
Pu-241	1.35E+04	4.92E+04
Total	5.46E+04	1.99E+05

Source: Electrowatt-Ekono (UK) Ltd.

Table 6.3. Estimated Inventory, by major radionuclide, of reference PHWR Spent Fuel Medium Burnup, 10 years cooling period.

developed by U.S. Lawrence Livermore Laboratory and first released in 1985. It provides emergency response personnel and emergency planners with an instantaneous set of results for evaluating incidents involving radioactive material. The HOTSPOT user documentation suggests that if D is the calculated radiation, then 50 percent of the time, the true dose should lie between $D/3$ and $3D$.⁵⁹ Later on (Mid 1990s), the HPAC was employed to predict the effects

of hazardous material released into the atmosphere and its impact on civilian and military targets.⁶⁰ HPAC has the capability to include terrain, land-cover, and detailed meteorological data for increased accuracy, but can also be used without any of the above, making it quite flexible in operational use. Despite the major differences in the transport and diffusion models used in HPAC and HOTSPOT, the results of very simple scenarios are similar.⁶¹ A reasonable agreement between the two models was also observed in our studies using the source terms of SNF. The two dose curves are quite close together at the site of the incident; however, large differences of an order of magnitude between the two were observed up to 10 kilometers downwind (as much as a factor of D/3 and 3D). Given the greatest relative variability in the Gaussian plume model with increasing distance, further disagreement in the results beyond 10 kilometers distance were observed (see Figure 6.2).

Given the ability to interface with online information on geographical locations of the incident, meteorological conditions, and population data, and applying these to reliably predict the deposition of radioactive material to the surface and estimate any residual hazard, HPAC was used to analyze radiological scenarios involving both the scenarios of RDDs. Since the HPAC built-in option is restricted to predict dispersion of PWR spent fuel, the necessary correction factor was applied to the PWR SNF source terms to model dispersion of PHWR SNF as discussed previously (Tables 6.2 and 6.3). The population dose was calculated by superimposing acute-dose isopleths onto a map of Karachi and Lahore.

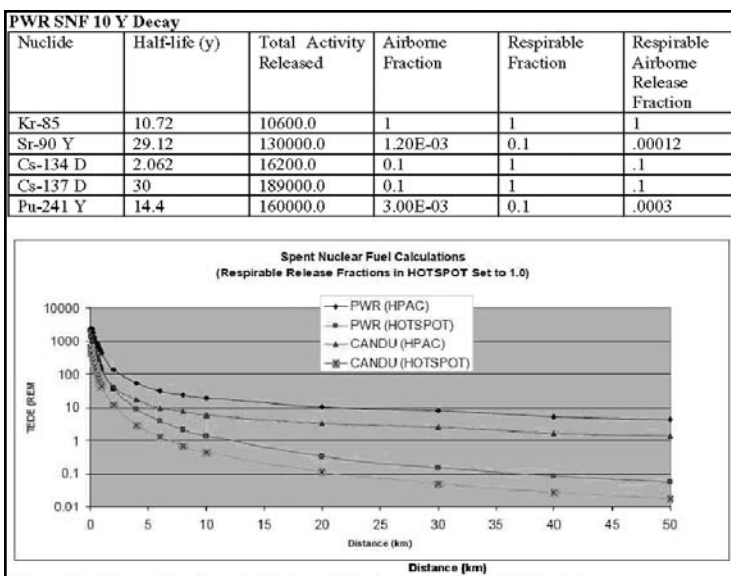


Figure 6.2. Release Fractions for Radionuclides in the Spent Fuel Calculations.

HYPOTHETICAL CASE STUDIES

In order to illustrate trends of how radioactivity could be released from a damaged flask and possible consequences during transportation within Pakistan, we consider two hypothetical scenarios. The first scenario is the sabotage of a truck containing a cask of SNF within a populous city like Karachi. The second is the sabotage of a truck containing 200,000 Ci Co-60 source near Lahore.

SCENARIO AND SOURCE TERM

Scenario I (SNF at Karachi).

While RDD attacks can be carried out with any source of radioactivity, SNF constitutes a potential

source of concern all over the world including in Pakistan. Transporting SNF to a central storage or repository must have serious security considerations from a sabotage point of view.

As described earlier, while a Type B SNF Flask is designed to keep its integrity under fire at 800°C for 30 minutes, it may eventually fail in a fire involving higher temperatures and a longer duration.⁶² I assume that a terrorist carries out “hybrid sabotage” on the radioactive consignment transported in a truck as compared to the study by Luna, *et al.*⁶³

The study estimated a maximum of 0.01 percent release by taking into consideration the blowing down effects in damaged fuel resulting from the attack. Furthermore, the release levels have been criticized by several independent experts as the study was too narrow in the sense that only a single limited attack is considered using a single High Energy Density Device (HEDD) missile (see Figure 7.1). A case of multiple missile firings involving weapons with much higher penetration power coupled with an additional truck bomb collision may have catastrophic effects. Similarly, the consequences would be greater if the attack included an incendiary device or was accompanied by a fire from igniting the vehicle’s fuel supply or another nearby fuel source.⁶⁴



Source: en.wikipedia.org/wiki/Shaped_charge.

Figure 7.1. Shape Charge, Courtesy of Journal of National Defense.

These additional factors could result in:

1. A potentially larger percentage release of cask contents, possibly as great as 10 percent.
2. A potentially higher percentage of respirable particulates and/or vaporized radionuclides.
3. A potentially more widespread dispersal and deposition.

A less sophisticated but effective approach to increasing radionuclide release from a breached SNF cask would be to inject fuel into the cavity and ignite it. This would cause ignition of the zircaloy cladding, and at a minimum would greatly enhance the release of cesium and other semi-volatile elements that remain in the fuel pellets. The BNL spent fuel pool study assumed that 100 percent of the fuel Cs inventory would be released. Recent results from France indicate that heating at 1500°C of high-burnup spent fuel for one hour caused the release of 26 percent of the Cs inventory.⁶⁵

Based on the above hypothesis, a scenario is set where terrorists with the convenience of an insider are able to get information on an SNF movement. The terrorists carry out multiple missile firings on the truck cask (see Figure 7.2) while the truck is stationed for the repair of one of its tires at a petrol pump (see Figure 7.3) located in a congested location in Karachi (see Figure 7.4). The cask has a breach of containment followed by an engulfing fire for several hours. The explosive attack followed by a fire leads to increased radioactive release.⁶⁶



Source: en.wikipedia.org/wiki/Spent_nuclear_fuel_shipping_cask.

**Figure 7.2. A Typical Small SNF Shipping Cask Being Mounted on a Truck.
(Courtesy of Nuclear Energy Institute.)**

Scenario I: Spent Nuclear Fuel (SNF)

- Terrorist get information on the movement of SNF from an insider
- Terrorists carry out a “hybrid attack” on the transport truck while it was stationed for the repair of one of the tires of the vehicle at a petrol pump in a congested location in Karachi
- Multiple missiles are fired on the truck cask which results in a breach in containment
- This is followed by a fire that engulfs the cask for several hours



Source: en.wikipedia.org/wiki/Pakistan_state_oil.

Figure 7.3.



Figure 7.4. Karachi, Coutesy of Google Earth.

Firing missiles at the consignment will trigger explosions and fires at the station. A country like Pakistan is not well equipped to deal with fire involving a consignment containing mega curries of radioactive source. On November 7, 2005, in Karachi, cotton bales, toys, and tires worth thousands of rupees were gutted when fires broke out separately in three warehouses in SITE, Lee Market, and New Chali. Meanwhile, another office burned in a separate fire incident. Seven to ten firefighters were rushed to the sites and controlled the fires in 5 to 10 hours or longer.⁶⁷

In this case, it could pose serious difficulties due to the radioactive nature of the hazards encountered. It is therefore assumed control of the blaze would take 6

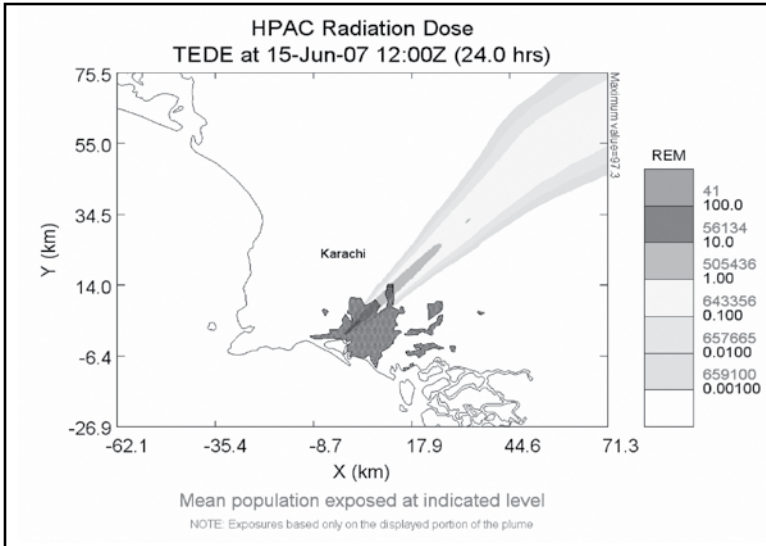
hours. Based on the foregoing discussions, this would lead to a release of 10 percent of Cs inventory as a conservative estimate. A respirable release fraction of 3×10^{-4} for Pu-241 and 1×10^{-4} for Sr-90 is used, recommended as an upper limit for use in safety assessment studies involving chunks of plutonium exposed to hydrocarbon fuel fires.⁶⁸

Dispersion And Consequences.

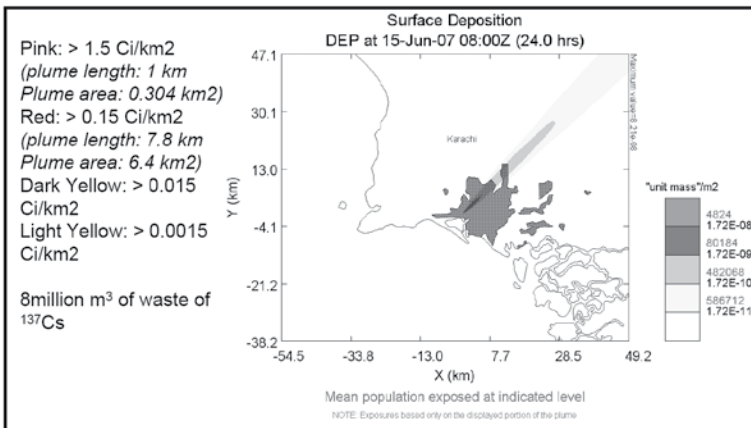
In the first scenario, we consider the sabotage involving a truck cask containing PHWR fuel assemblies leading to release of radionuclides in the heart of the city of Karachi at daytime at 12:00 hr on June 15 (see Figure 7.5a). The debris cloud is lifted 562 m high (using HOTSPOT Code) which is expected to be further elevated by fire. The contaminated region includes hundreds of industries, residential row houses, crowded shopping areas, school, colleges, and several mosques. Within an area of 0.304 km^2 , maximum total effective dose equivalent TEDE (100 Rem)⁶⁹ is predicted by the model due to release of radionuclides from the breached flask containment only, which is far below the level to cause acute radiation syndrome. However, exposure in the immediate vicinity of the blast to a high radiation field of around 250 Gy/h at one meter distance due to the remaining 90 percent Cs-137 still contained in the breached SNF Flask, cannot be ignored, thereby creating a difficult situation for the first responders.⁷⁰ Whole body exposure to 2000 rem without any post exposure treatment may damage the central nervous system within minutes and cause death in hours to days.⁷¹

Any attempt to approach the damaged flask without any protective measures would result in acute

exposure within a few minutes. The wind blowing (WSW) at an average speed of 6.7 m/s disperses the radioactive aerosols to 36 kilometers from the blast location contaminating the population externally as well as internally to a dose contour down to 1 Rem in approximately 167 km² area in around 4 1/2 hours time (see Figure 7.5b). Consequences of radiation effects due to a single exposure to population groups has been estimated on the basis of the BIER VII lifetime risk model which predicts that approximately one individual in 100 persons would be expected to develop cancer from a dose of 10 rem [0.1 Sv] while approximately 41 individuals would be expected to develop solid cancer or leukemia from other causes.⁷² In general, the magnitude of estimated risks for cancer fatalities is not different from the International Commission on Radiological Protection (ICRP) estimates of 5 percent probability of occurrence of cancer per sievert for whole-body irradiation.⁷³ Based on single exposure, cancer morbidity and fatality were estimated for various population groups exposed to radiation levels of 100 Rem down to 1 Rem using the BIER VII lifetime risk model, as presented in Table 7.1. The HPAC Model predicts about 41 persons receive high exposure of 100 Rem within a dose contour area of 0.4 km². The number of exposed persons increases to 56,134; 505,436; 643,356; 657,665, and 659,100 to radiation levels of 10, 1, 0.1, 0.01 and 0.001 Rem respectively, living in dose contour areas of 4.6, 167, >800, >900 and >900 km² areas. Cumulative excess cancer fatality has been estimated to be 649 out of 2,521,732 exposed population. In other words, there would be an increase of 0.13 percent in cancer fatalities due to the incident as compared to deaths due to other circumstances.



**Figure 7.5a. Karachi Spent Nuclear Fuel Scenario:
10% of Truck Cask of CANDU-SNF; Historical
Weather Data; Actual Population.**



**Figure 7.5b. Karachi Spent Nuclear Fuel Scenario:
10% of Truck Cask of CANDU SNF; Historical
Weather Data; Actual Population.**

Facts					
Karachi, Pakistan					
1,000 lbs. TNT					
160kg PWR SNF (64 kg CANDU SNF)					
June Historical Weather Data					
Actual Population Figures					
REM	Persons	Excess Cancers	Excess Cancers Fatalities	Dose Length (km)	Dose Contour Area (km ²)
100	41	17	8	<0.1	0.4
10	56,134	637	320	5.7	4.6
1	505,436	574	288	36	167
.1	643,356	73	37	>50	>800
.01	657,665	7	4	>50	>900
.001	659,100	1	0	>50	>900
Totals		1,292	649		

Table 7.1. Radiation Effects.

The extent of contamination will be a major challenge because Cs-137 is highly water-soluble and chemically reactive with a wide range of materials, including common building materials such as concrete and stone. The contamination will settle on streets, sidewalks, building surfaces, and personal property—including vehicles and items inside buildings. In such a situation, the recovery/remediation/restoration measures have been documented in a Homeland Security draft document.⁷⁴ The document suggests measures for surface, interior, and roof decontamination of most buildings, major thoroughfares, sidewalks, and the water treatment plants as quickly as possible, repavement of streets, removal of surface soil and vegetation for disposal, and replacement with fresh material. Moreover, secondary events may lead to a release of hazardous chemicals, and fires on ruptured gas lines may complicate the situation requiring immediate remedial actions. In

such an event, the city transportation system is severely affected and would require continuous monitoring to restrict further spread of the contamination. Hospitals, already at maximum capacity with injuries from the blasts, are inundated with “worried well,” most of whom were not in the blast or plume zone but are concerned about health issues. The sewage treatment plant is quickly contaminated as a result of people showering and decontaminating personal effects.

Currently, the Cs-137 level in most parts of Pakistan including Karachi is not well-defined. However, areas in the former Soviet Union contaminated by the Chernobyl accident have been defined with reference to the background level of Cs-137 deposition caused by atmospheric weapons tests which, when corrected for radioactive decay to 1986, is about 2 to 4 kBq m² (0.05 to 0.1 Ci km²). Considering variations about this level, it is usual to specify the level of 37 kBq m² (1 Ci km²) as the area affected by the Chernobyl accident. Approximately 3 percent of the European part of the former USSR was contaminated with Cs-137 deposition densities greater than 37 kBq/m².⁷⁵

In terms of deposited contamination (see Figure 7.5b) the contamination level above 1Ci/km² would require decontamination action out to 1 km and further as foot and vehicular traffic transfer contamination for hours afterward until the entire scene has been effectively controlled and cordoned, contributing to contamination spread beyond the deposition zone. Waste produced as result of decontamination following a hypothetical spent fuel accident is likely to fall into the lowest of the U.S. NRC’s categories of low level radioactive waste, Class A, in which Cs-137 has a concentration less than one Ci/m³.⁷⁶ Based on the estimation of 90 m³ per person, a population of 4,824

living in an area of around 0.304 km² (see Figure 7.5b) are likely to generate waste around 0.4 million m³ of Cs-137.

Scenario-2 (High Activity Radioactive Source at Lahore).

Terrorists carry out multiple missile firings on a truck cask carrying 200,000 Ci of Co-60 near Lahore (see Figure 7.7), followed by further immediate attack with a fully laden road petroleum tanker hijacked and brought to the incident site to fuel a fire (see Figure 7.6). This could lead into a situation even worse than the December 12, 2006, incident when terrorist detonated a truck loaded with 440 pounds of explosive in Baghdad, killing 71 laborers and wounding 220 others.⁷⁷


Scenario II: High Activity Radioactive Source	
<ul style="list-style-type: none">• Similarly, terrorist gain information on a consignment of 200,000 Ci of Co-60 being moved.• Terrorists carry out multiple missile firings on the truck cask near Lahore.• Immediately after the initial attack, a hijacked petroleum tanker truck is brought to the incident site to fuel a fire.	

Figure 7.6. Picture Courtesy of MDS Nordion.

Consequences of dispersion of 200,000 Ci of Co-60 with an explosive power equivalent to that of 440 pounds of TNT were analyzed by HOTSPOT and HPAC. HOTSPOT code using Sandia National Laboratories Blast Model reveals a safe distance of 678 meters for unmitigated blast damage. Although, a 200,000 Ci Co-60 source without a shielding would give rise to a dose of around 1.3E+3 Gy/h at a distance of one meter,

due to dispersion effect maximum dose contour of 10 Rem was estimated by HPAC encompassing an area of 0.087 km² up to a distance of 0.5 km from the blast site (see Figure 7.8a).⁷⁸ Within this dose contour of 10 Rem, a person is neither expected to die nor to suffer from acute health effects; however, casualties comparable to that of Baghdad incident could be expected due to the blast effect.⁷⁹ Survivors from within the highest dose area could carry radioactive contamination back to their homes and contaminate their neighbors and families (see Figure 7.8b). Panic and disinformation may lead to a massive exodus of people from Lahore city into neighboring towns and cities. Additionally, the cobalt plume would contaminate a vast area to levels requiring cleanup and destruction of residential, commercial, as well as agricultural lands. Cleanup efforts and destruction of property and land would generate huge amounts of waste. Assuming 90 m³/person of waste generation for Co-60 as well, the total waste is expected to be around 12.6 million metric tons.⁸⁰ Application of BEIR VII cancer risk estimates for single exposure reveals excess cancers of 17 out of 1,498 exposed population, 202 out of 17,792 exposed population, 86 out of 75,930 exposed population, 11 out of 10,081 exposed population due to dose contours of 10 rem, 1 rem, 0.1 rem, and 0.01 rem out to distances of 0.5 km, 5.3 km, 24.9 km, and 155 km respectively. Of these, cancer fatalities of around 160 (almost 50 percent suffering from excess cancer) are expected (see Table 7.2).⁸¹



Figure 7.7. Lahore High Activity Radioactive Source Scenario, Courtesy of Google Earth.

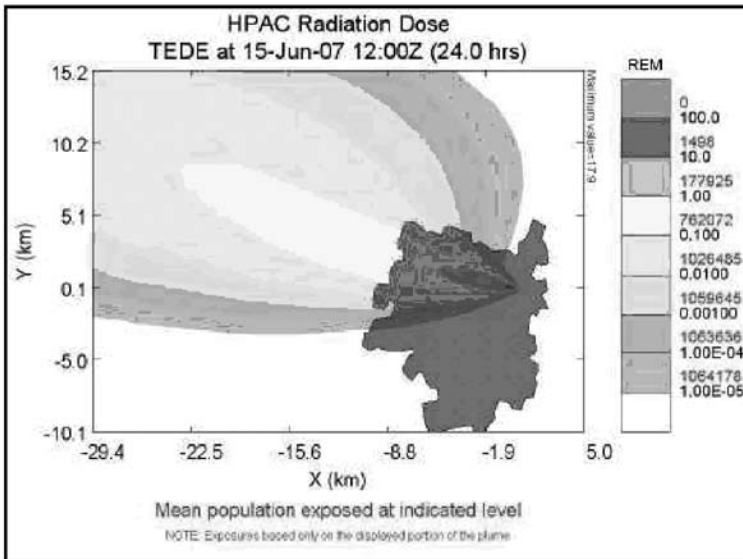


Figure 7.8a. Lahore High Activity Radioactive Source Scenario; Historical Weather Data; Actual Population.

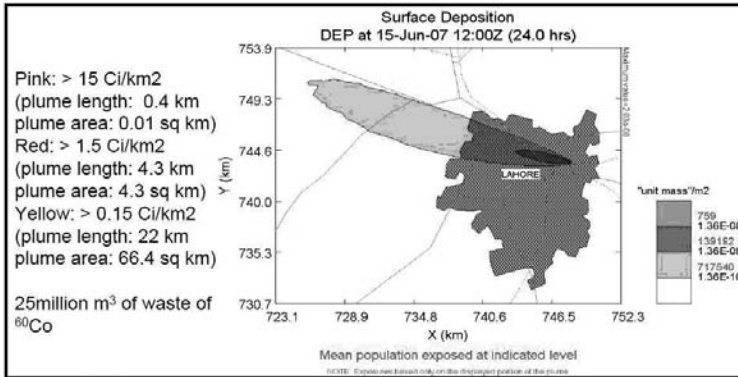


Figure 7.8b. Lahore High Activity Radioactive Source Scenario; Historical Weather Data; Actual Population.

Facts					
Lahore, Pakistan					
440 lbs. TNT					
200,000 Ci Co-60					
June Historical Weather Data					
Actual Population Figures					
REM	Persons	Excess Cancers	Excess Cancers Fatalities	Dose Length (km)	Dose Contour Area (km ²)
10	1498	17	9	.5	.087
1	17792	202	101	5.3	3.9
.1	75930	86	43	24.9	77.17
.01	10081	11	6	155	3028.43
.0001	10395	1	1	300	33026.2
Totals		317	160		

Table 7.2. Radiation Effects.

ADDRESSING PAKISTAN'S VULNERABILITY

The Federal Government has tasked the Pakistan Nuclear Regulatory Authority (PNRA) with the physical protection of nuclear and other radioactive material. The PNRA has initiated towards the last

quarter of 2006, a 5-year National Nuclear Safety and Security Action Plan (NSAP) to establish a more robust nuclear security regime. It seeks capacity growth in Pakistan's ability to plan for, respond to, and recover from terrorist incidents in collaboration with relevant governmental agencies.

The salient features of the plan cover five areas.

SECURE RADIOACTIVE SOURCES OF GREATEST CONCERN

Of the approximately 140 firms that handle radioactive sources in government and private sectors, a third interact with "Greatest Concern Sources." Periodic inspections of these facilities revealed a need to upgrade security. Inspections must be more frequent, carried out at least quarterly to biannually depending on the category and vulnerability. A follow-up mechanism would ensure issues are addressed promptly.

It is necessary to add Inspectorates to the already existing PNRA Regional Directorates located at Islamabad, Chashma, and Karachi. Additional Inspectorates at Peshawar, Multan, and Quetta are proposed within the Regional Nuclear Safety Directorates I, II, and III. There will be an addition of 18 inspectors over the next 5 years, with increases to support staff.

Inspectors will require radiation survey, communication, and secretarial equipment in addition to suitable vehicles. Personnel would be trained to required competencies in radiation protection, use of radiation survey equipment, identification of sources, and regulatory requirements. Beyond inspectors, an education program for the licensees and their staff is needed to propagate a security culture.

ESTABLISH A PNRA NUCLEAR SAFETY AND SECURITY TRAINING CENTER

The PNRA would be the focal point of training in nuclear safety and security. This Center would require laboratories with appropriate state-of-the-art equipment and at least six officers and supporting staff.

To start, a few select senior PNRA staff would be trained in appropriate institutions and centers in collaboration with the IAEA. They would then be responsible for developing the training modules for the Center and establishing its needed infrastructure. They would then educate trainers, having a “multiplier” effect.

New junior officers would be trained in review, assessment, and inspection techniques. Externally, first responders expected to deal with radiological emergencies would be trained in the identification and handling of radioactive sources as well as emergency management skills. The Center would continuously facilitate this training throughout Pakistan due to the significant rotation and redeployment of first responders. Additionally, the Center would provide consultation and evaluation to licensees. Further, the Center would have a research role in techniques and technologies in nuclear safety and security.

ESTABLISH NATIONAL NUCLEAR SECURITY EMERGENCY COORDINATION CENTER

A National Nuclear Security Emergency Coordination Center (NuSECC) would assess, respond, and coordinate in case of a nuclear security emergency at

the national level. It would track all movements of large radioactive sources in Pakistan. The center would be manned 24 hours a day with at least six officers and support staff. It would also establish six mobile monitoring laboratories, distributed and located at each of the regional Directorates and Inspectorates.

LOCATE AND SECURE ORPHAN RADIOACTIVE SOURCES

An “orphaned source” is material that poses a sufficient radiological hazard to warrant regulatory control but never was controlled because it was abandoned, misplaced, stolen, or otherwise transferred without proper authorization. It is unknown how many orphaned sources there are in Pakistan. Sources and/or their containers can be attractive as valuable metals and may not display a radiation warning label. Unsuspecting victims might tamper with these sources causing injury or even death.

The risk to the public and the risk of their possible malicious use will be addressed. The strategy would involve launching a public campaign seeking information on orphan sources, nonphysical/physical searches, and finally, eventual recovery, secure storage, and disposal.

DEPLOY RADIATION DETECTION EQUIPMENT WIDELY

None of the major points of entry in Pakistan have radiation detection devices. Thus, we remain unaware of any radioactive/nuclear material moving in or out. It is proposed to provide these systems, perhaps in a phased program. Initially one radiation monitoring

instrument at each point of entry supplemented later by vehicle/pedestrian portal monitoring equipment where needed. Fixed detectors may be installed at airports. Random inspection of personnel luggage may also be carried out.

In addition, law enforcement and local governments need to have this equipment as well. They would be the first to survey incidents to determine if they were nuclear or radiological. Such equipment would be needed at the district level for a swift response. The PNRA would be responsible for preparing the equipment and training. The installation, operation, and maintenance would be the responsibility of other agencies.

RECOMMENDATIONS

Population Protection.

In the event of a successful RDD, the following measures may be taken to protect the population:⁸²

- Recommend all persons who were outside during the attack to shower and change clothes.
- Temporarily limit time spent outside.
- Temporarily stay in a basement or shelter; staying inside a house offers a safety factor of approximately 10.
- Limit the consumption of certain agricultural products.
- Ban harvesting, putting livestock out to pasture, hunting, and fishing.
- Recommend temporary evacuation.
- Have a definitive relocation of the affected population.

Strengthening Transportation Security.

Based on our current studies, the following recommendations are presented to improve security measures to cover a range of activities involving transportation of high risk sources.

Prevention. PNRA has taken stringent measures for the physical protection of nuclear facilities and radioactive sources. A cradle to grave concept is applied for preventing any radioactive source from getting out of regulatory control. Besides these considerations, preplanning and intelligence gathering are very important through well-developed and coordinated efforts of various agencies to deter, detect, and thwart a possible sabotage attempt.⁸³ The agencies should keep track of terrorist groups, their financial resources, and their linkages with the outside world; and assess their potential to engage in nuclear terrorism. Information sharing, especially with neighboring states, on activities of groups likely to engage in nuclear terrorism will be useful. Moreover, prevention efforts should also include measures to prevent illicit trafficking by monitoring at border cross points.

Transportation. Nuclear materials and high risk sources requiring shipment from one place to another should employ dedicated governmental vehicles driven by official drivers with proven trustworthiness. Authorization for simultaneous shipment of high risk sources within a city should be avoided to evade multiple sabotage events leading to dilution of an effective emergency response system. This measure would allow authorities to focus on only a single post radiological event and pool their resources to effectively implement and mitigate the consequences

Control over Missiles. Any successful sabotage event

and consequences would primarily depend on three factors, namely, RDD material, the missile, and fuel for fire. Therefore, effective control measures are needed against theft or illicit trafficking of portable anti-tank weapons.

Emergency Operations Center and Emergency Plans. PNRA's NRECC—an emergency operations center—is manned around the clock to receive national as well as international information regarding events related to nuclear or radiological incidents and to assist in national emergency response activities. However, the center has to develop capabilities for evaluating potential consequences of various threats to radioactive consignment during movement as well as transit and subsequent radiological impact. Based on threat assessment, the center has to perform emergency exercises to counter terrorism. Such exercises may include scenarios like dirty bombs, stolen radioactive material, sabotage of nuclear and radiation facilities, and sabotage during movement and transit of nuclear and high risk radioactive materials. It should also learn from national (e.g., earthquake of October 8, 2005, in Azad Kashmir and North West Frontier of Pakistan) and international experiences (e.g., U.S. Katrina havoc of 2004) of handling natural disasters in order to enhance its response capabilities in coordination with relevant national agencies in case of nuclear terrorism. PNRA should continue to interact with appropriate stakeholders to continually improve emergency preparedness capabilities at all levels. The Center, in coordination with national agencies, should have capabilities for emergency assessment and diagnosis of the sabotage event, for management, response, hazard mitigation, victim care, and for guiding advice on evacuation or shelter options. Decisionmakers

need to know what steps are taken automatically, and the nuclear regulatory authority needs to be present at the table with the decisionmakers; local leaders need to be in direct contact with national leaders; and the most important lesson is that all the systems must be exercised regularly.

Emergency Exercises at the Top Level. Top governmental level exercises of credible nuclear terrorism scenarios are often overlooked.

Sheltering and Evacuation. In an incident in an urban area like Karachi or Lahore, the estimated numbers of citizens affected by the release and dispersion of radioactivity and requiring shelter or even evacuation would depend on the prevailing weather conditions. Based on the assumption that during the event 90 percent of the public are indoors and thus are already sheltering at a 50 percent reduction in dose uptake, the additional benefit of implementing the organized sheltering countermeasure only applies to 10 percent of the potentially exposed population.⁸⁴ However, advice from the authorities regarding shelter and evacuation on the basis of national emergency reference levels might lead to a panic situation prompting a mass self-evacuation. If the public undertakes self-action, particularly self-evacuation, many more are likely to be on the streets without much protection and/or in poorly shielded vehicles and, indeed, some may unknowingly move into contaminated areas becoming trapped for hours in the jams and traffic chaos that are almost certain to arise. In such circumstances, the public may receive a greater radiation exposure than if, generally, they remained indoors. Therefore, unless adequate infrastructure is in place, a sheltering or evacuation directive may have counterproductive effects.

Robust e-Communication. Robust and direct electronic communication is needed between PNRA to share information amongst federal/provincial/local officials.

Credible Information. A designated, credible spokesman is needed that can deliver a statement shortly after an incident and can exchange credible real time information with all concerned agencies.

Crisis Management. A crisis management team is needed to handle the current situation as well as to preplan and organize in order to possibly deter another event at an unknown location.

Public Education. In order to minimize confusion and chaos, it is necessary to create public awareness about the potential effects of nuclear terrorism. This involves integrating the official and unofficial media to disseminate information and encourage public confidence without causing unnecessary panic. The use of the civil defense warning sirens and loud speakers at mosques may be used to alert people and to advise them to check the radio or television for further information.

Personnel Reliability Program. A personnel reliability program has to be an integral part of any nuclear security infrastructure. The elements of PRP have been described as,

several lines of inquiry to develop a comprehensive picture of the individual in question. A background check is conducted to verify identity, credit history, criminal history, reputation, and character. Psychological and medical screening are used to evaluate the mental health and stability of the individual; depression, schizophrenia, epilepsy, high/low blood pressure, and other disorders are all taken into consideration. Additionally, a detailed interview to verify background information and elucidate other potential concerns

is conducted at the time of employment or when a sensitive task is being assigned. Periodic reviews of job performance and coworker interaction are a standard means of ensuring that an employee's reliability remains high over time, and an individual's after work activities may also be monitored. The following occurrences may result in decertification for nuclear duty: alcohol abuse/dependency, drug abuse, conviction of or involvement in a serious incident, an adverse medical—physical and mental—condition or serious progressive illness, lack of motivation, and suicide attempt or threat.”⁸⁵

The efficacy of any transport security system specially dealing with nuclear materials and high risk sources would depend on the training, reliability, and integrity of the individuals, without which the system would remain vulnerable.

Non-nuclear Terrorism. Even during a case of a catastrophic non-nuclear sabotage event, radioactive consignment under shipment should be reassessed and until such time, all movement should be halted and shipments secured in a safe place.

CONCLUSION

The advancement in the knowledge of science and technology and their accessibility to terrorists has made the threat of nuclear terrorism no longer a fiction but real, especially considering terrorists' intention to inflict catastrophic damage to man, environment, and property. Pakistan is not considering reprocessing and therefore there may be no need for transportation; however, the case study, based on several low probabilities of sabotage events of spent fuel and high activity sources, has revealed that an explosion and subsequent fire would cause hundred of deaths and severe damage to surrounding buildings. Whereas in an explosion

alone only a few casualties could be expected due to radiation sickness in the area of 200m² amid the failure of SNF containment, aerosol containing mostly volatile Kr-85 and semi-volatile Cs-137, would be lifted into the air leading to extensive environmental contamination and potential exposure of thousands of individuals in the downwind zone. The number of people expected to get exposure to unsafe levels of radiation causing late effects leading to cancerous deaths would not only depend on the strength of the radioactive materials but would also depend on the timing and location of the attack. Any evacuation/sheltering of communities based on a 360° potential-hazard zone may be adopted instead of a cone shaped zone predicted by the code to eliminate the many associated uncertainties and changing wind directions in real situations. Difficulties are likely to arise in informing members of the public in an urban area where it may not be practicable to evacuate such large numbers, or in a rural situation where individuals may be unaware of the incident and who, scattered about the countryside, may be difficult to locate and advise in time. All exposed individuals will need to be monitored for health outcomes over their lifetimes, especially those that suffer internal contamination. Massive decontamination efforts would be needed for recovery and if decontamination remains unsatisfactory, institutional controls would become essential. To dilute the consequences of any successful sabotage event, preplanning is very important through well-developed and coordinated efforts of various agencies. Periodic integrated table-top and field exercises based on credible scenarios developed on the basis of intelligence information gathering should remain the focus at all levels.

The controls around various nuclear installations and radiation facilities in Pakistan are enough to deter and delay a terrorist attack and any malicious diversion would be detected in early stages. This chapter is an attempt to calculate the consequences of terrorist acts of very remote probability bordering near impossibility. Therefore, it can be concluded that the fabrication of a RDD and WMD is not very attractive to a terrorist group in general and especially within the context of Pakistan.

ENDNOTES - CHAPTER 7

1. IAEA *Nuclear Power Reactors in the World*, Reference Data Series No.2, April 2006, available at www.pub.iaea.org/MTCD/publications/PDF/RDS2-26_web.pdf

2. Matthew Bunn and Anthony Wier, *Securing the Bomb*, Cambridge, MA: John F. Kennedy School of Government, Harvard University, July 2006, available at www.nti.org/securingthebomb.

3. Richard G. Lugar, *The Lugar Survey on Proliferation: Threats and Responses*, June 2005, available at lugar.senate.gov/reports/NPSurvey.pdf

4. Charles Ferguson and William Potter, *Four Faces of Nuclear Terrorism*, Monterey, CA: Center for Nonproliferation Studies, 2004, p.5.

5. Sarin, also known by its North Atlantic Treaty Organization (NATO) designation of GB (O-Isopropyl methylphosphonofluoridate) is an extremely toxic substance whose sole application is as a nerve agent. As a chemical weapon, it is classified as a weapon of mass destruction by the United Nations according to UN Resolution 687, and its production and stockpiling was outlawed by the Chemical Weapons Convention of 1993.

6. Graham Allison, "Nuclear 9/11: The Ongoing Failure of Imagination?" *Bulletin of the Atomic Scientists*, Vol. 62, No. 5, September/October 2006, pp. 34-41.

7. Richard A. Falkenrath, Robert D. Newman, and Bradley A. Thayer, *America's Achilles' Heel: Nuclear, Biological, and Chemical Terrorism and Covert Attack*, Boston, MA: MIT Press, 1998.

8. Large & Associates, *Risks and Hazards of Transportation of Spent Fuel in the UK*, London: March 27, 2006.

9. Les Kennedy and Craig Skehan, "Nuclear Plant Target for Stolen Rocket Launchers, Police Allege," *Sunday Morning Herald*, January 6, 2007, available at www.smh.com.au/news/national/nuclear-plant-target-for-stolen-rocket-launchers-policeallege/2007/01/05/1167777281891.html.

10. Interview with Dr. Charles Ferguson, Washington, DC, January 8, 2007.

11. Graham T. Allison, *Nuclear Terrorism*, New York: Henry Holt, 2004; and Peter R. Beckman *et al.*, *Nuclear Weapons, Nuclear States and Terrorism*, 4th ed., 2007.

12. Ferguson and Potter.

13. Hui Zhang, "Radiological Terrorism: Sabotage of Spent Fuel Pools," *International Network of Engineers and Scientists Against Proliferation (INESAP)*, No. 22, December 2003, pp. 75-78, available at [www.inesap.org/pdf/INESAP Bulletin22.pdf](http://www.inesap.org/pdf/INESAP%20Bulletin22.pdf).

14. Graham Allison, "Nuclear 9/11: The Ongoing Failure of Imagination?"

15. Secretary-General Kofi Annan, "Keynote Address to the International Summit on Democracy, Terrorism and Security, Madrid, Spain," U.N. Press Release SG/SM/9757, October 3, 2005, available at www.un.org/News/Press/docs/2005/sgsm9757.doc.htm.

16. Pervez Musharraf, *In the Line of Fire: A Memoir by the President of Pakistan*, London: Simon & Schuster, 2006.

17. Pakistani Newspaper *Dawn*, November 9, 2006, available at www.dawn.com.pk.

18. Pakistan Nuclear Regulatory Authority (PNRA) Report 2001-05, available at www.pnra.org.

19. Bunn and Wier, Executive Summary, p. i.

20. Jacquelyn S. Porth, "U.S. Goal: Keep Weapons of Mass Destructions Out of Hands of Terrorists," 2002 U.S. Special Weapons Nuclear & Missile Proliferation News, March 13, 2002, available at www.fas.org/news/usa/2002/index.html.

21. Reported by the *Bulletin of Atomic Scientists*, November/December 2006.

22. Graydon Carter, "Homeland Insecurity," *Vanity Fair*, November 2003, p. 64.

23. Ferguson and Potter.

24. *Ibid.*

25. IAEA, *Fact Sheet 2005: Illicit Trafficking and Other Unauthorized Activities Involving Nuclear and Radioactive Materials*, available at www.iaea.org/NewsCenter/Features/RadSources/PDF/fact_figures2005.pdf.

26. Musharraf, p. 293.

27. Ferguson and Potter.

28. IAEA, *Safety Standards: Categorization of Radioactive Sources for Protecting People and the Environment*, No. RS-G-1.9, Safety Guide.

29. Charles McCombie and Bengt Tveiten, *Nuclear Waste Management Organization*, June 2004, Table 2.1, available at www.nwmo.ca/Default.aspx?DN=397,211,199,20,1,Documents.

30. Charles D. Ferguson, Tehseen Kazi, and Judith Perra, *Commercial Radioactive Source: Surveying the Security Risks*, Washington, DC: Center for Nonproliferation Studies, 2003.

31. *Ibid.*
32. Two digit figure numbers were retained from the original report.
33. IAEA, *Safety Standards Series: Regulations for the Safe Transport of Radioactive Material*, 1996 Ed., As Amended, 2003, Safety Requirements, No. TS-R-1.
34. See Figure 5.1, Typical design of a SNF Cask.
35. Christopher S. Bajwa, Harold E. Adkins, and Judith M. Cuta, *Spent Fuel Transportation Cask Response to a Tunnel Fire Scenario*, Washington, DC: U.S. Nuclear Regulatory Commission, and Richland, Washington: Pacific Northwest National Laboratory, available at www.nei.org/documents/NRC_Baltimore_Tunnel_Fire_Study.pdf.
36. Aamir Husain and Kwansik Choi, *Status of Storage, Disposal and Transportation Containers for the Management of Used Nuclear Fuel*, Ontario, Canada: Kinectrics Inc., August 2003, available at www.nwmo.ca/default.aspx?DN=244,237,199,20,1.
37. *Ibid.*; and Chemical Technical Division, ORNL/TM-13502, October 20, 1997.
38. British Nuclear Fuels, BNFL, *MOX Fuel Voyage Briefing Note*, 2002, available at www.bnfl.com/UserFiles/File/151_1.pdf.
39. *Terrorism Considerations in the Transportation of Spent Nuclear Fuel and High-Level Radioactive Waste*, available at www.ciaonet.org/cbr/cbr00/video/cbr_ctd/cbr_ctd_09.html.
40. M. Jonathan Haire and Charles W. Forsberg, *Characteristics of Next-Generation Spent Nuclear Fuel (SNF) Transport and Storage Casks*, Oak Ridge, TN: Oak Ridge National Laboratory, 2001, available at www.ornl.gov/~webworks/cppr/y2001/pres/121356.pdf.
41. Large & Associates; and *Terrorism Considerations in the Transportation of Spent Nuclear Fuel and High-Level Radioactive Waste*, available at www.ciaonet.org/cbr/cbr00/video/cbr_ctd/cbr_ctd_09.html.

42. Dr. Gail H. Marcus, written testimony on nuclear transportation submitted to the Senate Committee on Energy and Natural Resources, May 22, 2002, available at www.ans.org/pi/news/d-1022187916.

43. Committee on Science and Technology for Countering Terrorism, *Making the Nation Safer: The Role of Science and Technology in Countering Terrorism*, Washington, DC: National Research Council, 2002, p. 48.

44. *Spent Nuclear Fuel: Options Exist to Further Enhance Security*, GAO-03-426, Washington, DC: U.S. General Accounting Office, July 2003.

45. Robert Alvarez, *Reducing the Hazards of Stored Spent Fuel*, Princeton, NJ: Science and Global Security, 2003, p. 20.

46. *Ibid.*, p. 19.

47. *Transporting Spent Fuel: Protection Provided Against Severe Highway and Railroad Accidents*, Rockville, MD: U.S. Nuclear Regulatory Commission, March 1987.

48. *Projected Source Terms for Potential Sabotage Events Related to Spent Fuel Shipments*, SAND99-0963, Albuquerque, NM: Sandia National Laboratories, 1999.

49. *Terrorism Considerations in the Transportation of Spent Nuclear Fuel and High-Level Radioactive Waste*, available at www.ciaonet.org/cbr/cbr00/video/cbr_ctd/cbr_ctd_09.html.

50. Fact Sheet, *Terrorism Consideration in the Transportation of SNF and High Level Waste*, Carson City, NV: Nuclear Waste Project Office, State of Nevada, November 2001.

51. Robert J. Halstead, "Statement on behalf of the State of Nevada agency for nuclear projects regarding U.S. DOE's draft environmental impact statement for a geologic repository for the disposal of spent nuclear fuel and high-level radioactive waste at Yucca Mountain, Nevada," Public Hearing, Washington, DC, October 26, 1999.

52. Testimony of James David Ballard, Ph.D., Consultant, on behalf of the State of Nevada on transportation of Spent Fuel Rods to the proposed Yucca Mountain Storage Facility," Subcommittees on Transportation and Infrastructure, U.S. House of Representatives, April 2002.

53. Matthew Lamb and Marvin Resnikoff, *Radiological Consequences of Severe Rail Accident Involving Spent Nuclear Fuel Shipments To Yucca Mountain: Hypothetical Baltimore Rail Tunnel Fire Involving SNF*, New York: Radioactive Waste Management Associates, September 2001, available at www.nd.edu/~kshrader/interest/Baltrpt9_18.doc.

54. *Analysis of Rail Car Components Exposed to a Tunnel Fire Environment*, NUREG/CR-6799, Washington, NRC, March 2003.

55. *Rail Safety and Security: Some Actions Already Taken to Enhance Rail Security, But Risk-Based Plan Needed*, GAO-03435, Washington, DC: U.S. General Accounting Office, April 2003, p. 58, available at www.gao.gov/new.items/d03435.pdf.

56. Alvarez.

57. Chemical Technical Division, *Radionuclide Content For a Range of Irradiated Fuels*, ORNL/TM-13502, London: Nirex Limited, October 20, 1997, available at www.nwmo.ca/default.aspx?DN=244,237,199,20,1.

58. *Ibid.*; Husain and Choi, *Status of Storage, Disposal and Transportation Containers for the Management of Used Nuclear Fuel*; and Lih-Jenn Shyr et al., *Projected Consequence for Potential Sabotage Events Related to Spent Fuel Shipments*, SNL, SAND099-2138C, August 1999, Table-2.

59. *User Documentation: Introduction to Hotspot Health Physics Codes*, Sandia, NM: Lawrence Livermore National Laboratory, available at www.llnl.gov/nai/technologies/hotspot/.

60. See Defense and Threat Reduction Agency, November 2006, available at acecenter.cntr.dtra.mil/.

61. Alexander Hill, *Using the Hazard Prediction and Assessment Capability (HPAC) Hazard Assessment Program for Radiological Scenarios Relevant to the Australian Defence Force*, DSTO-CR-029, Australian CBRN Defence Centre, Platforms Sciences Laboratory, March 2003.

62. Large & Associates.

63. *Projected Source Terms for Potential Sabotage Events Related to Spent Fuel Shipments*, SAND99-0963, Sandia, NM: Sandia National Laboratories, June 1999.

64. Halstead.

65. Edwin S. Lyman, *A Critique of Physical Protection Standards For Transport of Irradiated Materials*, Presentation to the 40th Annual Meeting of the Institute of Nuclear Materials Management, Phoenix, AZ, Washington, DC: Nuclear Control Institute, July 1999.

66. Large & Associates.

67. "Goods Worth Thousands Guttled in Fire Incidents," *Daily News*, November 8, 2005, available at www.jang.com.pk/thenews/nov2005-daily/08-11-2005/metro/k3.htm.

68. Robert E. Luna, *A New Analysis of the Vixen A Trials*, SAND93-2528, Albuquerque, NM: Sandia National Laboratories, February 1994; and Lih-Jenn Shyr, *Projected Consequence for Potential Sabotage Events Related to Spent Fuel Shipment*, SAND99-2138C, Albuquerque, NM: Sandia National Laboratories, August 1999, Table 2.

69. Total Effective Dose Equivalent (TEDE). The radioactive material producing the dose equivalent may be external to the body, e.g., when material is on the ground or is in the air surrounding the individual, or internal, as when the individual has ingested or inhaled, and retained the material. The TEDE is the sum of the EDE (caused by the external material) and the CEDE (caused by the internal material). The TEDE is the most complete expression of the combined dose from all applicable delivery pathways. $TEDE = CEDE \text{ (inhalation)} + EDE \text{ (submersion)} + EDE$

(ground shine). See *User Documentation of Hotspot: Introduction to Hotspot Health Physics Codes*, Livermore, CA: Lawrence Livermore National Laboratories, available at www.llnl.gov/nai/technologies/hotspot.

70. For gamma energies between 60 keV and 1.5 MeV, the dose rate from a source A MBq and total energetic gamma emission per disintegration of E MeV == 0.14 AE microGy/h at 1 m. See, *Rules of Thumb and Practical Hints*, London: The Society for Radiological Protection available at www.srp-uk.org/serothumb.html.

71. "Understanding Radiation: Health Effects," U.S. Environmental Protection Agency, December 3, 2002, available at www.epa.gov/radiation/understand/health_effects.htm.

72. National Research Council's Committee on the Biological Effect of Ionizing Radiation, BEIR, *Health Effects from Exposure to Low Levels of Ionizing Radiation: BEIR VII -Phase 2*, available at books.nap.edu/catalog/11340.html. The committee concludes that the current scientific evidence is consistent with the hypothesis that there is a linear, no-threshold dose-response relationship between exposure to ionizing radiation and the development of cancers in humans.

73. *Understanding Radiation*, U.S. EPA. In other words, in a group of 10,000 people exposed to 1 rem of ionizing radiation, in small doses over a life time, we would expect 5 or 6 more people to die of cancer than would otherwise. In this group of 10,000 people, we can expect about 2,000 to die of cancer from all nonradiation causes. The accumulated exposure to 1 rem of radiation would increase that number to about 2005 or 2006.

74. *National Planning Scenarios*, Version 20.1 Draft, April 2005, available at media.washingtonpost.com/wpsrv/nation/nationalsecurity/earlywarning/NationalPlanningScenariosApril2005.pdf.

75. "Exposures and Effects of the Chernobyl Accident," *Sources and Effects of Ionizing Radiation*, Vol. II, Effects, ANNEX J, United Nations, 2000, para. 107, available at www.unscear.org/docs/reports/annexj.pdf.

76. Waste Classification, NRC Regulations, 10 CFR, Part 61.55, available at www.nrc.gov/reading-rm/doccollections/cfr/part061/. Waste needing disposal following a spent fuel accident is likely to be of the order of 100-million m³ for a 3.5 MCi release, one million affected persons times 90 m³ per person. See Jan Beyea, Ed Lyman, and Frank von Hippel, "Damages from a Major Release of 137Cs into the Atmosphere of the United States," *Science and Global Security*, No. 12, 2004, pp. 125-136.

77. "71 Killed in Baghdad Suicide Truck Bombing," *CNN News*, December 12, 2006, available at www.cnn.com/2006/WORLD/meast/12/12/iraq.main/index.html.

78. For gamma energies between 60 keV and 1.5 MeV, the dose rate from a source A MBq and total energetic gamma emission per disintegration of E MeV == 0.14 AE microGy/h at 1 m. See *Rules of Thumb and Practical Hints*, The Society for Radiological Protection, available at www.srp-uk.org/serothumb.html.

79. "71 Killed in Baghdad Suicide Truck Bombing."

80. A waste needing disposal following a spent fuel accident is likely to be of the order of 100-million m³ for a 3.5 MCi release, one million affected persons times 90 m³ per person. See Beyea, Lyman, and von Hippel, pp. 125-136.

81. BEIR VII, Phase 2, Free Executive Summary, available at www.nap.edu/catalog/11340.html.

82. Christoph Wirz and Emmanuel Egger, "Use of Nuclear and Radiological Weapons by Terrorists," *International Review of the Red Cross*, Vol. 87, No. 859, September 2005.

83. *Spent Nuclear Fuel Transportation: Lessons Learned from Security Planning and Execution*, Washington, DC: Department of Energy, August 2006, Final.

84. Large & Associates.

85. Ryan Crow, *Personnel Reliability Programs*, McLean, VA: Project Performance Corporation, 2004, available at www.ppc.com/modules/knowledgecenter/prp.pdf, and references therein.

CHAPTER 8

SECURITY ISSUES RELATED TO PAKISTAN'S FUTURE NUCLEAR POWER PROGRAM

Chaim Braun

INTRODUCTION

This chapter deals with the prospects for the expansion of the current Pakistani nuclear power program, and the dangers to national safety and security such expansion entails due to rapid expansion, and the potential military or terrorist attacks against future nuclear power plants. In terms of organization, this chapter is divided into two parts. The first part, including the front two sections, summarizes the current status of the Pakistani nuclear power program, and the prospects for its expansion. The second part deals with the nuclear safety risks that the expansion of the Pakistani nuclear power program might entail, and the security risks related to military or terrorist attacks against nuclear power stations. A detailed conclusions section completes the presentation.

It is concluded here that Pakistan has maintained its currently small nuclear power program in a safe mode, though plant performance records are mediocre, given the limited integration of Pakistani plants into the global nuclear industry. That Pakistan provides many of the requisite plant maintenance and upgrade capabilities from its own resources attests to the potential for improved operations if Pakistan's nonproliferation position could be resolved. Future expansion of the Pakistani program on the scale projected by the government depends on changes

in Pakistan's nonproliferation stance that might be related to resolution of the proposed U.S.-India nuclear cooperation agreement. A similar agreement between Pakistan and China, if possible, might allow significant expansion of the Pakistani nuclear program. It is further concluded here that rapid expansion of the installed nuclear capacity might strain the regulatory agencies' capability to supervise safe construction and operation of the prospective new nuclear power stations. Fast-rate capacity growth might strain Pakistan's ability to train adequate numbers of station operating staffs, support infrastructure, and regulatory manpower. The combined effects of the above could lead to safety problems related to plant operations and supervision by poorly trained personnel with potentially severe consequences.

We make the point here that the overall security situation in Pakistan is unstable, with large numbers of terrorist groups allowed to operate within the country, with an armed insurrection ongoing in Balochistan, and with the government's loss of control of several provinces to the Taliban and other Islamic and Arabic terror organizations. This generally unstable security situation is not conducive to stable long-term expansion of nuclear power capacity. An immediate problem may be the difficulty of security screening of all prospective nuclear stations and infrastructure employees, with the distinct possibility of terror supporters gaining access to power stations and providing insider support to putative terrorist attacks. Large multiunit nuclear power stations that likely will be constructed if the nuclear expansion plan is implemented would become vulnerable to terrorist attacks or attempted takeovers all supported by potential inside collaborators. Terrorist attacks against nuclear power stations could

be motivated by three factors: (1) the desire to obtain radioactive or fissile materials for the construction of radioactivity dispersion devices or nuclear weapons; (2) the intent to create significant damage to the station, nearby population, the environment, and the country as a whole as revenge for some government actions inimical to terrorist interests; or (3) the desire to force the government to accede to some terrorists demands and modify its policies accordingly. In similar fashion, military action against nuclear power stations can not be ruled out, motivated possibly by the intent to change or reverse government decisions and policies to respond to military demands. Since the military already controls security at all nuclear facilities in Pakistan, military takeover of future nuclear power stations is that much simplified. We conclude here that installing large multiunit nuclear power stations is in the economic interest of any country, like Pakistan, projecting large scale nuclear capacity growth. However, given the less than stable situation in Pakistan such stations are vulnerable to future security threats against the government. Both economic and security trade-offs should be evaluated when considering large scale nuclear capacity expansion in Pakistan's situation.

CURRENT STATUS AND PERFORMANCE OF THE PAKISTANI NUCLEAR POWER PROGRAM

Introduction.

The current status of the Pakistani nuclear power program is reviewed before the prospects for further expansion and the problem this expansion might entail are addressed. Discussion is limited to the commercial nuclear power plants operated, under construction, or

planned in Pakistan. The Pakistani nuclear weapons and fuel cycle programs, though indirectly affecting the civilian program as discussed below, are outside the scope of this review. It is important to understand the current small size and limited capabilities of the Pakistani nuclear power program so the multifold increase in capacity planned for it within a relatively short time span can be appreciated. Such rapid expansion will create safety and security vulnerabilities which will be discussed later. It is concluded that the Pakistani plants' performance has been below world standards, caused by the limited contacts established with the global nuclear power industry, given Pakistan's refusal to join the nonproliferation treaty regime. Yet the fact that Pakistan has operated its existing plants safely, and gained a degree of independence in providing plant services, attests to the inherently good capabilities of Pakistan's nuclear plants' personnel and to the potential for enhanced operations if improved relations with the world nuclear power community could evolve.

Current Status.

The current Pakistani nuclear power program is rather modest and consists of two operating nuclear power plants and one under construction. The total installed nuclear capacity is 462 MWe (gross) or 425 MWe (net). The reactor under construction has a capacity of 325 MWe (Gross) or 300 MWe (net).¹ Nuclear capacity represents but 2.4 percent of the total installed capacity of 19,252 MWe in Pakistan by June 30, 2004.² Nuclear generation in Pakistan in 2004 was 1.93 TW-Hr, or 2.4 percent of total generation.³ Thus nuclear contribution to current Pakistani total electricity supply

is limited. In comparison, 50.5 percent of total electricity generation in 2004 was produced by fossil thermal power plants, with hydroelectric plants providing 22.4 percent of total generation. The Pakistan Atomic Energy Commission (PAEC) operates all Pakistani nuclear power plants, and the Pakistan Nuclear Regulatory Agency (PNRA)⁴ performs nuclear safety regulation. Pakistan shares information with and obtains technical assistance from the CANDU Operators Group (COG), and the World Association of Nuclear Plant Operators (WANO).⁵

Pakistan is not a signatory to the Nuclear Nonproliferation Treaty (NPT). All commercial nuclear power plants are, however, operated under IAEA Safeguards.⁶ The Canadian origin KANUPP reactor is safeguarded under INFCIRC/135 of October 1969, and the Chinese origin CHASNUPP is safeguarded based on INFCIRC/418 of February 1993. Pakistan did not sign and did not ratify the IAEA proposed Additional Protocol to its safeguards agreements.⁷ Pakistan did sign and ratify the IAEA Convention on Physical Protection of Nuclear Material (CPPNM), which entered into force on October 2000. Pakistan did sign several other conventions with the IAEA;⁸ however, it is not a member to the Vienna Convention on Civil Liability for Nuclear Damage.

Pakistan is not a member of the Zangger Committee or the Nuclear Suppliers Group (NSG) and does not abide by the nuclear export guidelines issued by these two organizations. Pakistan has, however, recently held discussions with the NSG aimed at harmonizing its export control regulations with the requirements of the NSG.⁹ Given the past activities of the A.Q. Khan's network,¹⁰ which are outside the scope of this chapter, this could well be viewed as "locking the barn door after

the horses ran out” and is probably aimed at preparing groundwork for a future nuclear deal with the NSG including measures similar to those incorporated in the U.S.-India Nuclear Agreement,¹¹ as discussed later. Pakistan participates in the activities of the United Nations Security Council (UNSC) Resolution 1540 Committee, and has submitted a report to the Committee as well as provided later detailed answers to the additional questionnaire.¹²

A listing of plant data related to the construction and operation of the Pakistani nuclear power plants is provided in Table 1 below.¹³ A map of Pakistan indicating the location of nuclear power plants as well as nuclear military sites is shown in Map 1.¹⁴ A similar Pakistani map showing the location of nuclear plants and fuel cycle facilities is shown in Map 2.¹⁵

Station	KANUPP	CHASNUPP 1	CHASNUPP 2
Type	PHWR	PWR	PWR
Gross Capacity	137	325	325
Operator	PAEC	PAEC	PAEC
Status	Operational	Operational	Contract signed
Reactor Supplier	CGE	CNNC	CNNC
Construction Date	August 1, 1966	August 1, 1993	April 8, 2005
Criticality Date	August 1, 1971	May 3, 2000	
Grid Connection Date	October 18, 1971	June 13, 2000	~ 2011
Commercial Operation Date	December 7, 1972	September 15, 2000	
Shutdown Date	~2012		

Source: PAEC

Table 1. Current Pakistani Nuclear Power Plants Data.



Map 1. Nuclear Power Plants Locations in Pakistan.

The oldest Pakistani nuclear power plant is the Karachi Nuclear Power Plant (KANUPP), located at Paradise point, 15 miles west of Karachi on the Arabian Sea. A view of KANUPP is shown in Figure 1. KANUPP is a 125 MWe (net) CANDU type natural Uranium fueled and heavy water (Deuterium) cooled and moderated reactor. KANUPP was obtained from Canadian General Electric (CGE) in 1965, and the plant reached commercial operation in 1972. KANUPP and its sister plants in India, Rawatbhata 1 and 2, were based on the Canadian design for the Douglas Point early CANDU plant, which was shut down in 1985.¹⁶ All contacts with the Canadian suppliers were cut off in 1975 when it became clear that Pakistan would not



Figure 1. The Karachi Nuclear Power Plant (KANUPP).

in CANDU fuel assemblies manufacture by 1980. Following the Three Mile Island accident, Pakistan was accepted into the COG and WANO, and received additional technical assistance and performance assessment from the IAEA. Following 1991, PAEC has embarked on a life extension program referred to as Balancing Modernization and Rehabilitation (BMR) which involves upgrading of the plant's instrumentation and control (I&C) system and replacement of its computer equipment. The BMR program also calls for upgrading balance of plant (BOP) equipment as well as some nuclear island (NI) equipment. With these modifications, plant lifetime is estimated at 40 years, i.e., extended until 2012.¹⁷

The second nuclear power plant installed and commercially operated in Pakistan is the Chasma Nuclear Power Plant—Unit 1 of 300 MWe (net) capacity,

located in the Punjab Province, near Chasma Barrage on the west side of the Indus river. The plant was purchased from China National Nuclear Corporation (CNNC), the main nuclear power corporation in China, and represents the first case of South-South nuclear power plant technology transfer. The design of the CHASNUPP-1 unit is based on the Chinese Qinshan Phase I nuclear power plant, the first indigenously designed and built nuclear power plant in China. The Qinshan Phase I design is the current nuclear plant export model of China and has also been offered to Iran (cancelled in 1997 under U.S. pressure), and to all other countries interested in small capacity nuclear plants provided by a Third World nuclear supplier. Even though the reactor design is of Chinese origin, Mitsubishi Heavy Industry (MHI) produced the pressure vessel and the two primary pumps were manufactured in Germany.¹⁸ The CHASNUPP-1 nuclear plant is a two-loop pressurized water reactor (PWR), fueled with 3.4 percent enriched Uranium Oxide fuel provided by China. CHASNUPP-1 represents the second unit worldwide based on the Qinshan Phase I design and the first Chinese nuclear power plant export. As such, this is a prototype operation to both China and Pakistan. No information on possible spent fuel return to China is available, and wet pool storage of spent fuel at the reactor site is assumed. No information on possible reprocessing of spent fuel for military purposes, particularly from KANUPP, is available. The construction of the CHASNUPP-1 unit was started in 1992, and commercial operation was attained in 2000. Since then the plant has completed five annual operating cycles with an improving performance trend.¹⁹

The second unit of the Chasma nuclear power plant (CHASNUPP-2) will also be supplied by CNNC and is a 300 MWe PWR design similar to the Qinshan Phase I plant operating in China, and a replicate of the CHASNUPP-1 unit operating on site. The total investment in the new unit is estimated at 860 Million Dollars,²⁰ and a sum of 350 million dollars is financed by China, \$200 M through concessionary loans and \$150 M through preferential supplier credits provided by the Exim Bank of China.²¹ Site construction work started in April 2005 and commercial operation is expected by 2011. China became a member of the NSG in June 2004,²² and as a member is forbidden by NSG Guidelines from supplying nuclear equipment to countries that did not sign the NPT and did not accept full scope safeguards. However China claims that its contract negotiations with Pakistan regarding CHASNUPP-2 construction have been ongoing even before its accession to NSG membership, and are thus “grandfathered” from its NSG obligations.

The Chasma nuclear site includes also a reprocessing plant, based on a French design supplied by the Saint Gobain Corporation. With the cessation of French nuclear assistance to Pakistan in 1975, Pakistan has completed the construction of the plant by itself and PAEC operates it outside of the safeguards regime in support of its nuclear military program.²³ In close proximity to the Chasma site is the Khushab Plutonium production reactor provided by China.²⁴ Khushab is a 50 MW (Th) natural Uranium fueled, heavy waster moderated reactor operated by PAEC as a part of the Pakistan nuclear weapons program. Other military program facilities are indicated in Map 1. Several research reactors also operate in Pakistan, however they are outside the scope of this chapter.

Operating Record of Pakistani Nuclear Power Plants.

It is important to review the operating record of the current Pakistani nuclear power program in order to assess how future nuclear plants will be operated given the fast expansion plan proposed by the government. As discussed next, the current operating record is below world standards, even though the inherent capability for improved performance is there. The concern is that given the fast growth rate projected, the potential for better performance might not be realized for some time. Conversely, the Program might be vulnerable to safety and security problems brought about by inexperienced staffs or by terrorist sympathizers who managed to foil the clearance system and act as inside collaborators.

The energy availability factors (energy produced after all losses are deducted divided by total energy produced) which are related to the capacity factors (net energy produced divided by the total energy that could have been produced had the plant operated at full capacity all the time) are computed by the IAEA and reported on an annual and cumulative basis in the Power Reactor Information System (PRIS) database for each commercial nuclear power plant operating in IAEA member countries.²⁵ The history of the energy availability factors over the lifetime of the KANUPP reactor is reported in Table 2 below, and for the CHASNUPP-1 reactor in Table 3.²⁶

Inspection of the KANUPP performance data in Table 2 indicates a mediocre plant record with a lifetime energy availability record of less than 28 percent. This is particularly low for a CANDU type reactor, which

Year	Energy (GWe.h)	Capacity (MWe)	Energy Availability Factor (%)	
			Annual	Cumulative
1971	3	128	77.27	
1972	232.7	137	19.3	
1973	394.8	126	35.6	35.6
1974	583.9	126	52.75	44.18
1975	494.9	126	44.83	44.39
1976	487.3	137	40.49	43.35
1977	339.4	126	30.74	40.88
1978	228.4	125	20.88	37.62
1979	29.6	125	2.7	32.72
1980	67.9	125	6.17	29.45
1981	192.2	125	17.55	28.14
1982	70.9	125	6.48	26.01
1983	194	125	17.7	25.26
1984	290.65	137	24.9	25.23
1985	261.96	137	21.83	24.95
1986	476.22	125	43.49	26.24
1987	274.77	125	25.09	26.17
1988	171.41	125	15.6	25.52
1989	60.86	125	5.56	24.37
1990	375.906	125	34.33	24.91
1991	370.3	125	33.82	25.37
1992	499.74	125	45.51	26.36
1993	369.6	125	33.75	26.71
1994	523.64	125	47.82	27.66
1995	461.04	125	42.1	28.28
1996	310.86	125	28.31	28.28
1997	386.12	125	35.26	28.55
1998	353.35	125	29.74	28.6
1999	68.99	125	11.93	27.99
2000	368.31	125	33.54	28.18
2001	399.46	125	36.48	28.47
2002	444.02	125	40.55	28.87
2003	0	125		27.94
2004	183	125	24.71	27.84

Table 2. Annual Performance Data for the KANUPP Reactor.

Year	Energy (GWe.h)	Capacity (MWe)	Energy Availability Factor (%)	
			Annual	Cumulative
2000	529.15	300	72.19	
2001	1581.75	300	60.06	60.06
2002	1356	300	52.25	56.16
2003	1809.8	300	68.85	60.39
2004	1750.71	300	66.35	61.88

Table 3. Annual Performance Data for the CHASNUPP-1 Reactor.

operates on online refueling principles and is thus expected to demonstrate high availability and capacity factors. In fact, KANUPP performance is lower than even the oldest CANDU reactors operated in Canada and elsewhere except for the Rawatbhata reactors in

India. KANUPP represents the oldest CANDU model still refurbished and in commercial operation in the world today. Most other similar model CANDU reactors have already ceased operation and have shut down. That KANUPP still operates is a testament to the resourcefulness and determination of the Pakistani nuclear engineers. The operational history of KANUPP is the story of Pakistan's nonproliferation policy and external relations.

As seen in Table 2, the plant started commercial operation and after a slow start performance improvements were recorded until 1975, the year Canada cut off technical support due to Pakistan's refusal to sign the NPT. The KANUPP engineers were on their own with no fresh fuel assembly supplies, replacement parts, training or technical support from Canada. Performance deteriorated significantly and revived only in the mid-1980s when the Pakistanis learned to manufacture their own fuel assemblies and developed some domestic plant maintenance and component replacement capabilities. Since then the plant operated at varying performance levels never exceeding 48 percent and was down for different Pakistani initiated refurbishment campaigns. Performance, even at these low levels, has improved following the reestablishment of technical exchanges with the COG and with WANO. By that time the plant was getting older and its improving performance trend was overtaken by the need for further maintenance and modifications (M&M). The overall result is that of mediocre performance quite lower than other CANDU reactors operated elsewhere.

Another relevant element is the low burnup levels achievable at CANDU plants. The KANUPP reactor was designed for an average (over the core) assembly

burnup of 8,650 MW (th) D/MTU and for cycle length (period between refuelings) of 12 months.²⁷ At this low burnup level the percent fissile content of the discharged plutonium (Pu-239 + Pu-241) is estimated in the low 80 percent, almost weapons grade. If fuel assemblies were discharged annually regardless of the low achieved capacity factors, the realized fuel burnup would have been lower and the fissile content of the discharged plutonium would be higher, and close to weapons grade quality. It is also known that natural uranium fueled heavy water moderated reactors (like the CANDU models) are copious producers of plutonium in the discharged fuel assemblies ~ 360 Kg Fissile Pu/GWe/Year, according to the DOE Nonproliferation Alternative System Assessment Program (NASAP) report.²⁸

Thus, assuming annual refuelings, the KANUPP reactor could have produced significant amounts of weapons grade (or close to weapons grade) plutonium in its discharged fuel assemblies. The KANUPP reactor, including its spent fuel pool, is operated under IAEA safeguards. However, given the relatively mild application of safeguards by the IAEA prior to the early 1990s when the Iraqi nuclear weapons program was discovered, the Pakistanis might have been able to divert some fuel assemblies to their unsafeguarded program. This is only a speculation, based on the fact that the KANUPP spent fuel pool might contain, by now, significant amounts of high grade plutonium, thus offering a tempting target.

Inspection of the CHASNUPP-1 performance data shown in Table 3 indicates significantly higher energy availability levels, in the range of 60 percent plus as compared with the lower performance record of the KANUPP reactor discussed above. Evidently, the

more modern and simpler PWR design and possibly ongoing help from CNNC which may have wanted their first export project be a successful one, might have contributed to the improved plant performance. CHASNUPP-1 performance declined during the first three annual operating cycles until the plant “settled down,” and then the availability factor markedly increased over the next two cycles. Yet the fact is that the CHASNUPP-1 performance record lags the record of the Qinshan Phase I plant—its reference plant—by 10 to 20 annual percentage points over the same operating period. Review of the *Qinshan-I* data in the PRIS database²⁹ indicates that whereas *Qinshan-I* has a cumulative (lifetime averaged) energy availability factor of close to 80 percent over its first five operating cycles, CHASNUPP-1 has reacted with a cumulative availability factor of 62 percent only (still much better than the 44 percent cumulative availability factor recorded for the KANUPP reactor over its first 5 operating years).

Two general trends can be identified from review of the performance data of the first two Pakistani operating nuclear power plants. First, energy availability factors are lower than those recorded for similar plants located elsewhere, possibly reflecting Pakistan’s isolation within the global nuclear community given its nonproliferation stance. Second, valiant attempts have been made by the Pakistanis to improve plant performance, relying mostly on their own limited national resources. The results indicate improving performance records although lower than worldwide figures for similar plants over similar operating periods. Evidently more needs to be done, with significant external inputs to bring Pakistani nuclear plants performance to world-class level and

assure long-term safe plant operations. It could well be that with adequate external support (if this were possible) and with the development of additional nuclear infrastructure and technical capabilities within Pakistan, the performance of the Pakistani nuclear plants could reach levels similar to those achieved by other successful Asian nuclear nations like Taiwan or Korea.

Expansion Plans of the Pakistani Nuclear Power Program.

Pakistan's Mid-Term Development Framework of 2005 calls for the installation of an additional 8,500 MWe of nuclear capacity by the year 2030,³⁰ which will bring the operating capacity by that year to about 8,800 MWe. The first part of this overall program involves a Pakistani request to purchase eight 600 MWe reactors from China with a total program capacity of 4,800 MWe.³¹ Pakistan has requested export of the second generation of indigenously designed Chinese nuclear plants based on the Qinshan Phase II, a 2 x 600 MWe station now reaching full commercial operation in the Qinshan site near Shanghai, in Zhejiang Province. The first two 600 MWe units in Pakistan are planned for the KANUPP site near Karachi. It is surmised that one future nuclear station might be located in Balochistan.³² Should Pakistan manage to import only one 300 MWe unit in the early expansion phase, that unit might be built at the Chasma site as CHASNUPP-3 unit.

A recent report on the status of the Qinshan Phase II program was provided by Kang Rixin, the director General of CNNC.³³ The Qinshan Phase II station includes two units, each one being a two-loop PWR of 650 MWe (gross) or 610 MWe (net).³⁴ Construction

of the first unit on site was started in June 1996 and the plant reached commercial operation in April 2004. Construction of the second unit of Qinshan Phase II was started on April 1997, and commercial operation started in May 2005. CNNC received approval in 2005 to replicate on site the Qinshan Phase II units and these will become the third and fourth identical units on site, referred to as the Qinshan Phase IV project. China plans the Qinshan Phase II units to be the prototypes for all 600 MWe nuclear units of indigenous design which might be built in the future in remote nuclear plant sites in China, or exported to clients like Pakistan. As yet, no reactor of this type has ever been exported outside China.

The Qinshan Phase II plant design was based on Chinese expertise, though with significant French and Japanese contributions. In terms of components manufacture, 55 percent of Qinshan Phase II first unit equipment was of Chinese origin, the rest being imported, mostly from Japan. The localization content of the second unit on site was 60 percent. While China is capable of building the 600 MWe turbine generators used in this station, most of the nuclear island equipment—including the pressure vessel, steam generators, and primary pumps—were manufactured by the Mitsubishi Heavy industry (MHI) Corporation of Japan.³⁵ China is yet incapable of constructing the main components of the nuclear island of a 600 MWe nuclear unit, let alone larger sized nuclear units. This limits China's ability to export the 600 MWe sized plants since it must obtain the approval of the foreign NI equipment supplier (and its government) for the production of the nuclear components prior to the signing of an export deal with a client country.

Exporting new nuclear power plants to Pakistan (beyond contracts already negotiated) is difficult since most nuclear exporters belong in the NSG, and NSG guidelines prohibit export of nuclear components to countries that did not sign the NPT and signed “full scope” safeguards agreements with the IAEA. In Pakistan’s case, all its commercial power plants are under safeguards; however, its military facilities are excluded from the safeguards regime so it does not meet the “full scope” safeguards criterion. Pakistan did not sign the NPT, and furthermore, it might have helped and abetted the proliferation activities of A. Q. Khan and his network,³⁶ might not have come clean regarding the full extent of Khan’s activities, and has prevented independent interrogation of A. Q. Khan by foreign experts (except for limited contacts with the IAEA, and possibly the United States regarding the Iranian and North Korean putative enrichment programs). It is also possible that General Musharraf, while serving as army chief of staff, might have known, if not approved, of Khan’s last major proliferation program in Libya. Given this record, it is not clear that even the more lenient NSG members so far as Pakistan is concerned, like China, might be able to bypass the NSG guidelines and export future new nuclear plants to Pakistan. In the case of the Qinshan Phase II plant, export approvals might also need to be obtained from Japan and France, which might not be willing to bend the NSG Guidelines sufficiently on Pakistan’s behalf. It might be possible that when China develops independent manufacturing capability for heavy nuclear island components, it might be able to strike specific export deals with Pakistan, unencumbered by other more conservative NSG members. However, that capability does not yet exist in China, and its

development might require a gestation period of 10 to 20 years to achieve adequate high quality control in the domestic manufacture of such heavy components. Thus under normal business conditions, the ability of China to export Qinshan Phase II type reactors to a country like Pakistan is not a foregone conclusion.

This situation changed, however, with the signing of the U.S.-India nuclear cooperation agreement in July 2005 and the facilities separation plan of March 2006. Pakistan has demanded a similar deal for itself and has requested comparable nuclear cooperation agreements with the United States,³⁷ Russia,³⁸ China, France, Canada, and possibly others. Pakistan's demands for equal treatment with India are based on the fact that all its commercial nuclear plants, unlike India's, have always been under IAEA safeguards. Pakistan further claims that it has put the A. Q. Khan affair behind it, conducted adequate investigation of the affair, punished Khan and his collaborators, strengthened its institutional controls over its entire nuclear complex, and coordinated its export control policies with the NSG³⁹ as well as with the United Nations (UN) Resolution 1540 Committee.⁴⁰ As such, Pakistan views itself as having turned a corner and deserving of a special nuclear cooperation deal similar to that signed between the United States and India. Such an agreement could be signed between Pakistan and the United States (preferably); the United States, Pakistan, and India;⁴¹ Pakistan and China;⁴² or Pakistan, China, and any other member of a group of other friendly countries such as Russia, Canada, or France. So far, the United States has refused to consider a nuclear cooperation agreement with Pakistan similar to the India deal. President George W. Bush did not publicly address this issue during his visit to Pakistan in early March

2006, and U.S. Department of Energy (DOE) Secretary Samuel W. Bodman, during his visit to Pakistan on March 13, 2006, refused to discuss nuclear cooperation with Pakistan,⁴³ limiting his discussions to non-nuclear energy cooperation only. Pakistani contacts on these matters in both Washington and Beijing continue to await the review of the U.S.-India deal by the U.S. Congress and by the NSG. A possible new nuclear sale deal will be discussed during President Musharraf's visit to China in June 2006 to attend the meeting of the Shanghai Cooperation Organization (SCO).

To recapitulate, it seems that Pakistan's strategy is to convince the United States or China (and possibly other interested nuclear supplier countries) to offer it a nuclear deal similar to the agreement between the United States and India, and to have such a deal approved by the NSG. Since in the near-term China cannot manufacture all the nuclear island components of its new 600 MWe plant, it will require the consent of the supporting equipment manufacturers—Japan and France—before it can export the newer Qinshan Phase II plant to Pakistan. Pakistan will keep all its commercial nuclear power plants under IAEA safeguards but retain uninspected control over its military program facilities. Pakistan will also abide by the requirements of UN Security Council Resolution 1540 and harmonize its export control guidelines with the NSG, much like China did prior to accession to full membership. While this is a less than full scope safeguard as required by NSG guidelines, and while Pakistan could not thus sign the IAEA Additional Protocol (which may become an NSG condition of supply in the future), the agreement it *is* willing to sign is more comprehensive than the facilities separation agreement reached between the United States and India.⁴⁴

Assuming the above transpires and Pakistan could import 600 MWe class PWRs from China or eventually larger sized plants from China or other nuclear suppliers such as Canada, Russia, France, and eventually the United States so as to meet its target of 8,500-8,800 MWe installed nuclear capacity by 2030, this will require the identification, characterization, qualification, and regulatory certification of several new nuclear station sites. To estimate the number of sites required, assume that all capacity additions will be provided in terms of 600 MWe units. This implies that about 14 new units will have to be installed, the first two of which are already planned for the KANUPP site near Karachi. We can further assume that Pakistan will build multiunit sites, as Japan, Korea, India, China, and most other Asian nuclear power countries have done. Should Pakistan opt for four unit sites, its planned nuclear construction program will require the opening of three new four-unit station sites. This would be in addition to the two existing power plant sites near Karachi and Chasma.

The number of sites estimated here would increase if not all the proposed sites could accommodate four units or if some of the units ordered are of the 300 MWe size, and would decrease if larger units than 600 MWe could be constructed during the later phases of this nuclear plants expansion program. Considering the difficulties of obtaining approvals for the export of 600 MWe Qinshan Phase II plants from the multiple suppliers and from the NSG, China might revert to providing Pakistan with the 300 MWe Qinshan Phase I reactors that can be manufactured based mostly on China's internal resources only. This might require doubling the number of new sites required, until the issues involved with exporting the larger sized nuclear

plants are resolved. Given the landmass of Pakistan, the opening of three new multiunit nuclear sites between now and about the year 2020 (when the last site must be opened) seems achievable.

PROSPECTIVE NUCLEAR STATION SAFETY PROBLEMS

Introduction.

The fast expansion rate proposed for the Pakistani nuclear power plants' capacity from 325 MWe to 8,800 MWe over a 24-year period in a country with limited nuclear industrial infrastructure, may pose some safety risks as discussed below. In turn, these safety issues may also have national security implications, given the volatile security environment in Pakistan and along its borders with its neighboring countries, as discussed in greater detail in the next section. The need to hire and train at a fast rate large numbers of regulators, station staffs, and support personnel creates vulnerabilities for the nuclear program in terms of operation by inexperienced crews and the emergence of terrorist supporters within the system. Such vulnerabilities might lead to safety-related events discussed in this section or to security threats discussed in the next section. It is important to note that safety-related events might cause severe social and economic implications on their own, and might precipitate further national security related actions by the government, or terrorist attacks trying to capitalize on the general unrest created by a safety event. Each one of the safety issues discussed here is of concern, in and of itself. The possible combination of more than one of the factors listed here might prove problematic.

Inadequate Regulatory Oversight.

The nuclear capacity expansion plan proposed for Pakistan might strain the oversight capabilities of the Pakistani nuclear safety regulatory agency—the Pakistani Nuclear Regulatory Agency (PNRA). PNRA might be called upon within a period of less than 20 years to license the construction of 10 to 20 new nuclear units (depending on reactor capacity), i.e., a rate of one new plant license every 1- to 2-year period. This may be a fast rate for an agency that over its existence has licensed no more than two nuclear units (KANUPP having been constructed probably before PNRA was established). Worldwide experience indicates that a new nuclear plant licensing process may require several years—from 2 to 6 years. Thus it is likely that PNRA will have to undertake a parallel licensing process involving more than one unit at a time. This problem might be somewhat ameliorated given the Pakistani intent to standardize new plant purchases, so that the regulators might be familiar with units they may have licensed previously. If Pakistan might have to import several types of reactors from one country, e.g., Chinese 300MWe, 600 MWe, and later 900 MWe sized units, this will increase the strain on PNRA regulators who will have to become familiar with several types of new plants almost at the same time. If more than one supplier country will eventually be able to export nuclear plants to Pakistan—China, Canada, France, Russia or the United States—this will further increase the learning curve required of the PNRA staff.

A new plants construction program requires additional regulatory reviews of new sites qualification and licensing. As discussed above, the Pakistani nuclear

plants construction plan might require the licensing of at least three new sites during the next 20 years. While this is a “doable” effort in and of itself, coming on top of the reactor licensing commitments might further strain PNRA resources. Site licensing is a detailed process requiring the review of the site characterization studies and the evaluation of how many units of a particular type the site can accommodate given the reactor and site-specific data. Sites found to have limited capacity potential may require further opening of new sites. Local population density around the sites or political opposition to nuclear plants construction may exacerbate the problem of finding an adequate number of sites along with the regulatory review burden.

Finally, the PNRA will not only have to license new nuclear sites and reactor types, but it must also supervise the safe operation of the nuclear units already installed and operating. As we have seen before, the operating records of the existing Pakistani nuclear units show improving trends over time, but are lower than world standards. This will require continued monitoring of plant operations to assure occupational and public health and safety. In this arena, the independence of the safety regulators from external pressures to increase electricity generation at the expense of safety considerations will be important. As PNRA will constantly be expanding its resources to meet its regulatory obligations, it may well happen that new and yet inexperienced staffs might not be able to well withstand outside pressures to generate, with potentially serious consequences either immediately, or down the line. The history of the regulatory oversight vs. plant operational considerations in the Chernobyl plant is a case in point.

Thus, the overall strain on PNRA resources, having to contend with assuring the safety of operating plants, licensing new sites, and further licensing the construction of new nuclear units, all within a relatively short time of 20+ years may become severe. Given the limited trained manpower resources of Pakistan, even with foreign help, assuring adequate regulatory oversight may be a challenge.

Inadequate Operator Training.

The problems of qualifying trained manpower for nuclear plants operation may be as severe within the PAEC side (the nuclear operator) as they might be within the nuclear regulator (PNRA) side. Nuclear units require operations and maintenance (O&M) staffs estimated in the range of 0.5–1.0 Persons/MWe or even higher ratios (~1.5 Persons/MWe) in the nuclear programs of third-world countries. Thus for 8,800 MWe nuclear expansion program, an operations cadre of 4,400 to 8,800 persons or more may have to be trained and qualified over a 20-year period. On the surface, this seems easy for a country of 150 Million people. Yet most plant staff persons require special training and years of experience. Licensed nuclear plant operators, let alone Senior Reactor Operators and shift supervisors may require even additional years of training. The Koreans, with a larger and more mature nuclear plants program, refer to their licensed plant operators and senior operators as “Gold People” since they are viewed as “worth their weight in gold.” The training requirements for plant operators should be considered in conjunction with the need to train nuclear plant regulators for the PNRA, provide trained manpower for the nuclear infrastructure industry

supporting PAEC, and provide additional trained manpower for the Pakistani military program and the related nuclear fuel cycle industry. We can assume that the numbers of the additional civilian regulatory and nuclear infrastructure personnel that will have to be trained will about equal the number of nuclear stations personnel. At the outer envelope, this equates to an additional 8,800 persons. Thus the Pakistani training and educational system will have to qualify about 18,000 trained persons over a 20-year period or close to 1,000 persons per year over each of the next 20 years to provide the personnel needs of the expanding nuclear power program. Not all of these persons will have to be trained to the same levels, but all will have to receive basic radiation worker and plant safety training.

The consequences of having less than well-trained staff at an operating nuclear power plant could be significant. Routine plant operations and maintenance activities might suffer delays in identifying and fixing small-scale problems. This could be further exacerbated by the limited availability of industrial infrastructure supporting plant operations in the areas of diagnostics and surveillance. Outage management which requires long planning and preparation might be less than could be achieved in other nuclear programs. That all nuclear plants are operated by a government agency, PAEC, might limit the exposure of plant operations to economic market forces and the discipline of the market. All these factors combined might lead to the low capacity factors and energy availability factors incurred in the nuclear program, as noted above. This low plant availability situation might be tolerable in a 425 MWe program, which provided less than 2.0 percent of national generation. When the installed nuclear capacity might reach 8,800 MWe—close to 20

percent of total capacity and might be expected to provide 20 percent of total generation, low availability factors might be less well-tolerated, and PAEC might be pushed to increase electricity send-out from its generating stations whether the operating staffs are ready or not.

Nuclear plant operation with relatively inexperienced staff might increase the chance of severe nuclear accidents. Nuclear plants are designed with relatively large safety margins, which makes them somewhat forgiving of operational mistakes. However, if an accident precursor event occurs and the operators misread their computer and indicator dials and misdiagnose the significance of the event, they might initiate a wrong corrective action, which might worsen the situation, leading eventually to a full blown nuclear plant accident. The importance of having well-trained and drilled plant operations staff, with continuous on-the-job and simulator trainings, who are steeped in the discipline of following plant procedures and not operating beyond equipment technical specifications, was highlighted in the Three Mile Island and Chernobyl nuclear plant accidents. In both accidents inexperienced staff members either misdiagnosed equipment reading and plant monitoring systems, or willfully ignored operating procedures in order to achieve management-dictated performance goals. While more modern plants have incorporated significant improvements in man-machine interaction, the potential for an inexperienced crewmember making the wrong technical decision thus worsening an evolving accident chain cannot be discounted. This is particularly so when the nuclear capacity expansion plan gets into high gear and new nuclear units are commissioned at relatively high rates which outpace the rate of new operator training and maturation.

Another aspect of operating nuclear plants with less than well-trained staffs may be the lack of adequate response to security emergencies. As will be discussed later, various security emergency scenarios ranging from attempted takeover of the nuclear plant by subnational groups for political purposes to attacks on nuclear stations either to divert nuclear materials or to damage the reactors as an act of revenge for some grievance inflicted (real or imagined), cannot be ruled out in Pakistan's environment. Given such ever-present danger, a less than well-trained nuclear staff, which may not be familiar with plant security and protection procedures, might not be able to withstand a well-motivated attack led by experienced terrorists. In particular, new multiunit stations with relatively new staffs (newly arrived) may be susceptible to insider threats assuming some members of the new staffs might not have been adequately security vetted by the authorities. Even if no insider's threat materializes, it is not clear that a relatively new staff will know how to handle emergency situations caused by multiple explosive laden trucks similar to the (almost successful) Saudi al-Qaeda attack on the oil facilities in Abqaiq, Saudi Arabia, in early 2006.⁴⁵ Nor is it clear that a raw staff will know how to handle conflagrations which might ensue should a terrorist group manage to load a plane with explosives and dive it into a nuclear containment structure. This sabotage attack is not completely out of bounds in Pakistan, and newly arrived and less than adequately trained staffs might not be able to respond properly.

Protection of Spent Fuel Storage Pools.

One of the side problems engendered by multiple units sitting in one station is the large amount of spent

nuclear fuel that will accumulate in the cooling ponds of all the reactors located on site. A CHASNUPP type reactor discharges on an annual cycle of 11.9 MTHM/year.⁴⁶ The existing two units CHASNUPP station will have, after 5 years of equilibrium fuel cycles operation of both units, about 120 MTHM stored on site. This is not taking into account the early years of operation of CHASNUPP-1 and the first core discharges from both units. Since the station life is expected to be 40 years and since no plans for central storage of spent fuel, fuel reprocessing, or take back of the spent fuel to China were announced, then close to the end of life of the CHASNUPP it will contain on site about 1,000 MTHM of spent fuel. Spent fuel accumulation will double for prospective future four-unit CHASNUPP type stations rather than the two-unit station now being constructed.

More intensive accumulation of spent fuel is expected for future Pakistani stations containing 600 MWe reactors possibly copied from the Chinese Qinshan Phase II design. No data on fuel consumption and discharge from this reactor were yet published; however, the 300 MWe Qinshan Phase I reactor discharges 13.5 MTHM/year.⁴⁷ Assuming fuel consumption of a 600 MWe reactor will about double that of a 300 MWe reactor and rounding off for economy of scale, we can estimate that a Qinshan Phase II reactor will consume and discharge annually about 25.0 MTHM/year. Thus, a prospective four-unit Qinshan Phase II station operating in Pakistan, after a future 10-year operation period of all four units, will have accumulated on-site a spent fuel load of about 1,000 MTHM, and this amount will about quadruple towards the end of its life. Much larger spent fuel accumulation could be expected assuming it may be

possible to construct CANDU type reactor stations in Pakistan. The plutonium contained in such spent CANDU reactor assemblies will be closer to weapons grade as compared with the higher burnup plutonium discharged from the Chinese PWR stations.

The large accumulation of plutonium containing spent fuel in the future Pakistani nuclear power stations, assuming the nuclear expansion plan is implemented, could act as a magnet for all sorts of terrorist groups or subnational organizations with a grievance against the central Pakistani government. This issue will be discussed in greater detail in the next section. Suffice it to say here that unless plant staffs and their security complements are well-trained, they might not be able to effectively protect their stations from future attacks. It is just possible to assume that due to the multiple units co-location feature planned by PAEC, an external attack has a greater chance of hitting or capturing one part of a station, if not all of it. A subnational group attack against a multiunit station such as truck bomb convoy, commando style land attack, or an airplane attack, even if deflected from one unit, might still succeed against another. Once a hostile force captures one unit in a station or heavily damages a unit, the fight is over and the station is effectively lost, with all the attendant consequences. This is a risk element that should be considered when implementing an extensive nuclear power expansion plan based on multiunit stations in a politically unstable environment. If it will be decided to construct smaller-sized stations due to security considerations as noted above, then a larger number of sites will have to be qualified, licensed, and eventually protected.

Common-Mode Failures and Impacts on Grid Stability.

Multiunit siting carries with it also nuclear safety risks related to common-mode failures and power station impacts on the electric transmission grid. Common-mode failures are events or accidents that affect entire groups of co-located units or similar technology and design units. In the past, the most notorious common-mode failures that have affected entire classes of plants were the need to replace steam generators in PWRs due to stress corrosion cracking in Inconel 600 constructed steam generators; the need to replace PWR reactor vessel heads due to cracking near the control rod penetration tubes; the core shroud corrosion in Boiling Water Reactors (BWRs) that have shut down the entire BWRs fleet of Tokyo Electric Power corporation (TEPCO); the need to retube CANDU reactor pressure tubes due to tube sagging under thermal and radiation induced stresses; and the need to remove tritium from CANDU reactors' heavy water due to increased accumulation of tritium in the heavy water with the attendant radiation risks. During the last year, a new problem has emerged in Westinghouse-designed modern four-loop PWRs constructed by the Commonwealth Edison Corporation of Chicago (CECO, now part of Exelon corporation)—that of tritium leaks from the primary system to local water sources.⁴⁸

Most of the above noted failures have been corrected by the global nuclear industry and remedies were most likely incorporated into the designs of relatively modern plants that might be offered to Pakistan such as the Qinshan Phase II reactor. Yet, the potential for discovering new generic problems can not be

discounted as the case of the tritium leaks from the more modern Exelon plants demonstrates. In this regard, we should note that the Qinshan Phase I reactors (one in operation and one being constructed in Pakistan) are based on a 1980s vintage domestic Chinese design which may not incorporate the latest plant design innovations, materials, or modern equipment. This reactor represents the second of its type constructed anywhere and the first Chinese nuclear plant export. The potential for future defects being discovered and potentially leading to the initiation of a nuclear accident chain cannot be discounted given the relatively limited operations experience accumulated. The Qinshan Phase II reactors represent a mix of design data and components supply from China, Japan, and France. There exists even more limited operational experience to indicate that no unforeseen problems will emerge in this complex plant, than the case is with the Qinshan Phase I reactor. These putative problems were hinted at by Indian authors.⁴⁹ Thus, the two reactors that are available or proposed to Pakistan might exhibit later in life safety problems that could affect all such plants to be constructed: in the first case due to a relatively older design and in the second case due to design complexity. Should a generic problem occur in a multiunit future Pakistani station, the units might need to be shut down one at a time, or the entire station might need to be shut down to implement the required fix-ups and modifications. Should more than one multiunit station be operational at the time a generic problem is discovered, the impact on PAEC operations and on the entire Pakistani electric grid could be that much more severe. The impacts of generic reactor problems and the need for corrective action might be hampered if the station staffs are relatively new and inexperienced, as

discussed above. This might delay completion of the required modifications and further loss of electricity generation.

Typical of common-mode failures are events such as loss of off-site power, restart problems with emergency diesel generators (EDG) of gas turbines providing station emergency power, loss of intake cooling water supply, or limitation of hot water discharges from the cooling systems into local water bodies due to a rise in average water temperature particularly in summer months. A good example is a loss of off-site electric power event.⁵⁰ Off-site electric power is usually required to operate station in-house electric power consumption for running pumps, compressors, air conditioners, computers, office equipment, etc. Usually plant generation is up-voltaged in the station's transformer yard and sent to the grid, while the grid through a separate line provides low voltage power for station internal consumption. If the line carrying grid power to the station is cut due to an accident or deliberate sabotage action, then the station has to rely on internal electric power supplies provided by batteries (short duration supply to essential operations such as the control room), EDGs, or gas turbines. Both EDGs and gas turbines which are normally idle might fail to start up when suddenly called upon to generate. Should the station staff fail to start the emergency power sources, then an accident chain might be initiated with potentially severe consequences. If we are dealing with multiple-unit stations, the loss of off-site power might impact all units on site thus making corrective action and recovery more difficult. Such difficulties might be compounded if the station staffs are relatively inexperienced and not well trained in handling emergency situations.

The potential effects of common-mode failures within a multiple-unit station on the national electricity transmission grid should also be considered. This is both a safety concern and a point of vulnerability to terrorist attacks as discussed later. A multiple-unit station with an installed capacity of about 2,000 MWe, e.g., a 4 x 600 MWe Qinshan Phase II reactor station, represents a significant generation node injecting electric power into the grid. Such a station would represent about 1-10th of the total installed capacity in Pakistan. Should such a station shut down due to a generic design flaw, or due to a common-mode failure, then the entire transmission grid in the regional vicinity might become unbalanced in that the load exerts a pull on the grid while the grid suddenly cannot supply the existing demand. In such a situation, the grid operators will attempt to shed some load centers to restore balance, call on reserve plants to generate, and shift available extra power from more remote regions to support the local demands. Depending on the existing grid equipment and experience of grid operators, such remedial actions might stabilize the system, or in the worst case might lead to a regional or total grid shutdown as happened in the U.S. Pacific grid partial blackout event of 2001, the U.S. Northeast blackout of August 2003,⁵¹ and similar blackouts during the 2003-04 period in Italy, France, and elsewhere. Thus installing large multiple-unit nuclear stations might carry the additional risk of grid instability, which could be protected against to some degree, by constant beefing up of grid equipment and installation of multiple transmission lines at great cost. However, even better protected grids such as in the United States and European Union (EU) countries were found to be prone to blackouts as recently discovered. We cannot assume that the Pakistani electric grid will

be free of disturbances whose consequences could be more severe when large nuclear stations are built.

Impacts of Natural Disasters.

Finally, the impacts of natural disasters on multiunit nuclear stations, on the electric grid, and on the interactions between the grid and the stations could not be ignored. Due to its geographical location, Pakistan is prone to earthquakes as was unfortunately discovered during the large-scale earthquake that hit the Northwest Frontier Province and the Kashmir area in October 2005. Furthermore, Pakistan is also prone to Monsoon floods hitting closer to the coastal areas. Any such naturally occurring event might severely impact the operation of a multiunit nuclear station if it is located in an area relatively near to the disaster's epicenter, or if the electric grid has been disturbed near the disaster area and grid instability has percolated to the location of the nuclear station. In either case, the combination of the direct effects of the disaster, ensuing transmission grid instability, and the possible initiation of a nuclear accident chain such as loss of off-site power, coupled with loss of on-site emergency power supply, could lead to very difficult consequences involving a severe nuclear plant accident. Such events could be exacerbated if a multiunit nuclear station is located near the disaster-impacted area and if the station staffs are relatively inexperienced and insufficiently trained in emergency response procedures.

PROSPECTIVE NUCLEAR STATION SECURITY PROBLEMS

Introduction.

In this section interactions and cross-impacts between Pakistani security issues and the proposed expansion of the Pakistani nuclear power system including multiunit nuclear power stations are discussed. The rapid growth rate planned for Pakistani nuclear power and its safety implications were reviewed above. Here related security implications are analyzed. A short review of some of the national security and stability issues particularly affecting Pakistan and their impacts on multiunit nuclear stations are considered. It is possible that large multiunit stations that would be constructed if the nuclear expansion plan is implemented might constitute tempting targets for terrorist attacks or military takeover, given their large size, economic importance, and significance as national growth and development symbols. These issues are discussed below. It should be stated, for fairness sake, that no case of terrorist attack against a Pakistani nuclear power station site, or any other nuclear site, is known to have occurred so far. Yet the past may not be an indication as to the future.

Pakistan's National Security Issues Possibly Affecting Power System Infrastructure.

In this section, discussion is limited to those national security considerations which might directly impact the Pakistani electric and nuclear power infrastructure. Specifically, the existence of terrorist organization networks and subnational instabilities and sectarian violence are discussed, all of which could be considered

as sub-sets of the more general problem of the lack of democracy and the rule of law.

The inception of the Islamic terrorist infrastructure in Pakistan is related to the evolution of the state itself. Pakistan was ruled by the military for all but 6 years of its history as an independent state. The community is divided among Sunni and Shia followers of Islam. The state is controlled mostly by Punjabi elites, leading to ethnic tension with the Sindhi and Baluchi regions, Afghan refugees, and groups of foreign terrorist elements (Chechens, Arabs, Uzbekistanis, etc). The military regimes have failed to produce results for the country in terms of political and economic development, competition with India, and Pakistan's regional position. Several wars have resulted in the loss of the majority of Kashmir to India, East Pakistan (now Bangladesh), loss of control of Afghanistan, and an almost nuclear war situation with India in 2000. There is a high degree of availability of weapons and of heroin, opium, and other drugs coming from the mountainous regions near the border with Afghanistan, as a result of 25 years of continued strife in that area. The period 1970-80 brought the unsuccessful war with India and dismemberment of East Pakistan, the emergence of the Khomeini Shia revolution in Iran, the Soviet Invasion of Afghanistan, and the introduction of Wahabi Sunni influences into Pakistan by Saudi Arabia as a counterweight. All these were serious shocks to the state, its political system, and its citizens, with one result of all of the above being the feeling that the state as a civil institution had failed its citizens and a possibly better answer could be found in Islam and in the establishment of a strictly Islamic regime. The penetration of Islamic influences into the affairs of the state and into the armed forces was accelerated towards the end of the Bhutto regime, and particularly during

the military dictatorship of General Zia ul Haq. The international Moslem insurgency win in Afghanistan against the atheistic Soviet Union further strengthened the push towards Islamization of the state.

During the last 30 years or so, the armed forces began to encourage the emergence of Islamic terrorist organizations as once-removed instruments of state power to bring pressure on India to accede to Pakistani demands in Kashmir and in Afghanistan. Terror groups were used to defeat the Soviet Russian invaders of Afghanistan, and then the Taliban movement was brought into existence and encouraged to establish a pro-Pakistani regime that would enlarge Pakistan's hinterland and enhance its overall position vis-à-vis India. Additionally, various irredentist movements have developed their affiliated terrorist groups to help carry out their sectarian strife aims. Among these are the rising Baluchistan insurrection, the Taliban attacks on Afghanistan from the Quetta region in southwest Pakistan, ongoing Shia/Sunni attacks, Sikh terrorism, and various other attacks related to the Pakistani and Afghan drug trade. A general discussion of the development of the Pakistani state, the role of the army in society, and the government's indirect encouragement and control of the Islamic terrorist movement are provided by Haqqani,⁵² Ahrari,⁵³ and Isaac Kfir.⁵⁴ The political and terrorist unrest in Baluchistan,⁵⁵ in the Jammu and Kashmir area,⁵⁶ and in the North West Frontier Province (NWFP)⁵⁷ is also discussed. A subset of the large body of literature related to terrorism and Pakistan can be found in the prolific writings of B. Raman of India, who attempts to link state supported Pakistani terrorist groups and the quest for nuclear weapons,⁵⁸ as well as in other sources.⁵⁹ Ramen has reported in some detail on a Baloch Liberation Army (BLA) terrorist mortar attack

on the PAEC nuclear installation near Dera Ghazi Khan in Balochistan on May 15, 2006, which resulted in a large fire in the nearby area.⁶⁰

A listing of terrorist and extremist groups operating in Pakistan is shown in Table 4.⁶¹

Terrorist Groups		Extremist Groups
Domestic organizations	Transnational organizations	
1. Lashkar-e-Omar (LeO)	1. *Hizb-ul-Mujahideen (HM)	1. Al-Rashid Trust
2. *Sipah-e-Sahaba Pakistan (SSP)	2. *Harkat-ul-Ansar (HuA, presently known as Harkat-ul Mujahideen)	2. Al-Akhtar Trust
3. Tehreek-e-Jaferia Pakistan (TJP)	3. *Lashkar-e-Toiba (LeT)	3. Rabita Trust
4. Tehreek-e-Nafaz-e-Shariat-e-Mohammadi	4. *Jaish-e-Mohammad Mujahideen E-Tanzeem (JeM)	Ummah Tamir-e-Nau
5. *Lashkar-e-Jhangvi (LeJ)	5. *Harkat-ul Mujahideen (HuM, previously known as Harkat-ul-Ansar)	
6. Sipah-e-Muhammad Pakistan (SMP)	6. *Al Badr	
7. Muttahidda Quami Movement - Altaf Hussain (MQM)	7. *Jamait-ul-Mujahideen (JuM)	
8. Haqiqi Muhajir Quami Movement (MQM-H)	8. Lashkar-e-Jabbar (LeJ)	
9. Baluch People's Liberation Front (BPLF)	9. *Harkat-ul-Jehad-i-Islami	
10. Baluch Students' Organistaion (BSO)	10. Muttahida Jihad Council (MJC)	
11. Jamaat-ul-Fuqra	11. Al Barq	
12. Nadeem Commando	12. Tehrik-ul-Mujahideen	
13. Popular Front for Armed Resistance	13. Al Jihad	
14. Muslim United Army	14. Jammu & Kashir National Liberation Army	
15. Harkat-ul-Mujahideen Al-alami	15. People's League	
16. Baluch Students' Organistaion - Awami (BSO-A)	16. Muslim Janbaz Force	
	17. Kashmir Jihad Force	
	18. Al Jihad Force (combines Muslim Janbaz Force and Kashmir Jihad Force)	
	19. Al Umar Mujahideen	
	20. Mahaz-e-Azadi	
	21. Islami Jamaat-e-Tulba	
	22. Jammu & Kashmir Students Liberation Front	
	23. Ikhwan-ul-Mujahideen	
	24. Islamic Students League	
	25. Tehrik-e-Hurriat-e-Kashmir	

*Also listed in the U.S. Department of State 2004 Terrorist Report.

Table 4. Terrorist and Extremist Groups of Pakistan.

Terrorist Groups whose name is preceded by an asterisk are also listed in the U.S. Department of State's Annual Terrorism Report of 2004,⁶² and information related to their activities is reviewed in the Congressional Research Service (CRS) report on Terrorism in South Asia.⁶³ Inspection of Table 4 indicates that currently there are about 48 domestic and international terrorist groups operating in Pakistan. This number in itself represents a record of sorts. Assuming that not all groups are really active, we can estimate about 40 active terrorist groups. As discussed above, the installed nuclear capacity in Pakistan is now about 450 MWe (Gross) comprised of KANUPP-137 MWe, and CHASNUPP-1-325 MWe. This is the equivalent of 0.45 GWe of installed capacity. A notional ratio of the number of active terrorist organizations per GWe of installed capacity can now be defined, and that ratio is found to be about 90 Terrorist Groups/GWe. Note that this is only a notional number, not implying that there are about 90 terrorist groups in Pakistan or that there is a firm GWe of installed capacity. This number represents an artificial ratio computed to make a point. Once CHASNUPP-2, which is now under construction, is completed, the installed nuclear capacity in Pakistan will increase to 775 MWe or 0.775 GWe. The ratio of terrorist organizations per GWe of installed capacity will then decline to about 52 Terrorist Groups/GWe. In the future, it can be assumed that with the general stabilization of South Asia and of Pakistan particularly, the number of active terrorist organizations in Pakistan might halve to about 20 organizations by 2030. At that point, the installed nuclear capacity is projected by the Pakistani Government to reach about 8,800 MWe or 8.8 GWe, and the notional ratio will decline to about 2.3 Terrorist Groups/GWe of installed nuclear capacity,

still probably a world record. It should be considered, however, that most terrorist organizations active in Pakistan will not have the capabilities or motivations for attacking nuclear power plants. Only a small number of the organizations listed in Table 4 present a possible danger to future nuclear power stations. All Pakistani nuclear installations are guarded by the army, and no attacks against nuclear power stations by such groups or others have occurred thus far. Yet the fact that *some* terrorist organizations are still capable or motivated enough to launch such a hypothetical attack, should give us pause.

Superimposed on the ratios developed above is the data shown in Figure 2,⁶⁴ depicting the number of sectarian violent incidents that have occurred in Pakistan till 2003. The data shown in Figure 2 indicate a positive long-term trend of a decline in sectarian violence. This decline is, however, punctuated by periodic episodes of large-scale eruptions of violence occurring about once every 4 years, and indicating an element of short-term instability in intersectarian relations that could manifest itself in future similarly violent episodes. The short-term instability feature indicated in Figure 2 could be detrimental to the evolution of nuclear power infrastructure, which requires a long-term stability trend. This is so due to the long lead-times for the development of nuclear power and fuel cycle facilities and due to the long-term need to acquire operators experience and good plant operating practices.

In summary, Pakistan is unique in having encouraged the development of a large terrorist infrastructure resulting in a significant number of terrorist organizations that are allowed to operate within the country. That terror system is also internally used in various episodes of sectarian violence that encom-

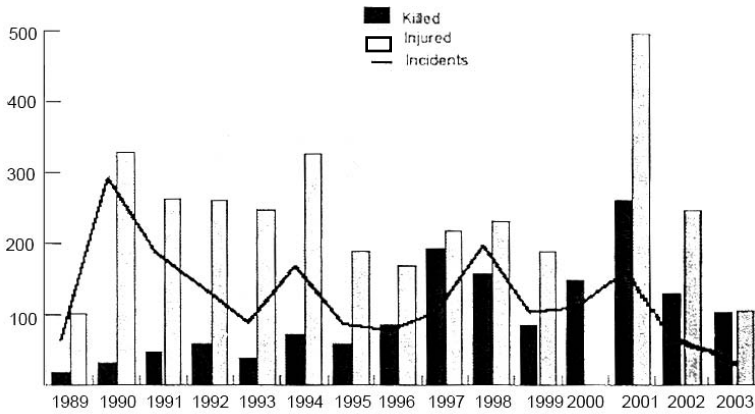


Figure 2. Sectarian Violence in Pakistan (1989-2003).

pass various minority groups within the diverse Pakistani society. There exists an ambiguity as to the relations of the regime to the terrorist organizations, some of which might have been utilized by the Government, one step removed, to accomplish irredentist goals in Indian Kashmir and in Afghanistan. Some elements of the terrorist infrastructure resident in Pakistan represent foreign terrorist groups (al-Qaeda Arabs, Chechens, Uzbekistanis) which were left stranded in Pakistan following the various Afghan wars which are only notionally controlled by the regime, and are allowed to pursue their specific grievances regardless of the interests of Pakistan itself. Sectarian violence is concentrated mostly in the large population centers such as Karachi and has not spilled far into the countryside where nuclear stations are (to be) located. However, it is questionable whether this climate is the most propitious for a significant nuclear power expansion plan, and some of the potential security risks involved are discussed next.

Missile Material Diversion from Nuclear Power Stations.

As mentioned above, a large amount of spent fuel will be discharged annually from the operating reactors in multiunit stations such as those planned for Pakistan, and will accumulate in the spent fuel storage pools. A 4 x 600 MWe reactor station will discharge on an equilibrium cycle about 100 MTHM/year from all four reactors, and that spent fuel will reside in the four pools located next to the reactor buildings on-site. As estimated elsewhere, the discharged first core is only partially "burned," does contain higher grade plutonium, and will lose its shielding protection earlier than equilibrium burnup spent fuel.⁶⁵ We have estimated that at least three new large stations will have to be constructed to meet the stated capacity expansion plans of PAEC. Each station will also store on an annual basis an equal amount of fresh fuel waiting to be loaded into the reactors during their annual refueling outages. Usually each reactor will have its outage at a different time to prevent significant contiguous loss of generation for the grid. This implies that fresh fuel supplies will reside for a significant amount of time in each multiunit station. Additionally, a large nuclear power station contains other radioactive sources such as cobalt irradiation sources, neutron sources, etc. that could be utilized by experienced saboteurs with technical education for the production of radioactive dispersion devices (RDDs). Within such a large station, there will likely be found some large lead shielded containers which might provide (nearly) adequate protection for the transport of radioactive sources or possibly long cooled spent fuel assemblies. In short,

such large multiunit stations operated by PAEC might offer tempting targets—might in fact act as magnets—for future terrorist groups determined to obtain WMD capabilities.

As further indicated above, the large staffs required to operate such stations—within the range of 1,200 to 2,400 persons or even more—offer the opportunity for a terrorist group to recruit a staff member as insider support or coerce one, under various threats, to provide data and cooperation. Even within such a populous country as Pakistan, one can assume that the leadership of some terrorist group and nuclear station operators may well have roots in the same social group, which might ease prospective recruitment. It may be possible to assume that terrorist organizations might cooperate, with one group having developed an insider support providing control over that staff person to a different terror group interested in breaking into the station and diverting radioactive material. Furthermore, Pakistani intelligence, which might control components of the guard force in these power stations, or rogue elements within the intelligence apparatus, might provide a terrorist organization they cooperate with, with inside person(s) contacts. In this way, the putative attackers might gain information on site characteristics, location of sources, and means of transport; or even get active support in disarming various alarms and detection devices.

In summary, the future emergence of large nuclear power stations containing radioactive material, the existence of a large number of well-armed and well-trained terrorist organizations, some of which might be interested in acquiring WMD/RDD components and possess technical training, the potential for developing insider support to facilitate such attacks, and the fact

that station staffs at some point might be relatively new and inexperienced and thus unable to protect their stations from outside attack, all point to the possibility that future nuclear material diversion attempts might prove successful. To be fair, we must point out that Pakistan has operated a nuclear reprocessing plant in Chasma, a uranium enrichment plant in Kahuta, and several other weapons facilities for almost 20 years, and no diversion attempts from these facilities are known to have occurred. Likewise, the IAEA has not recorded any diversion of nuclear material from facilities under safeguards in Pakistan thus far. It is possible that this is so, since these facilities were guarded by the military as parts of its nuclear weapons complex and thus were well-protected. It is not clear if future nuclear power stations operated by the civilian PAEC will be subjected to as thorough a protection by the military as the military weapons facilities, thus making prospective diversion from the power stations more feasible.

Terrorist Attack, Seizure or Takeover of a Nuclear Power Station.

Terrorist attacks on nuclear power stations in a complex society such as Pakistan, might be launched for other purposes than radioactive material diversion. A nuclear station might be attacked to create radioactivity release and dispersion, thus creating a major national and possibly international crisis and punishing the central government, or neighboring countries' governments, for having committed some sins (from the perspective of the terrorists). A terrorist attack on a nuclear power station—a government prestige project—might be launched to extract specific concessions from the government—release of captives, guaranteed amnesty, a change in specific government

polices whether domestic or foreign—or to publicize some terrorist political demands against the government or against foreign governments. Finally, an attack against a nuclear power station might be launched during a period of regime change, political instability or regional sectarian strife when the terrorists might view the control of the station as a bargaining chip to extract from the incoming regime specific concessions for their organization or for a sectarian group they might claim to represent.

The considerations discussed above apply here: i.e., the desirability of attacking a nuclear power station as a government status symbol; the station might contain significant amounts of radioactive material the dispersion to the atmosphere of which might create havoc in nearby and possibly far off communities; terrorist organizations in Pakistan might be well-equipped, trained, and motivated—more so than some nuclear station staffs; the relative ease of securing or coercing insider support for an attack plan; and the possibility that a new nuclear station staff might not yet be well-trained and versed in security procedures, thus increasing the likelihood that a terrorist attack might succeed and that some elements in the government intelligence agencies might cooperate with the terrorists and support, if not encourage, their impending attack. The important point here is that a multiunit nuclear station will represent an attractive target for control by a terrorist organization. This is due to the immense publicity such attack might create which will provide free advertisement for the terrorist organization and its political demands. Due to the public fear created relative to the large accumulation of radioactive material on site, political pressure on the government to accede to the terrorist demands so as to prevent a

nuclear catastrophe might be a result. The calculation of relative terrorist organization's attacking strengths (including possible insiders support and/or covert support by elements of the government intelligence agencies) vs. the weakness of the station security staff and military guards, might indicate that a prospective attack might well succeed.

These considerations indicate the unintended effect of constructing large multiunit nuclear power stations in a politically unstable country such as Pakistan, with its unique concentration of (partially government sanctioned) terrorist organizations. Under normal (politically stable) environment, constructing nuclear reactors within multiunit stations carries many advantages related to design standardization, on site replication, greater construction efficiency, and ultimately, improved operations efficiency. All these might result in significant cost savings over time. In Pakistan's unique situation, these advantages might be negated by the fact that such large national prestige projects could, perversely, become magnets for prospective terrorist attacks.

Airplane Attacks on Nuclear Power Stations.

A terrorist attack mode which has gained notoriety following the September 11, 2001 (9/11), attack on the World Trade Center in New York City and on the Pentagon in Washington, DC, is attack by airplanes on civilian targets, prospectively including commercial nuclear power stations. It has been revealed in the interrogation of captured al-Qaeda operatives since then that they contemplated, though never practically attempted to implement, coordinated aerial attacks on specific U.S. nuclear stations. It is also hypothetically possible that some rogue elements of the Pakistani Air

Force might attempt such attacks for purposes of their own. Airplane attacks could be mounted in two main ways:

1. kidnapping commercial passenger planes and flying them into the target, relying on the penetrating power of the airplane body and the engine turbine shafts to achieve containment structure penetration, and on the mass of jet fuel to catch fire and burn inside the breached containment; and,

2. smaller commercial aviation planes laden with explosives that rely on the explosive power of the total charge placed inside the planes to breach the containment structure.

To be fair, we should state that no airplane attack against a nuclear power station, let alone a multiunit station, has ever taken place, though again, this is no indication as to the future.

An airplane attack is different from the terrorist attacks discussed so far in that it is meant to breach at least one containment structure or spent fuel storage pool and cause a major radioactive release with all the attendant population exposure hazards along the radioactive plume's path. There is no mistaking the terrorist's intentions in mounting this sort of an attack, and all the ambiguities that might surround a terrorist action are swept away. The purpose here is clearly to punish the regime by hurting the civilian population so as to "pay" for having committed some sins against the terrorists or the people they might claim to represent.

If this is the terrorists' declared intention, then a multiunit nuclear station could be a useful target from their perspective. First, the symbolic nature of (even partially) destroying a prestige national project such as a large nuclear station cannot be understated. Second,

if successful, such an attack might cause a significant radioactive release leading to casualties in the nearby and further away populations and potentially causing exposure in neighboring countries—India in Pakistan’s case. Third, the economic damage to the station itself, to the regional and national electric grids, to the contaminated area due to loss of work and the expense of decontamination, and to the national economy due to loss of electricity supply and reduction in national productivity, could be substantial.

Furthermore a multiunit station is an attractive target since there is always the chance that if one reactor target is not hit, then another reactor or critical site facility might be hit. A reactor building is a relatively small target within all other structures to be found in a nuclear power station, including the turbine generator buildings, the cooling towers, the electrical buildings, and the transmission station. Near ground air turbulence might make it difficult to maintain aim and steadily point the airplane towards the reactor building. There exists, however, the possibility that in the last few seconds before the actual hit, even if the suicide pilot is deflected from hitting one reactor structure, he might still be able to point his plane and hit another reactor building. The chances of a successful hit on a multiunit station is then that much greater.

This is even more important if the terrorist pilot’s intention is to hit the spent fuel storage pool and cause heating and meltdown of the stored fuel, with a release of the inventory of volatile fission products contained therein. The spent fuel pool is but a small appendage on top of the “wraparound” auxiliary buildings surrounding the reactor containment structure. It is difficult for the pilot diving on the power station and struggling to point his plane, to aim specifically at the spent fuel

storage pool, if he can identify it at all. However, the pilot stands a greater chance of success on a multiunit station in that he might hit a different pool than the one he originally intended, since the choice of targets is multiple and more varied. In general, the more critical target structures are identified on-site, the greater the chance that at least one of them would actually be damaged, with all the attendant consequences. This is particularly true in a country such as Pakistan with a number of terrorist organizations, some of which might ultimately wish to hurt the central government in this way. PAEC's reasonable goal of multiple sitings of the nuclear units it plans to build might blow back on it by creating targets for high-consequences putative terrorist attacks.

Military Takeover of Nuclear Station Sites.

The discussion on possible military takeover of nuclear power stations follows the above discussion of potential terrorist attempts to occupy nuclear power sites. The major difference is that terrorist groups might intend to harm those facilities and cause radioactive leaks, whereas a military takeover of a nuclear facility might be more in the nature of acquiring political bargaining chips rather than harming the plants. We should recognize that all Pakistani nuclear installations, including power stations, are guarded by military units to start with. A takeover of the station implies local military control over the station disregarding central government orders. (The station's military guard force might belong to a different unit.) It may even suffice for the military just to hint that it might take full control over the nuclear power station to achieve its political aims, without even resorting to actual exercise of control.

Why would the military contemplate such a move? The reasons mostly involve a change of political regime in Pakistan where a regional corps commander might feel that his interests as a regional commander and as a representative of his region are not respected, or the commander might actually be threatened with dismissal by the new incoming regime. To maintain his position, privileges, and concessions to his region, the corps commander might notify the central government that unless his conditions are met, he might take control of the large nuclear power station located in his region from the special unit guard force. Alternatively, the corps commander might actually do so or just block lines of communications to the station. Under such threats or real action, the central government might accede to the regional commander's demands rather than face the possible consequences of his actions.

A large multiunit nuclear power station might be the logical target for such military/political maneuverings since it represents a national prestige project, of which the national government would be loath to lose control. The economic consequences for such loss of control and the political backlash might be worse, from the government's perspective, than the political fall-out from the fact that the government capitulated to the local corps commander and met his terms. Thus, taking over a nuclear station, or just threatening to do so, could produce benefits to regional military commanders viewing themselves under risk. This is another perverse result related to the fact that a large-scale nuclear stations construction program is planned for a country where the military presence and impacts on society are very pronounced. Pakistan has been referred to in the past as "A military with a country, rather than a country with a military."⁶⁶ In

this climate where the military views the country as under its direct, or indirect, control, national prestige projects such as nuclear power stations could be used as hostages in political/military confrontations not of their own makings.

Foreign Military Attacks on Nuclear Power Stations Sites.

Future large nuclear sites in Pakistan such as multiunit nuclear power stations might prove tempting targets for foreign military attacks should Pakistan be embroiled in a war with any of its neighboring countries. Nuclear facilities have already been targeted in war situations, specific evidence being the Iranian aerial attacks on the Tuwaitha nuclear site in Iraq (home of the Osiraq reactor as well as other nuclear facilities), as well as the Iraqi air force attacks on the Bushehr nuclear power plant, then under construction in Iran. Both attacks occurred during the Iran-Iraq war of the 1980s.⁶⁷ The precedent of attacking nuclear power station sites has thus been established, though the Bushehr station was under construction and not yet operational, and did not contain nuclear fuel. The Tuwaitha site, on the other hand, contained radioactive material—the cores of the Osiraq and other research reactors on site, all under IAEA safeguards. This did not prevent another IAEA member country (Iran) from attacking the site. It should be noted that both Iran and Iraq were IAEA members, both signed the NPT, and both had safeguard agreements in force with the IAEA at the time of the Iran-Iraq war. Despite their treaty commitments, the Iraqis were developing nuclear weapons capabilities prior to the war, and the Iranians are most likely engaged in a similar program as

a result of that war, this under the guise of developing a nuclear power program.

Prospective attacks on operating nuclear power stations could be considered under two scenarios. First is the preemptive takeover of a nuclear site to prevent it from being captured by an internal Pakistani terrorist organization during the general turmoil that a war brings. The aim here is protective—preventing potential destruction of the power station and possible radioactive release due to capture and damage by a nihilistic terrorist organization. Second is capture of a large operating nuclear station by an enemy country—India for instance—to deny electricity to the Pakistani government and disrupt the electric power grid remaining under Pakistani control. This would be a form of a sophisticated economic warfare in which the capture and denial-of-use of large infrastructure projects such as dams, refineries, or nuclear power stations might bring about the collapse of the enemy government regardless of other military offensives. In either case the actual destruction of, or significant damage to, the nuclear power station would not be contemplated as the attacking military might be aware of the potential consequences of a damaged nuclear plant, and would not want a nuclear debris plume to spread over its own country.

Under the scenarios listed here, multiunit nuclear power stations as well as military nuclear sites could be attractive targets for capture by an attacking foreign army. In order to assure the undamaged capture of such high value targets in the early stages of the war so as to prevent damage to the facilities that could be inflicted by either side through the “fog of war” situation, it is likely that a commando type operation would be planned and carried out by highly trained and

disciplined military units. Such attacks might succeed without causing significant damage to the reactors, though the risks are great. Placing a relatively small one-unit nuclear power station in the path of an invading army is one matter. Constructing a multiunit nuclear power station in regions susceptible to war between neighboring countries (contemplated as recently as 5 years ago) raises the risks and consequence scales considerably.

CONCLUSIONS

In this chapter we have reviewed the current nuclear power situation in Pakistan and the plans and prospects for its significant expansion. We have then reviewed the safety and security of the prospective large multiunit nuclear power stations that will have to be constructed in Pakistan under its ambitious capacity expansion plan.

Our conclusions regarding the nuclear power growth prospects in Pakistan are ambivalent. Under the current rules of nuclear trade, it will be difficult to construct any large sized nuclear power reactors in Pakistan not yet committed. The U.S.-India nuclear power deal, if approved by the U.S. Senate and by the Nuclear Suppliers Group (NSG), could open the door to a similar deal with Pakistan to be possibly sponsored by China and supported by other nuclear suppliers such as Canada and potentially France or Russia. If such a deal is initiated, there is little doubt that Pakistan could effectively participate in the construction of future nuclear stations and be able to operate them. Successful world class operation of future Pakistani nuclear power plants depends to a large extent on improved communication and flow

of technical support and training between the global nuclear power industry encompassing its various institutions, both private and public, and PNRA, PAEC, and Pakistani industry. Additionally, extensive training and retraining programs for all nuclear personnel will have to be instituted by Pakistani educational organizations supported by foreign technical experts. For that to happen, Pakistan's position within the NPT world community and the NSG would have to be regularized, possibly building on a modified (more stringent) version of the U.S.-India deal. Furthermore, the security situation in Pakistan will have to improve so that foreign experts could be assigned to work with, provide technical assistance to, and train their Pakistani counterparts without concerns for their personal safety and security.

The record indicates that even with limited technical contacts with the global nuclear power industry, Pakistan did well in preserving the safety of its operating plants and managed to maintain them in operation, though at lower capacity factors than achieved by other Asian countries better integrated into the global nuclear community. The raw potential for operational excellence is there, and it requires additional refinements to break through and shine.

The two limiting factors on the expected fast growth of the Pakistani nuclear industry are (1) the ability of the regulatory agency PNRA to license new sites and new power stations fast enough to meet the target expansion schedule and to properly supervise the safe operation of the constructed nuclear power stations, and (2) the ability of PAEC to train new plant operators and stations' O&M staff members to meet the staffing requirements of the newly established stations. It is yet to be determined whether the Pakistani

technical institutes could train adequate numbers of new personnel fast enough to meet the expected demand. Lack of trained personnel could hamper the safe operation of future nuclear power stations and contribute to nuclear accident initiation.

Based on current information, Pakistan will most likely expand its nuclear capacity, if possible, relying on the Chinese reactor designs of Qinshan Phase I—a 300 MWe reactor and Qinshan Phase II—a newer 600 MWe unit. Pakistan will attempt to standardize its growing nuclear capacity by relying on a few standard designs with reference plants in operation. We estimate that to expand to the full extent of its plan—8,800 MWe of new installed capacity by 2030—Pakistan will have to license and open at a minimum three new nuclear sites, each site containing a 4 × 600 MWe station. In this way, Pakistan might enjoy the economic benefits of both plant standardization and on-site replication of identical units.

All plant standardization and replication programs do, however, carry inherent risks. If the reference design chosen happens to have unexpected technical problems that crop up only after years of operation, then all reactors built to that point will suffer from the same generic problem, and technical fixes will have to be retrofitted later into the operating reactors. Both Chinese designs contemplated by Pakistan are relatively new (particularly the 600 MWe units) with a limited operational track record and thus present risks that future problems might emerge. Should repairs and retrofits be required, these will result in economic penalties both due to the direct cost and due to lost generation from the repaired reactors while undergoing modifications.

The more serious consequence of a generic reactor problem is that it might lead to the initiation of an accident chain which could evolve into a full blown nuclear accident if the station's staff was still inexperienced and not very familiar with emergency procedures. Multiunit stations could further suffer from common-mode reactor failures caused by operational error within the station or within the electric grid—the loss of off-site power—or caused by natural disasters such as earthquakes or floods. All such events would further be exacerbated by new and inexperienced station staffs. We should realize that station operation and electric grid operation are interrelated. Common-mode reactor problems, which might shut down a nuclear station, might also cause cascading plant shutdown throughout the electric grid, which could eventually (under the worst case) lead to a grid collapse and electricity blackout with severe social and economic consequences.

Due to its unique characteristics, history, and the nature of its internal as well as external politics, Pakistan has allowed the emergence of an entire infrastructure of terrorist organizations within its borders. Up to 50 to 60 active or partially active terrorist groups are estimated to operate in the country in pursuit of their own nihilistic, sectarian, or pan-Islamic goals. It is further suspected that some of these groups receive direct or indirect aid from Pakistani intelligence or some rogue elements within the Pakistani intelligence community, which use terror tactics to promote Pakistan's interests in its conflict with India over Kashmir and its attempts to control the Afghanistani regime. Only a limited number of these organizations have got the requisite capabilities and the motivation to attack a nuclear power station, though such attacks have not yet

materialized. In addition to this terror infrastructure, one should consider simmering regional and sectarian strife between the Punjabi and the Sindhis, the Punjabis and the Baluchis, and between the majority Sunni and minority Shia communities. On top of all these, we should consider the existence of large-scale foreign terrorist base areas within Pakistan, only partially controlled by the government, if at all. In this category, we include the Taliban and the International Islamic Group (al-Qaeda and their associate Chechen, Uzbekistani, Arab, and other groups). All these concentrate along the border areas between Pakistan and Afghanistan; however, they maintain active terrorist cells within the main Pakistani population centers.

The overall conclusion from this enumeration of the unstable environment within Pakistan is that the country may not present the most secure environment in which to construct a large system of nuclear power plants and their supporting infrastructure. Due to their long lead-times, all nuclear projects require long stable periods to allow licensing, construction, and successful operation. Thus a long-term stable security environment would be conducive to the development of a large nuclear power program within any country, and the converse is also true. Unfortunately, as discussed above, Pakistan is not a model of a stable country, and developing a large nuclear power program under these conditions might present considerable risks.

The risks that the terror infrastructure and unstable national security environment present to operating multiunit nuclear stations are diverse. Terrorist groups might initiate a diversion campaign or a direct attack against a multiunit nuclear station, relying in part on an insider's help, which they might recruit. Given the

large number of terrorist groups existing, it is possible that some group might identify a sympathetic insider or coerce one into cooperation and pass him along to the group initiating the fissile material diversion operation. Terrorist groups might try to capture intact a nuclear station and use it as a bargaining chip in their negotiations with the central government regarding their own, or general political demands. Terrorist groups might, under some grievous conditions, attempt to destroy a nuclear station, creating large radioactive dispersion within Pakistan which could spread to neighboring countries. To achieve such a goal, the group might mount an aerial attack or use an explosive laden truck convoy to attack the station. Airplane attacks could come in two variants: (1) kidnapping and piloting a large passenger jet into a containment building or into the spent fuel storage structure on top of the auxiliary building next to the reactor, or (2) piloting several smaller commercial aviation planes laden with explosives placed there by the terrorists into the reactor buildings. In all cases, multiunit nuclear stations would be tempting targets for such kinds of attacks due to the multiplicity of high value targets. The prospective success of such attacks would be enhanced with insiders' support and assuming that the station staffs are yet new and not well-versed in emergency procedures.

Finally, the general political instability in Pakistan could lead to attempted takeover of nuclear power stations by regional military commanders during times of political turmoil, either to protect the stations, which are prestige national projects, or to use them as bargaining chips to secure conditions desirable to the commander, his command, or the sect he represents. Even the threat of a takeover might suffice rather

than actual occupation. Such preemptive protective takeover of a nuclear station might be carried out by an invading army in case of a war between Pakistan and one of its neighboring enemy countries (e.g., India). This takeover would likely be carried out by commando-style attacks so as to prevent attempted terrorist attacks in times of general instability such as a war, or as a way to deny Pakistan the electricity the station generates until hostilities cease.

In general, the more attack scenarios against multiunit nuclear power stations that one can identify, the greater the indication that these type stations may not be the most desirable means of generating electricity in an unstable environment such as exists in Pakistan. This may happen despite the economic benefits that a well-managed and executed nuclear power program could bring, and despite the external assistance the Pakistanis might garner in implementing the program.

ENDNOTES - CHAPTER 8

1. World Nuclear Association, *Nuclear Power in India and Pakistan*, London, February 2006, www.world-nuclear.org/info/printable_information_papers/inf53print.htm.

2. International Atomic Energy Agency (IAEA), *Pakistan Country Profile* (December 2004 Update), Vienna, March 2006, www-pub.iaea.org/MTCD/publications/PDF/cnpp2004/CNPP_Webpage/countryprofiles/Pakistan/Pakistan2004.htm.

3. IAEA, *Nuclear Power Reactors in the World*, Reference Data Series No. 2, Vienna, April 2005.

4. IAEA, *Pakistan Country Profile*.

5. *Ibid.*

6. *Ibid.*

7. *Ibid.*

8. *Ibid.*

9. Nuclear Threat initiative (NTI), "Pakistan Meets with Nuclear Exporters," Global Security Newswire, Washington DC, March 21, 2006. See also United Press international (UPI), "Pakistan Talks to Nuclear Suppliers Group," Islamabad, Pakistan, March 21, 2006.

10. There exist a large number of references summarizing the activities of the A. Q. Khan's network. Among the recent ones are Sharon Squassoni, "Closing Pandora's Box: Pakistan's Role in Nuclear Proliferation," *Arms Control Today*, Washington DC, April 2004. Also see Chaim Braun and Christopher F. Chyba, "Proliferation Rings: New Challenges to the Nuclear Nonproliferation Regime," *International Security*, Vol. 29, No. 2, Fall 2004, pp. 5-49. See also Richard P. Cronin, K. Alan Kronstadt, and Sharon Squassoni, "Pakistan's Nuclear Proliferation Activities and the Recommendations of the 9/11 Commissions: U.S. Policy Constraints and Options," Congressional Research Service (CRS) Report to Congress, RL 32745, Washington DC, updated May 24, 2005.

11. U.S. Department of State (DOS), "U.S. India Civil Nuclear Cooperation Initiative, Bureau of Public Affairs release, Washington DC, March 9, 2006. See Statement to Parliament, "Text of the Document Titled 'Implementation of the India-United States Joint Statement of July 18, 2005: India's Separation Plan'," Tabled in Parliament, New Delhi, India, March 7, 2006. See also The White House, "Fact Sheet: United States and India: Strategic Partnership," Press Release, Washington DC, March 2, 2006, www.whitehouse.gov/news/releases/2006/03/20060302-13.html.

12. Permanent Mission of Pakistan to the United Nations, "Pakistan's National Report on National Measures on the Implementation of Security Council Resolution 1540 (2004)," Annex to Note Verbale Addressed to the Chairman of the Committee, Document S/AC.44/2004/(02)/22, New York,

October 27, 2004, daccessdds.un.org/doc/UNDOC/GEN/N04/597/46/PDF/N0459746.pdf?OpenElement. See also Permanent Mission of Pakistan to the United Nations, Addendum 1 to Document S/AC.44/2004/(02)/22, issued in New York, September 19, 2005, daccessdds.un.org/doc/UNDOC/GEN/N05/542/40/IMG/N0554240.pdf?OpenElement.

13. IAEA, *Pakistan Country Profile*.

14. Virtual Information Center (VIC), "Pakistan Primer," U.S. Pacific Command, Department of Defense (DOD), Update July 1, 2002, www.vic-info.org/regionstop.nsf/e77b05d93ef548b20a256c6a000cc1b7/654811faa730ef120a256be90081391d?OpenDocument.

15. Joseph Cirincione, Jon Wolfsthal, and Miriam Rajkumar, "Deadly Arsenals: Nuclear, Biological and Chemical Threats," Second Ed. Revised and Expanded, Washington, DC: Carnegie Endowment for International Peace (CEIP), 2005, www.carnegieendowment.org/images/npp/pakistan.jpg.

16. World Nuclear Association; IAEA, "Nuclear Power Reactors in the World."

17. Pakistan Atomic Energy Commission (PAEC), "Karachi Nuclear Power Plant (KANUPP)," KANUPP Main Page, MIS Division, PAEC, Islamabad, Pakistan, updated April 2005, www.paec.gov.pk/kanupp/kanupp-index.htm.

18. B. Raman "Nuclear Accident in Pakistan?" South Asia Analysis Group (SAAG), Paper No. 290, New Delhi, India, August 7, 2001, www.saag.org/papers3/paper_290.html. See Dr. S. Chandrasekharan, "Chasma Nuclear Plant: CHASNUPP will continue to be Accident Prone," South Asia Analysis Group (SAAG), Paper No. 295, New Delhi, India, August 16, 2001, www.saag.org/papers3/paper_295.html. See also PAEC, "Chasma Nuclear Power Plant -1 (CHASNUPP-1)," MIS Division, PAEC, Islamabad, Pakistan, updated November 2005, www.paec.gov.pk/chasnupp1/index.htm.

19. *Ibid.*

20. Power Engineering International, "China to Give \$ 350m

Loan for Pakistan Nuclear Plant," May 12, 2004, pepei.pennet.com/articles/article_display.cfm?&ARTICLE_ID=204153.

21. *Ibid.*

22. "The NSG: Strengthening the Nuclear Non-proliferation Regime," Summary Statement of NSG Plenary Session, *NSG_GOT/Press/Final*, Goteborg, Sweden: Nuclear Suppliers Group (NSG), May 27, 2004, www.nuclearsuppliersgroup.org/PRESS/2004-05-goteborg.pdf.

23. VIC, "Pakistan Primer"; Cirincione *et. al.*, "Deadly Arsenals."

24. *Ibid.*

25. IAEA, "Power Reactor Information System (PRIS)," December 31, 2004, updated 2005, Vienna, Austria, www.iaea.org/programmes/a2/index.html.

26. *Ibid.*

27. Nuclear Engineering International, *2004 World Nuclear Industry Handbook*, Power Reactors Data Table, Core, and Fuel Section, Report ISBN-1 903077362, Sidcup, Kent, United Kingdom: Wilmington Publishing, 2005, www.connectingpower.com.

28. DOE, Report of the Nonproliferation Alternative Systems Assessment Program (NASAP), *Vol. IX: Reactor and Fuel Cycle Description*, Table B.1., Washington, DC, June 1980, p. B-21.

29. IAEA, "Power Reaction Information System."

30. Fida Hussain, "Government to Run Nuclear Power Plants at Higher Capacity," *Daily News*, Pakistan, January 20, 2006. See also "Musharraf to Turn to China for N-Help," *Asian News International*, Islamabad, Pakistan, February 14, 2006. See also NTI. "Pakistan, China Might Sign Nuclear Pact," *Global Security Newswire*, Washington DC, April 11, 2006.

31. Tarique Niazi, "Thunder in Sino-Pakistani Relations," *The Jamestown Foundation China Brief*, Vol. 6, Issue 5, March 2, 2006,

jamestown.org/publications_details.php?volume_id=415&issue_id=3637/. See also Afzal Bajwa, "Pak-China to ink Pact for N-Plant," *The Nation Journal*, Islamabad, Pakistan, April 24, 2006, *nation.com.pk/daily/april-2006/24/index1.php*. For further information regarding locating one future nuclear station in Balochistan, see B. Raman, "Balochistan Freedom Fighters attack Nuclear Establishment," SAAG, Paper No. 1801, New Delhi, India, May 17, 2006, *www.saag.org/papers19/paper 1801.html*.

32. *Ibid.*

33. Ministry of Foreign Affairs of the People's Republic of China, "General Manager Kang Rixin of China National Nuclear Corporation (CNNC) Elaborates on the Development Status of China's Nuclear Power and the Exchanges and Cooperation with International Counterparts," Press Briefing at the International Press Center (IPC), Beijing, China, June 6, 2005, *www.fmprc.gov.cn/eng/xwfw/wgjzxwzx/ipccfw/t199253.htm*. See also China Nuclear Industry 23rd Construction Corporation, "Qinshan Nuclear Power Plant, Phase II," Corporate Information Brochure, Beijing, China, 2004, *www.cni23.com/cni23_04_a04_en.htm*.

34. China Nuclear Industry 23rd Construction Corporation, "Qinshan Nuclear Power Plant, Phase II," Corporate Information Brochure, Beijing, China, 2004, *www.cni23.com/cni23_04_a04_en.htm*.

35. Hideo Ikuno, MHI, "MHI Receives Chinese Order for Reactor Coolant Pumps for Units 3 and 4 of Qinshan Nuclear Plant Phase II," Mitsubishi Corporation Press release, Tokyo, Japan, October 24, 2005.

36. Christopher O. Clary, "The A. Q. Khan Network: Causes and Implications," M. A. Thesis submitted to the Naval Postgraduate School, Monterey, CA, December 2005. See record of Hearings before House of Representatives Subcommittee on International Terrorism and Nonproliferation, Committee on International Relations, May 25, 2006. In particular, see testimonies at that Hearing by David Albright, "A. Q. Khan's Network: The Case is Not Closed"; Leonard Weiss, "Testimony on A. Q. Khan's Network"; and Andrew Koch, "A. Q. Khan's Network: Case Closed?" Washington, DC, May 25, 2006.

37. NTI, "Pakistan Seeks Civilian Nuclear Deal," Global Security Newswire, Washington, DC, September 8, 2005. See Shyam Bhatia, "Pakistan Seeks Nuclear Parity with India-U.S.," DH News Service, Washington, DC, January 2006. See also Anwar Iqbal, "Follow-Up Talks Held with U.S. Officials," Dawn Internet News, Washington, DC, January 26, 2006.

38. "Pakistan May Seek Russian Nuclear Reactors, Prime Minister," Interfax News agency, Moscow, Russia, January 27, 2006.

39. NTI, "Pakistan Meets with Nuclear Exporters."

40. Permanent Mission of Pakistan to the United Nations, "Pakistan's National Report on National Measures on the Implementation of Security Council Resolution 1540," Annex to Note Verbale Addressed to Chairman of the Committee.

41. AFX News, "Pakistan Wants U.S. to Match India Nuclear Deal," AFX UK Focus, Islamabad, Pakistan, March 2, 2006. See also NTI, "India Praises Russia for Uranium Sale," Global Security Newswire, Washington, DC, March 20, 2006.

42. Hussain; "Musharraf to Turn to China for N-Help"; NTI, "Pakistan, China Might Sign Nuclear Pact"; Tarique Naizi, "Thunder in Sino-Pakistani Relations," The Jamestown Foundation China Brief, Vol. 6, Issue 5, March 2, 2006, jamestown.org/publications_details.php?volume_id=415&issue_id=3637; Majwa; Raman, "Balochistan Freedom Fighters Attack Nuclear Establishment."

43. "Top U.S. Official Refuses to Discuss Nuclear Energy with Pakistan," AFP News, Islamabad, Pakistan, March 13, 2006.

44. DOE, "U.S.-India Civil Nuclear Cooperation Initiative"; Statement to Parliament, "Text of Document Entitled 'Implementation of the India-United States Joint Statement of July 18, 2005'"; White House "Fact Sheet: United States and India." Also see Jeffrey Lewis, "India Legislative Text," ArmsControlWonk Web site, March 14, 2006, www.armscontrolwonk.com.

45. U.S. Nuclear Regulatory Commission (NRC), "Groundwater Contamination (Tritium) at Nuclear Plants," Information Report, Washington, DC, March 31, 2006, www.nrc.gov/reactors/operating/ops-experience/grndwtr-contam-tritium.html.

46. *Ibid.*

47. *Ibid.*

48. NRC, "Groundwater Contamination . . ."

49. Raman, "Nuclear Accident in Pakistan?"; Chandrasekharan.

50. There exists a wide body of technical literature dealing with loss of off-site power issues. The latest summary of the problem and required regulatory actions and countermeasures is found in NRC, "Issuance of Nuclear Regulatory Commission Generic Letter 2005-xx, 'Grid Reliability and the Impact on Plant Risk and the Operability of Off-Site Power'," NRC Report SECY-05-0219, Washington, DC, December 22, 2005, www.nrc.gov/reading-rm/doc-collections/commission/secys/2005/secy2005-0219/2005-0219scy.html.

51. For summaries of the 2001 and 2003 blackouts, impacts on the grid and on power plants, and the required countermeasures, see Electric Power Research Institute (EPRI), "The Western States Power Crisis: Imperatives and Opportunities," EPRI White Paper, Palo Alto, CA, June 25, 2001. Also see DOE, "National Transmission Grid Study, "Report Submitted to the Honorable Spencer Abraham, Secretary of Energy, Washington, DC, May 2002; Randy Hurst, "Historic Blackout Prompts Spotlight on Grid Weakness," *Electricity World*, Issue 5, October 2003; Damir Novosel, KEMA Consulting, "System Blackout Causes and Cures," *Energy Pulse Paper*, October 6, 2003, www.energypulse.net/centers/article/article_print.cfm?a_id=495.

52. Hussain Haqqani, "Pakistan Between Mosque and Military," Washington, DC: Carnegie Endowment for International Peace, 2005.

53. M. Ehsan Ahrari, *Jihadi Groups, Nuclear Pakistan, and the New Great Game*, Carlisle Barracks, PA: Strategic Studies Institute (SSI), U.S. Army War College, August 2001.

54. Isaac Kfir, "The Paradox That Is Pakistan: Both Ally and Enemy of Terrorism," *Middle East Review of International Affairs*, Vol. 10, No. 1, March 2006, pp. 74-84, meria.idc.ac.il/journal/2006/jv10no1a6.html.

55. Amir Mir, "Balochistan: Dire Prophecies," *South Asia Intelligence Review*, Weekly Assessments and Briefings, Vol. 4, No. 30, February 6, 2006, www.satp.org/satporgrp/sair/Archives/4_30.htm. See also Frederic Grare, "Pakistan: Resurgence of Baloch Nationalism," Carnegie Paper No. 65, Washington, DC: Carnegie Endowment for International Peace, January 2006, www.CarnegieEndowment.org/pabs; Tarique Niazi, "Baloch Insurgents Escalate Attacks on Infrastructure," Jane's Information Group, London, May 22, 2006; Ramen.

56. Praveen Swami, "Beastly Tales from the Jihadi Zoo," *South Asia Intelligence Review*, Weekly Assessments and Briefings, Vol. 4, No. 35, March 13, 2006, www.satp.org/satporgrp/sair/Archives/4_35.htm.

57. Kanchan Lakshman, "Troubles on the Western Front," *South Asia Intelligence Review*, Weekly Assessments and Briefings, Vol. 4, No. 32, February 20, 2006, www.satp.org/satporgrp/sair/Archives/4_32.htm. See Sayed Saleem Shahzad, "Pakistan Battles the Forces Within," Asia Times Online, Karachi, Pakistan, May 2006; Carlotta Gall, "In Remote Pakistan Province, A Civil War Festers," *New York Times*, April 2, 2006.

58. B. Raman, "Pakistan and Dangers of Nuclear Jihad," SAAG, Paper No. 904, New Delhi, India, January 27, 2004; B. Raman, "International Jihadi Terrorism: A U.S. Perspective Part IV and Last," SAAG, Paper No. 1369, New Delhi, India, May 6, 2005; B. Raman, International Terrorism Monitor Paper No. 21, "A. Q. Khan, Sudan, Iran, and Al Qaeda," Paper No. 21, SAAG, Paper No. 1690, New Delhi, India, January 28, 2006; B. Raman, International Terrorism Monitor Paper No. 21, "A. Q. Khan and Al Qaeda: Bush Turns the Screw on Musharaf," SAAG, Paper No. 1720, New Delhi, India, March 6, 2006. All available at www.saaq.org.

59. Clary; Record of Hearings before House of Representatives Subcommittee on International Terrorism and Nonproliferation, Committee on International Relations; Albright; Weiss; Koch. See also Amir Mir, "Terror and the Bomb: Dangerous Cocktail," SAIR, Weekly Assessments and Briefings, Vol. 3, No. 51, July 4, 2005, www.satp.org/satporgtp/sair/Archives/3_51.htm.

60. Naizi, "Thunder in Sino-Pakistani Relations"; Bajwa; Raman, "Balochistan Freedom Fighters Attack Nuclear Establishment."

61. South Asia Terrorism Portal (SATP), "Pakistan Terrorist Groups, Terrorist Outfits: An Overview," www.satp.org/satporgtp/countries/pakistan/terroristoutfits/index.html.

62. Office of the Coordinator for Counterterrorism, *Country Reports on Terrorism*, Chapter 6, "Terrorist Groups," Washington, DC: Department of State Report, April 27, 2005, www.state.gov/s/ct/rls/crt/45394.htm.

63. K. Alan Kronstadt and Bruce Vaughn, CRS, "Terrorism in South Asia," Washington, DC: CRS Report for Congress, RL32259, December 13, 2004.

64. SATP, "Pakistan Backgrounders," Figure 1, Constructed from Media Reports, www.satp.org/satporgtp/countries/pakistan/backgrounders/index.html.

65. Michael M. May, General Editor, *Verifying the Agreed Framework*, Section 4.4.1, "The Special Problem of the Beginning-of-Life and of the End-of-Life Fuel Discharges," Report UCRL-ID-142036, CGSR-2001-001, April 2001.

66. Haqqani.

67. There is a great body of literature related to military or terrorist threats to nuclear power plants. See early book on this topic by Bennett Ramberg, "Destruction of Nuclear Energy Facilities in War," Lanham, MD: Lexington Books, 1980. See also Charles D. Ferguson and William C. Potter, *The Four Phases of Nuclear Terrorism*, Chapter 5, "Releasing Radiation Power Plants

and other Facilities," New York: Routledge Publishing, 2005; C. Braun, F. Steinhausler, and L. Zaitseva, "International Terrorist's Threat to Nuclear Facilities," Paper Presented at the 2002 ANS Winter Meeting, Washington, DC, November 19, 2002.

CHAPTER 9

BAD OPTIONS: OR HOW I STOPPED WORRYING AND LEARNED TO LIVE WITH LOOSE NUKES

Thomas Donnelly

“The prospect that a nuclear-capable state may lose control of some of its weapons to terrorists is one of the greatest dangers the United States and its allies face.” So states the 2006 report on the *Quadrennial Defense Review*, noting that, at its core, the problem is one of “internal stability.” While this sort of language might seem vague and euphemistic, Pentagon planners have a very specific scenario in mind: Pakistan. Our most strategically immediate proliferation problems are posed by North Korea and Iran, two states obviously hostile to the United States. But a more important problem may be that of Pakistan, a crucially important ally in the global war on terrorism and the larger “Long War” for the future of the Islamic world. The Pakistan problem magnifies the military difficulties of operating in the shadow of nuclear weapons by trying to focus them through a very cloudy political lens. To be effective, any operation would have to be excruciatingly precise, yet the opacity of Pakistani politics, especially its domestic politics, naturally diffuses any military option. It would be hard to know in advance whether American intervention in a Pakistani crisis—whether related to nuclear weapons, materials, or facilities—would make things better or make them worse.

An unstable nuclear state poses a novel conundrum for American strategists. We thought we knew how to deter the massive nuclear force of the Soviet Union through 5 decades of superpower Cold War—although the unanticipated collapse of the Soviet empire and the resulting nuclear chaos suggests that the principles of deterrence might have rested on a more liquid foundation than we understood at the time. But the Soviets appeared to be the model of implacable, unchangeable stability, and to them, we appeared to be “rational actors,” predictable and open to carrot-and-stick diplomacy, even if their assessment of carrots and sticks might have been very different than ours.

Despite a high degree of rhetorical hand-wringing by both the Clinton and Bush administrations and also by other nations, a barely-diminished belief in the efficacy of deterrence remains at the core of the proliferation and broader strategy for Iran and North Korea. The U.S. and international approach in both cases can be regarded as a recycling of Cold War containment, if only because no one can think of a better option. Even though the leaders in Pyongyang and Tehran seem to be the embodiment of irrational, even megalomaniacal, autocrats, we act as though we can do business with them if we are properly cautious. We pretend not to notice the odd behavior of Kim Jong Il, whose eccentricity was encapsulated by *The Economist* magazine’s cover portrait with the caption, “Greetings, Earthlings,” or even Iranian President Mahmoud Ahmadinejad, whose apocalyptic pronouncements are too frequent to keep up with—the daily declarations to incinerate Israel or bring death to the Great Satan America have simply become part of the background chatter. We take their hostility for granted but retain our belief in their rationality as international actors.

Only in the cases of Pakistan—to repeat, an important, if uncertain ally—and the remnants of the former Soviet Union, do the prospects of dealing with nuclear instability and unpredictability appear to have pierced the adamant brows of American strategists. In the case of Russia, the primary approach has been a kind of renewed arms control reflected in the 1991 Nunn-Lugar Nuclear Threat Reduction Act. And only, really, in the post-September 11, 2001 (9/11) world have the dangers of “loose nukes” suggested by Pakistan’s backing of the Taliban in Afghanistan, its nuclear brinksmanship with India, and the used-car-salesman proliferation practices of A. Q. Khan, begun to take root in the imagination. Indeed, we are coming very late to thinking about a military option for this very perplexing problem.

Inherently Unstable?

On the other hand, Pakistan has always been a somewhat unstable state; one might even argue it was built upon not just a myth but a falsehood. Even before they created Pakistan, the Muslims of the subcontinent have been divided and confused about many basic questions defining the nation and the state.¹ The original conception, as Stephen Cohen of the Brookings Institution has explained, was for a Pakistan as an “extraordinary” state, “a homeland for Indian Muslims and an ideological and political leader of the Islamic world.”² At the same time, the ideology of the Pakistan movement was opaque and contradictory, with the contradictions seemingly captured in the figure of its leader, Muhammad Ali Jinnah, Karachi-born but trained as a lawyer in England and retaining a lifelong affinity for fine English tailoring. Though a partner of

Gandhi and Nehru in the Indian Congress, Jinnah was suspicious of their all-India approach, and as British imperial power on the subcontinent began to wane in the early 20th century, the compact between Indian Hindu and Muslim likewise weakened. Moreover, Kemal Ataturk's abolition of the Ottoman caliphate in 1922 threw the Muslim world into turmoil, with the particular effect of politics becoming ever more local; the pan-Islamic caliphate movement collapsed entirely. There was rising political uncertainty not only in the subcontinent but across the broad Islamic world.

Thus, at the 1928 session of the Indian Congress, Jinnah proposed not only guaranteed seats for Indian Muslims in national and provincial legislatures, but the creation of three "designated Islamic states"—Sind, Baluchistan, and the Northwest Frontier Province—within a future independent Indian federation. In other words, while the subcontinent was still struggling to separate itself from British rule, Jinnah was proposing an ethnic state-within-a-state that held within it the promise of further separation. To be sure, to Jinnah and others, the allegedly inclusive All-India Congress appeared more like a vehicle for Hindu political dominance. And the definition of who was a "Muslim" was mostly defined in distinction to Hinduism and elided traditional differences between regions and tribes. The deeply secular Jinnah declared in 1940 that the two communities "are not religious in the strict sense of the word, but are in fact different and distinct social orders. And it is a dream that the Hindus and Muslims can ever evolve a common nationality."³

Jinnah's dream also held an expansionist tendency. When Gandhi embarked upon his "Quit India" campaign at the nadir of Britain's fortunes in World War II, Jinnah seized the opportunity to double his

territorial demands, adding Kashmir, the Punjab, and Bengal to his list of Muslim provinces. Though this would prove to be an inherently unstable strategic fantasy, Britain, in its haste to leave India after the war, allowed the growing fissures between Hindu and Muslim to fester. In the final solution to the Raj, the Punjab and Bengal were split, inciting massive ethnic cleansing and resulting in the deaths of nearly 1 million people and, of course, leaving Kashmir a contested province. The fundamental instability of the new Pakistan was apparent from the start, and was confirmed—though hardly entirely resolved—by the 1971 secession of East Pakistan. That the nascent “Bangladesh” would rely on Hindu India to secure the separation, showed the weakness of Jinnah’s and Pakistan’s ideas of Muslim brotherhood. The bond of Islam was not strong enough to convince Bengalis that they should remain confederate with, and subordinate to, Punjabis.

“Pakistan is a paranoid state,” writes Stephen Cohen, “that has enemies.” Pakistani strategists and political elites fear they may become a “West Bangladesh—a state denuded of its military power, and politically as well as economically subordinated to a hegemonic India.”⁴ Yet, somewhat perversely, the result is a strategic “adventurism,” by which Cohen means Pakistan’s ambitions in Kashmir and Afghanistan, but which should be applied equally to Pakistan’s nuclear program, its relations with China, and its ambiguous stance vis-à-vis the Taliban, al-Qaeda, various “associated movements” internationally, and its homegrown radicals. Indeed, it is hard to escape the conclusion that Pakistan began as and remains a profoundly unsettled and unsettling political phenomenon, both internally and internationally.

Curiously for a self-conceived Islamic state, Pakistan has found it difficult to deal with a narrower but more immediately powerful vision of Islam—that advanced by al-Qaeda and the radicals. Islamist *madrassas* have provided education and other state services when and where the Pakistani government has not. The Pakistani army, by far the strongest institution of the state, has long had cozy relations with Islamist groups, particularly in the eternally troublesome North-West Frontier Province. The traditional wisdom is that the army holds the upper hand. Cohen expresses this perfectly. “The political dominance and institutional integrity of the Pakistani [army] remain the chief reasons for the marginality of radical Islamic groups,” he concluded even in 2003. “Although the army has a long history of using radical and violent Islamists for political purposes, it has little interest in supporting their larger agenda of turning Pakistan into a more comprehensively Islamic state.”⁵

But who is using whom is difficult to tell from a distance. At a minimum, there seems to be a strong correlation of interests between Islamic radicalism and Pakistan’s otherwise “national” interests, or the interests of Pakistan’s Pashtuns. Indeed, the history of Pakistan is—to oversimplify for the sake of clarity—a history of the pact between Punjabis and Pashtuns, a partnership reflected particularly through the Pakistani army and officer corps. While this has itself been an unstable relationship, it has helped keep a lid on the even more fissiparous tendencies of Sindhis and Baluchis. It has also made the Punjabis partners in the nationalistic yearnings of Pashtuns to reclaim “Pashtunistan”—a homeland cut in half by the 1893 Durand Line, the border that allegedly advanced British colonial interests but, like a good number of

the borders throughout the Islamic world, left constant conflict in its wake.

This has made for unending border wars, both in Kashmir—it was Pashtun tribesmen, supported by the Pakistani army, who sparked the fighting that began in October 1947, shortly after the British withdrawal, and continues to this day—and in Afghanistan. The persistence of terror and guerilla attacks in Kashmir, such as the recent series of bombings in Srinagar, is in part a product of “tolerance” in Islamabad, as is the continuing tension with Afghanistan. Speaking at a counterterrorism conference in Turkey in March, Afghan President Hamid Karzai—a Pashtun himself, it should be remembered—complained that extremist tendencies and terrorism in Afghanistan were not just an internal problem, but the result of “political agendas and the pursuit of narrow interests by governments.” By this euphemism, Karzai meant Pakistan, as he made clear when talking about the Taliban, whose rise in the 1990s he described as a “hidden invasion propped up by outside interference and intended to tarnish the national identity and historical heritage” of Afghanistan.⁶

Yet it would be a mistake to blame all of Pakistan’s internal and border problems on the Pashtuns; Punjabis have often been at odds with their Baluchi and Sindhi countrymen. Recent deployments of the Pakistani army to Karachi, ostensibly to dampen unrest in the wake of a suicide attack that killed three Sunni Muslim clerics but seen to be a move against the large Baluchi population there, have fueled Baluchi separatist feelings. Islamabad “has treated Baluchistan like a colony,” complained Imran Khan, a member of the Pakistani parliament. Baluchi nationalist Humayun Baluch charges that Punajbis are being introduced as

settlers, traders, and miners. “[Our] provincial resources are being exploited and looted,” he says. “People’s rights are being compromised and everything is being done for the benefit of the Punjabis. Army troops, army weaponry, helicopters, jets, and F-16s are being used in Baluchistan. The population is being forced out and primarily living in Sindh [in Karachi]. Houses have been burned and looted.”⁷

Also irritating to Baluchi national pride is the construction of the Gwadar port and the influx of Chinese engineers who oversee the project. On May 3, 2004, the “Baluchistan Liberation Army” killed three Chinese engineers working on the port project, an effort that employs several hundred Chinese nationals. Baluchi nationalists believe that Beijing is in league with Islamabad to develop and export the province’s natural gas resources. Pakistan’s leading natural gas company, Sui, is located in Baluchistan but provides products for the entire country.

Pakistan was born in instability and retains a political culture marked by deep insecurity and uncertainties that underlie the idea of the Pakistani nation and the formation and history of the state of Pakistan. These distortions are exacerbated by the army’s dominance of the state; civil society has been unable to soothe either Pakistan’s real fears or the fears that are the unsurprising result of “adventurism.” Even those accustomed to Pakistan’s “normal” instability, like Stephen Cohen, cannot be sure that the army will continue to balance these many competing demands in the face of rising Islamic populism or Baluchi separatism; he is not confident much beyond the immediate future. The more Pakistan acts as though it were cornered, the more cornered it becomes. The more tightly the army grips the reins of power, the more likely the bridle may break.

A Nuclear Nightmare.

The marriage of seemingly incorrigible instability and nuclear weapons is a profoundly frightening prospect, as the *Quadrennial Defense Review* noted:

Several other [weapons of mass destruction (WMD)]-armed states [beyond Iran], although not necessarily hostile to the United States, could face the possibility of internal instability and loss of control over their weapons. The lack of effective governance in many parts of the world contributes to the WMD dangers, providing opportunities for terrorist organizations to acquire or harbor WMD. The prospect that a nuclear-capable state may lose control of some of its weapons to terrorists is one of the greatest dangers the United States and its allies face.⁸

The report goes on to observe that collecting reliable intelligence on such programs and activities is a challenge. Research efforts are easy to conceal and difficult to detect and track; the study forecasts “further intelligence gaps and surprises.” Despite such difficulties, the United States must be prepared to “act in cases where a state that possesses WMD loses control of its weapons, especially nuclear devices.”⁹ If this is an injunction to act should Islamabad lose control of its nuclear weapons—or its nuclear materials or nuclear expertise—it is asking an awful lot, not just in a military operational sense, but in a strategic and geopolitical sense.

Consider, to begin with, the extent of Pakistan’s nuclear program. The effort was begun in 1972 shortly after the secession of Bangladesh, under the direction of Pakistan’s then-Minister for Fuel, Power, and Natural Resources, Zulfikar Ali Bhutto—a man who

was later prime minister, ousted in a military coup by General Muhammad Zia ul-Haq, and executed as a murderer. Pakistan was hit with an embargo of Western nuclear imports after India's 1974 nuclear test, but the program took a huge step forward in 1975 with the arrival of Dr. Abdul Qadeer Khan, a German-trained metallurgist who had worked at the URENCO uranium enrichment plant in Holland and had great experience with gas centrifuges. He also, it seems clear in retrospect, had great experience in espionage, for not only did he supervise the construction of the Kahuta weapons facility—formally, the Khan Research Laboratories—which produces highly enriched uranium and also ballistic missiles, he also enhanced Pakistan's standing in the clandestine networks of proliferation.

Kahuta is a massive complex east of Islamabad, with dozens of buildings and reportedly housing 3,000 centrifuges. It is said to produce enough material to make three to six warheads per year. While estimates vary, Pakistan's total inventory of highly enriched uranium is something on the order of 1,000 kilograms, enough material for approximately 60 fission devices. In addition, in the 1990s Pakistan began construction of a research reactor at Khushab, near the city of Faisalabad in the Punjab, capable of producing plutonium and perhaps tritium—ingredients key to making smaller-sized nuclear devices. Overall, the Carnegie Endowment for International Peace has estimated that Pakistan's nuclear weapons, nuclear testing, civilian nuclear, and related facilities extend to nearly two dozen sites, clustered in the Punjab and centered on Islamabad, but also as far away as Karachi, where the Canadian-supplied KANUPP reactor provides power to the city.

All in all, Pakistan maintains a relatively small amount of nuclear material, which it guards closely; under U.S. pressure, formal command and control mechanisms have been improved. The Pakistani army has gained firm control over the nuclear program, which it did not always maintain previously. At the same time, the possibilities of an “insider job,” from those in the Pakistani nuclear establishment with radical Islamic sympathies or from a rogue army officer, can no longer be dismissed out of hand. For that, thank A. Q. Khan.

This is not the place to rehearse the entire story of Dr. Khan’s proliferation activities. Experts differ as to how complicit the Pakistani military may have been in the creation and running of the networks that included North Korea, Libya, and Iran, but in many ways, the more disturbing interpretation would be that Khan operated without the army’s knowledge. The civilian prime ministers of the era, Benazir Bhutto and Nawaz Sharif, were both extraordinarily weak, though in different ways. Khan’s nuclear programs were nominally under civilian control, although in practice, Khan enjoyed a large degree of autonomy during times of military rule.

While Khan’s clients and potential clients were states—possibly including the Taliban’s Afghanistan¹⁰—the nature of his networks and motivations remains as opaque as, well, as opaque as Pakistan. Khan had an undeniable profit motive, but there was more: He was “also motivated by pan-Islamism and hostility to Western controls on nuclear technology.”¹¹ These two traits—pan-Islamism and resentment of Western constraints on Pakistani strength—are part of what make Dr. Khan a figure of Pakistani pride.

The extent of the Pakistani nuclear infrastructure, and the resulting array of potential targets, calls for an arbitrary analyst. To examine the strategic, operational, and tactical issues embedded in the Pentagon's rhetoric about securing other nations' nuclear materials, one must simply manufacture a scenario and hope that it contains some illustrative value. Thus, I intend to discuss a situation in which the facility at Kahuta is penetrated and partially seized by a relatively small force of insurgents in concert with some radicalized elements of the Pakistani army and nuclear bureaucracy. I will further suppose that while the larger part of this force seizes and defends part of the installation, one or more smaller detachments may have made off with materials in order to produce a "dirty bomb"—a simpler device more in keeping with the immediate capabilities of al-Qaeda and its affiliates. Thus the military task for U.S. and allied Pakistani forces is to reclaim the facility, render it safe, and attempt to recover whatever has been pirated away. I do not intend to discuss much a "Phase IV" post-combat environment, but any serious planning would have to do so. The operation will be a watershed event in Pakistani politics, in the politics of the region, and for the United States; a tactical success could still create larger strategic problems.

To repeat: This is a very arbitrary scenario, at once as realistic as any other, and at the same time fantastical. Some Pentagon analyses—which seem to be driven more by operational and programmatic than strategic considerations—posit a larger breakdown of the Pakistani state. I cannot judge the relative plausibility of any particular scenario, but intervening in what would amount to a civil war in Pakistan is enough to set the strongest heart aflutter. And whatever set of circumstances one might imagine, many of the

strategic, operational, and tactical issues would remain constant from scenario to scenario.

Strategic Issues.

While the periodic assassination attempts on Pakistani President General Pervez Musharraf have spurred U.S. military planners to begin to work through the operational issues associated with a potential loss of control of nuclear weapons, facilities, materials, and expertise, the prospect remains, as the *New York Times* reported, “an extremely difficult and highly risky venture.”¹² And when former Central Intelligence Agency (CIA) Director George Tenet and former Deputy Secretary of State Richard Armitage visited Islamabad prior to the invasion of Afghanistan, an important secondary issue to the invasion was the safety of Pakistan’s nuclear program.

Any operational assessment—even one as brief as the one to follow—must make some strategic assumptions. Although an India-Pakistan exchange occupied many analysts’ minds in the 1990s, clearly the sort of scenario envisioned by the Pentagon now is a far more limited, if more likely, danger. The first assumption is to stipulate that any U.S. military action in Pakistan must have at least the tacit agreement of the central command of the Pakistani army, if not the government in Islamabad. Indeed, it might be that a split between a future civilian government and the high command would be the event that leads to loose nukes. But any notion of fighting to gain access to Pakistan makes speculation so complicated as to make it an exercise in futility or, at minimum, an operation that takes so long to unfold that it is not responsive to the situation. Also, it must be assumed that the situation that leads to loss of control is not a broad-based rebellion or insurgency against

the Pakistani army or the Musharraf government. Fighting for access in the face of a popular uprising across Pakistan, or even across the Punjab, is too hard to contemplate. Another correlated but necessary assumption is that the Pakistani army allows U.S. forces to deploy through some—and at least several—airfields and ports. Indeed, in this illustrative exercise, I will tend to assume the most benign conditions, if only to show how complex even the “easiest case” might be.

A second kind of political presupposition must be made about the international politics of the situation. Attempting to gain a United Nations (UN) resolution, for example, could well slow any useful military action, even if the climate were generally favorable; it is hard to imagine the Chinese being very “forward leaning”—although if the Pakistanis made an appeal to the “international community” in the moment of such a crisis, it might be hard to keep the Chinese out, and even harder to do so the longer the operation continued. As in the 2001 invasion of Afghanistan, allied participation would not be of much military value; at the same time, any U.S. deployment would require international cooperation, such as the use of airfields in Germany. The sole exception to this rule might be Indian assistance, which would be useful tactically and operationally, but any hint of Indian cooperation would make a U.S. intervention more toxic to Pakistanis than it would be otherwise.

A third set of assumptions has to be made about the level of political and strategic preparedness on the part of the United States. This means not just traditional intelligence “indications and warning,” but a predisposition on the part of an American president and his advisers—and the political system more broadly—to react in a timely fashion. These will be circumstances where indecision can be fatal. It may be

that the crisis in Pakistan comes at the denouement of a process that unfolds over weeks or at least days, but that is hardly a certainty. The key issue is how much predeployment notice is given to U.S. forces. In the spirit of arbitrariness, let us say one week, enough time to allow the movement of some U.S. forces, but not, for example, large-scale ground forces.

More important than the strategic preparedness would be the preparedness of the American body politic. Under today's climate, it is difficult to imagine a great enthusiasm for further American "adventurism" in the Islamic world, especially if premised upon worries about WMD. Such public doubtfulness may be a reaction to Bush administration policies and performance since 9/11, but the public's mood would shape the choices of a future administration, too. Even if there were a "rallying" effect in time of crisis, it might be difficult to get a congressional resolution authorizing the use of military force—if, indeed, the Congress were even in session. In sum, the domestic politics of a "preemptive" operation to secure Pakistani loose nukes is at best uncertain and might well provoke strong opposition.

Fourth, one must stipulate the regional posture of U.S. units. Will we have significant forces still in Afghanistan? What will be the location of U.S. carriers, surface combatants, submarines, and Marine expeditionary forces? What other operations will be ongoing at the time, such as in Iraq? Again, one must be somewhat arbitrary. For the sake of this argument, I will assume that U.S. forces will have access to Afghanistan for purposes of deployment, that some significant land force will still be deployed there, but, with the exception of small special operations units, its ability to redeploy from Afghanistan will be limited.

It should be possible to deploy naval forces, including Marines, to the Indian Ocean littoral within striking distance of targets in Pakistan. But the core assumption must be that this is largely a strategic deployment by units based in the United States itself.

Operational Issues.

The most immediate challenge of any military operation to secure Pakistan's nuclear materials will simply be to get there. It is a long way from the United States to Pakistan, from Fort Bragg to Islamabad. As suggested above, the cooperation of some substantial elements of the Pakistani army and government will be essential. Without access, for example, to multiple airfields and ports in Pakistan—not just for initial strategic access, but to stage follow-on operations—a U.S. operation would not be possible.

The core of the operation will be infantry-style land forces; air and naval forces can and must provide support, but the operation should not be an exercise in firepower. The most essential units—the small, highly trained teams of Delta Force or the Navy's SEALs—are held in constant readiness to deploy, and indeed, it is reasonable to expect that some of these forces may already be in the region, engaged in the al-Qaeda manhunt. But even those units held in high states of readiness would have to deploy from their bases half a world away from Pakistan; conversely, those forces most likely to be in the region might not be ideal for the immediate mission.

It is reasonable to assume that amphibious forces and Marine infantry, with limited lift capability, are within reach of Pakistan in times of crisis. Additionally, prepositioned stocks on the Indian Ocean island of

Diego Garcia would be quite valuable, especially for follow-on operations. Still, the scope of such an operation would overwhelm the capabilities of such small units. This is not simply a “snatch” operation. Two factors argue strongly in favor of a larger force: the size and city-like complexity of the Kahuta facility, and the need to cast a wider “dragnet” to cover possible escape routes—Kahuta is located hard by the mountains and not far from the North-West Frontier Provinces. While Pakistani forces will be able to provide an outer shell of security, along with whatever heavy forces and additional firepower is necessary, and will certainly demand to take nominal command at every step of the way, the United States will want to take every step possible to ensure tactical success. A substantial number of Special Forces would be required for liaison with Pakistani tactical units and raids and other highly demanding operations; perimeter-securing numbers of U.S. Army Rangers or Marine infantry would also be required. Moreover, prudence demands that there be a second substantial “on-call” force should an extraction operation be required or, heaven forbid, an escalation. Ideally, the flow of forces into the region should continue for several weeks; one might deploy, for example, a brigade of the 101st Airborne into Afghanistan, and a follow-on force of Marines or soldiers and their helicopters afloat on a large-deck carrier.

Securing Pakistani air space might well be a challenging task. Even if one stipulates that the Pakistani air force—a not insignificant fleet—is generally friendly, the number of man-portable, heat-seeking air defense missiles available to the “rebels” would be a major worry. U.S. cargo aircraft would be vulnerable, at the very least on take-off and landing, as would assault

helicopters. But even when the air space is secure, the more benign job of building an “air bridge” from the United States to Pakistan in a timely fashion and with sufficient carrying-capacity to move and sustain units in the field would itself be complex and costly.

With the possible exception of the most elite special operations forces (SOF) units, there would be several stages of deployment after the initial strategic movement. This is not going to be a case of deploying directly to the fight. Whether staging in Afghanistan or in Pakistan proper, the force will require tactical and even operational mobility—this means vehicles and helicopters. In addition, the operation will require a small forward headquarters element, but it must be commanded by a very senior general; the military practice of a three-star joint task force headquarters is probably the wrong, one-size-fits all approach. Political sensitivities alone demand a four-star officer; the commander must be able to speak authoritatively and win trust among Pakistanis, as well as in Washington. At the same time, it would be folly to try to direct tactical events from a distance.

Nor would the operational problems be solved once deployment to the theater has been accomplished. Getting from, say, Islamabad to the vicinity of Kahuta would itself be a challenge; for example, there is a single access road the front gate of which is closer to the city than to the facility. And there probably would be as much worry about “leakers”—small teams carrying nuclear materials into the surrounding countryside or to the megalopolis of Islamabad and beyond—as about any force holed up in Kahuta. Again, much would depend upon the level of cooperation by the Pakistani army and the overall state of the

country, but any situation dire enough to demand an American intervention would also complicate military operations.

Tactical Issues.

To be precise, let us imagine that an American force actually makes it to the scene of a Kahuta crime. The deployment will have been a difficult challenge, but the situation at the site will be no cakewalk.

The Kahuta facility is a large one, as discussed above. It is a small city nestled into the ridges of a mountain, making access difficult, and any operations inside the facility itself a kind of urban warfare. Since Kahuta, in addition to being a nuclear facility, also hosts the factory for Pakistan's ballistic missiles, there would be plenty of explosive material to handle. Whether a break-away group might be able to manufacture a radiological "dirty bomb" on the premises is an interesting question.

Penetrating the Kahuta perimeter should be relatively easy to do, despite the fact that there is a single access road. But the situation inside would be a challenge. Any intelligence about the site itself—and I would assume Pakistani army cooperation here—would still be of limited value. The location of nuclear weapons, materials, scientists, hostages, and the disposition of the enemy inside would be hard to determine. The enemy within would have a fair amount of time to prepare multiple fighting positions, plant mines and booby-traps, and plan retreat and escape routes.

Additionally, there might be very little time for intelligence preparation of the battlefield; time would most likely be an overriding factor. It would be hard to preserve the virtue of patience. Satellite surveillance

would be useful, but ideally, more persistent and penetrating intelligence-gathering platforms, from unmanned aerial vehicles to larger manned electronic warfare aircraft, would be among the first units to deploy. But how much capability would be available is difficult to say.

Even supposing that, like a George Clooney movie, the operation ends relatively successfully, a number of further questions would remain. Was all the nuclear material accounted for? How would we know? If some has gone missing, where is it, or how far might it have gone? (It is not very far, for example, from Kahuta to Kashmir.) Even if we believe we have all the stuff, what is to be done with it? What, exactly, is meant by “rendering safe”—the term of the art for dealing with recovered nuclear materials—in this situation?

And what happens after the immediate operation is concluded? What will have been the larger effect on what we have stipulated will be an extremely chaotic situation in Pakistan? Will we hold the nuclear materials “in trust” for a future Pakistani government? Will such a U.S. intervention tip the balance in a civil war—how could it not? What is a reasonable “exit strategy” in this situation?

Inventing New Options.

In the end, the very complexity of such an operation—which would be similar in the cases of North Korea or Iran—makes it quite right for the Pentagon to start thinking about options for dealing with “loose nukes” other than the kind of recycled arms-control thinking reflected in the Nunn-Lugar program, International Atomic Energy Agency (IAEA) reform, or other international agreements. Traditional

nonproliferation approaches can have a value, and the danger is great enough to warrant the effort, but working on a military “Plan B” is more than prudent. At the same time, taking the bottom-up, tactical-and-operational approach can only be expected to achieve limited goals, making a “military option” only slightly less unappealing while still leaving the strategic and geopolitical conundrums to be solved on the spot. One of the strongest reasons to work through the operational and tactical challenges is the need to make informed strategy. The likelihood of the above scenario ever coming to pass is less important than that the distances, geography, and other military realities are, more or less, constants.

As hopeless as this chapter may have made it seem, perhaps the best protection against a loss of control of nuclear materials in Pakistan is for the United States to adopt a long-term policy of engagement with the army and with the people of Pakistan. As things now stand, our desire for stability and nuclear control depends entirely on General Musharraf and the Pakistani army, a necessity that will continue for the foreseeable future. At the same time, the dominance of the army and the Punjabi elite has stifled any hopes for a more legitimate and responsible government in Islamabad. Fortunately, the Bush administration appears to have realized that South Asia is a strategic priority for the United States; the American commitment to Afghanistan and the budding strategic partnership with India have the potential to shape a more stable future for the region. Pakistan has every reason to feel itself an important part of this future, and to become something other than a paranoid state beset by enemies with nothing more than nuclear weapons to guarantee its safety. That would be a genuinely new option.

ENDNOTES - CHAPTER 9

1. This argument is developed more fully in Thomas Donnelly, "Countering Aggressive Rising Powers: A Clash of Strategic Cultures," *Orbis*, Summer 2006, pp. 1-16.

2. Stephen Cohen, "The Nation and the State of Pakistan," *Washington Quarterly*, Summer 2002, p. 109.

3. Quoted in Lawrence James, *Raj: The Making and Unmaking of British India*, New York: St. Martin's Griffin, 1997, p. 523.

4. Stephen Cohen, "The Jihadist Threat to Pakistan," *Washington Quarterly*, Summer 2003, p. 7.

5. *Ibid.*, p. 19.

6. Ron Synovitz, "Afghanistan: 'Pashtunistan' Issues Linger Behind Afghanistan-Pakistani Row," *Radio Free Europe/Radio Liberty*, March 24, 2006.

7. Ayesha Khan, "Pakistan: Simmering Baluchi Insurgency Complicates Regional Relations," *Radio Free Europe/Radio Liberty*, April 20, 2006.

8. U.S. Department of Defense, *Report of the Quadrennial Defense Review*, Washington, DC: Department of Defense, 2006. p. 32.

9. *Ibid.*, p. 33.

10. See David Albright and Corey Hinderstein, "Unraveling the A. Q. Khan and Future Proliferation Networks," *Washington Quarterly*, Spring 2005, pp. 111-128.

11. *Ibid.*, p. 112; see also William J. Broad, David Sanger, and Raymond Bonner, "How Pakistani's Network Offered the Whole Kit," *New York Times*, February 13, 2004.

12. David E. Sanger and Thom Shanker, "A Nuclear Headache: What If the Radicals Oust Musharraf?" *The New York Times*, December 30, 2003.

ABOUT THE CONTRIBUTORS

CHAIM BRAUN has 33 years of management and consulting experience in the electric and nuclear power industries emphasizing domestic and international power plant economics, and international nuclear power nonproliferation issues, particularly as related to the United States, East Asia, and Eastern Europe. Dr. Chaim is currently a Science Fellow at the Center for International Security and Cooperation (CISAC) at Stanford University, where he conducts studies related to nuclear proliferation spread and has coined the term "Proliferation Rings." He has developed a concept for providing incentives to reduce national motivations to pursue the development of weapons of mass destruction (WMDs), referred to as the Energy Security Initiative (ESI). Dr. Chaim now works on analyzing nuclear fuel supply assurance measures, the nexus between international nuclear power growth and nonproliferation concerns, and on nuclear power economics and nuclear fuel cycle under deregulation. Previously, he worked as a member of Bechtel Power Corporation's Nuclear Business Line management group, specializing in nuclear operating and maintenance initiatives and international nuclear power plant projects, particularly in East Asia and in Eastern Europe. Prior to that he worked as the Director of the Advanced Energy Technologies Department in United Engineers and Constructors (UE&C) Corporation, and as Technical Manager in the Energy Study Center of the Electric Power Research Institute (EPRI). In EPRI he managed power plant economic studies for the first three presidents of EPRI. Prior to that, Dr. Chaim served as research scientist in Brookhaven National Laboratory (BNL), where he worked on electric

energy storage optimizations, hydrogen production and storage and hydrogen injection into natural gas pipelines. Dr. Chaim received his education in Chemical and Nuclear Engineering, Nuclear Chemistry, and in Operations Research in the Technion (Israel Institute of Technology), in the Weizmann Institute in Israel, and in Cornell University, Ithaca, New York.

THOMAS DONNELLY is presently a Resident fellow at the American Enterprise Institute (AEI). He specializes in defense and national security. From 1995 to 1999, Mr. Donnelly was Policy Group Director and a professional staff member for the Committee on National Security (now named the Committee on Armed Services) in the U.S. House of Representatives. Mr. Donnelly is the author of AEI's *National Security Outlook*. His latest book is *Operation Iraqi Freedom: A Strategic Assessment* (AEI, 2004). He has also been editor of *Army Times* and deputy editor of *Defense News*. Mr. Donnelly received his B.A. from Ithaca College and his M.I.P.P. from the Johns Hopkins University School of Advanced International Studies.

GREGORY S. JONES is currently a Senior Researcher at RAND. He served as a defense policy analyst for the past 34 years, joining RAND in 1989. In May 1974, India's "peaceful nuclear explosion" steered his research into the areas of nonproliferation and counterproliferation. He was heavily involved in the studies which helped formulate the Ford-Carter policies in this area. The nuclear tests in 1998 again drew his research focus to nuclear weapons developments in South Asia. Over the course of his career, a major emphasis of his work has been the study of the potential for terrorists as well as hostile countries to acquire and

use nuclear, chemical, biological, and radiological weapons, and the formulation of policies and actions to control and counter these weapons. Mr. Jones is a coauthor of the book *Swords from Plowshares*, as well as the author or coauthor of over 60 reports and articles.

PETER R. LAVOY directs the Center for Contemporary Conflict (CCC) and is Senior Lecturer at the Naval Postgraduate School (NPS) in Monterey, California. In the NPS Department of National Security Affairs, where he has been since 1993, Dr. Lavoy teaches graduate courses and supervises master's theses on nuclear strategy, weapons proliferation and counterproliferation, and South Asian politics and security. He served in the Office of the Secretary of Defense in 2000 as Principal Director for Requirements, Plans and Counterproliferation Policy, and for 2 1/2 years before that as Director for Counterproliferation Policy. Dr. Lavoy edited *Nuclear Weapons Proliferation: 2016* (special issue of *The Nonproliferation Review*, Vol. 13, No. 3, Fall 2006); and *Planning the Unthinkable: How New Powers Will Use Nuclear, Biological, and Chemical Weapons* (Cornell University Press, 2000). His newest books are *Learning to Live with the Bomb: India and Nuclear Weapons, 1947-2002* (Palgrave-Macmillan, forthcoming, 2008); *Asymmetric Warfare in South Asia: The Causes and Consequences of the Kargil Conflict*, editor, (Cambridge University Press, forthcoming, 2007); and *Terrorism, War, or Disease: Unraveling the Use of Biological Weapons*, co-editor (forthcoming, 2007). Dr. Lavoy received a Ph.D. in Political Science from the University of California, Berkeley and a B.A. in Government from Oberlin College.

ZIA MIAN is a Research Scientist and Director of the Project on Peace and Security in South Asia, at the Program on Science and Global Security, Woodrow Wilson School of Public and International Affairs, Princeton University. He is also a member of the core staff of the International Panel on Fissile Materials, an independent group of arms-control and nonproliferation experts from 15 countries working for cooperative international policies to secure, consolidate, and reduce stockpiles of highly enriched uranium and plutonium that can be used for making nuclear weapons. He teaches at the Woodrow Wilson School, and previously has taught at Yale University and Quaid-i-Azam University, Islamabad. He has worked at the Union of Concerned Scientists, Cambridge, Massachusetts, and at the Sustainable Development Policy Institute, Islamabad. In addition to his research and writing, Mr. Mian is active with a number of civil society groups working for nuclear disarmament, peace and justice, including serving on the Board of the Los Alamos Study Group, the United Nations NGO Committee on Disarmament, the International Network of Engineers and Scientists Against Proliferation, and Abolition 2000, a network of over 2000 peace groups in 91 countries. He also serves on the Board of the Eqbal Ahmad Foundation. Mr. Mian is the editor of several books, most recently *Between Past and Future: Selected Essays on South Asia by Eqbal Ahmad* and *Out of The Nuclear Shadow* (2002). Other books include *Pakistan's Crises of State and Society* (1997) and *Pakistan's Atomic Bomb and The Search for Security* (1995). His writings have also appeared in journals, magazines, and newspapers around the world. He has made two documentary films with Pervez Hoodbhoy, *Crossing The Lines: Kashmir, Pakistan, India* (2004) and *Pakistan and India Under The Nuclear Shadow* (2001).

ABDUL MANNAN is Director of the Directorate of Transport and Waste Safety at the Pakistan Nuclear Regulatory Authority. His responsibilities include establishing and maintaining regulatory frameworks for the physical protection of civilian nuclear facilities and transport links including import and export. He has authored or co-authored over 25 scientific papers on various research topics related to radiation and safety. Dr. Mannan holds masters' degrees in Physical Chemistry from Karachi University and Nuclear Engineering from the Centre for Nuclear Studies in Pakistan.

ABDUL H. NAYYAR served for over 30 years on the faculty of the Department of Physics, Quaid-i-Azam University, Islamabad. He has been a Research Fellow, and is now visiting research fellow, at the Sustainable Development Policy Institute, Islamabad, where he led the program on energy and education. Dr. Nayyar has also been a regular visiting fellow with Princeton University's Program on Science and Global Security since 1998. His research interests include fissile-material production, nuclear weapons proliferation, consequences of nuclear war, and nuclear-reactor safety. He currently serves as President of Pakistan's Peace Coalition, a national network of peace and justice groups, and is the Co-convener of Pugwash Pakistan. Dr. Nayyar is the Executive Director of the non-profit group, Developments in Literacy, Pakistan.

GEORGE PERKOVICH is Vice President for Studies – Global Security and Economic Development, and Director of the Nonproliferation Program at the Carnegie Endowment for International Peace. His

personal research has concentrated on nuclear strategy and nonproliferation, with a focus on South Asia and Iran, and on the problem of justice in the international political economy. Dr. Perkovich is the author of the award-winning book *India's Nuclear Bomb*, which *Foreign Affairs* called "an extraordinary and perhaps definitive account of 50 years of Indian nuclear policymaking," and the *Washington Times* has called an "important . . . encyclopedic . . . antidote to many of the illusions of our age." The book received the Herbert Feis Award from the American Historical Association, for outstanding work by an independent scholar, and the A. K. Coomaraswamy Prize from the Association for Asian Studies, as an outstanding book on South Asia. Dr. Perkovich recently coauthored a major Carnegie report, *Universal Compliance: A Strategy for Nuclear Security*, a new blueprint for rethinking the international nuclear nonproliferation regime. The report offers a fresh approach to deal with states and terrorists, nuclear weapons, and missile materials to ensure global safety and security. He is also developing a project on fairness in the international system, drawing on his interests in trade and globalization. His article, "Giving Justice Its Due," published in the July/August 2005 issue of *Foreign Affairs*, establishes the central theme of this project.

RAMAMURTI RAJARAMAN is emeritus professor of theoretical physics at Jawaharlal Nehru University, New Delhi. He has been a professor at the Indian Institute of Science, Bangalore, Cornell University, and visiting faculty at the Massachusetts Institute of Technology, Harvard, Berkeley, and Stanford Universities. He is a Fellow of both the Indian Academy of Science and the Indian National Science

Academy. He has twice been a member of the Institute of Advanced Study, Princeton, and is a regular visiting research scholar at Princeton University's Program on Science and Global Security since 2000. His research interests include, apart from different areas of theoretical physics, ending the production of fissile material for nuclear weapons, capping South Asia's nuclear arsenals, the dangers of accidental nuclear war, civilian nuclear energy, and science and education policy in India.

M. V. RAMANA is currently a Fellow at the Centre for Interdisciplinary Studies in Environment and Development (CISED), Bangalore, India. He has held research positions at the University of Toronto, the Massachusetts Institute of Technology, and Princeton University. He has taught at Boston University, Princeton University, and Yale University. Dr. Ramana specializes in studying Indian nuclear energy and weapons programs. Currently he is examining the economic viability and environmental impacts of the Indian nuclear power program. He is actively involved in the peace and anti-nuclear movements, and is associated with the Coalition for Nuclear Disarmament and Peace as well as Abolition-2000, a global network to abolish nuclear weapons. Dr. Ramana is co-editor of *Prisoners of the Nuclear Dream* (New Delhi: Orient Longman, 2003) and author of *Bombing Bombay? Effects of Nuclear Weapons and a Case Study of a Hypothetical Explosion* (Cambridge, MA: International Physicians for the Prevention of Nuclear War, 1999). Dr. Ramana holds an M.Sc. from the Indian Institute of Technology, Kanpur; and a Ph.D. from Boston University.

HENRY D. SOKOLSKI is the Executive Director of the Nonproliferation Policy Education Center, a Washington-based nonprofit organization founded in 1994 to promote a better understanding of strategic weapons proliferation issues for academics, policymakers, and the media. He served from 1989 to 1993 as Deputy for Nonproliferation Policy in the Office of the Secretary of Defense under Paul Wolfowitz and received the Secretary of Defense's Medal for Outstanding Public Service. Prior to his appointment to this post, Mr. Sokolski worked in the Secretary's Office of Net Assessment on proliferation issues. In addition to his Executive Branch service, Mr. Sokolski served from 1984 through 1988 as Senior Military Legislative Aide to Senator Dan Quayle and as Special Assistant on Nuclear Energy Matters to Senator Gordon Humphrey from 1982 through 1983. Mr. Sokolski also served as a consultant on proliferation issues to the intelligence community's National Intelligence Council. After his work in the Pentagon, Mr. Sokolski received a Congressional appointment to the Deutch Proliferation Commission, which completed its report in July of 1999. He also served as a member of The Central Intelligence Agency's Senior Advisory Panel from 1995 to 1996. Mr. Sokolski has been a resident fellow at the National Institute for Public Policy, the Heritage Foundation, and the Hoover Institution. He currently serves as an adjunct professor at the Institute of World Politics in Washington and has taught courses at the University of Chicago, Rosary College, and Loyola University. Mr. Sokolski has authored and edited a number of works on proliferation related issues, including *Best of Intentions: America's Campaign Against Strategic Weapons Proliferation* (Westport, CT: Praeger, 2001), *Getting Ready for a Nuclear-ready Iran* (Carlisle, PA: Strategic Studies

Institute, 2005); *Checking Iran's Nuclear Ambitions* (Carlisle, PA: Strategic Studies Institute, 2004); *Getting MAD: Nuclear Mutual Assured Destruction Its Origins and Practice* (Carlisle, PA: Strategic Studies Institute, 2004); *Beyond Nunn-Lugar: Curbing the Next Wave of Weapons Proliferation Threats from Russia* (Carlisle, PA: Strategic Studies Institute, 2002); *21st Century Weapons Proliferation: Are We Ready?* (London: Frank Cass, 2001); *Planning for a Peaceful Korea* (Carlisle, PA: Strategic Studies Institute, 2001); *Prevailing in A Well Armed World* (Carlisle, PA: Strategic Studies Institute, 2000), and *Fighting Proliferation* (Maxwell AFB: Air University Press, 1996). Mr. Sokolski attended the University of Southern California and Pomona College and received his graduate education at the University of Chicago.

BRUNO TERTRAIS was the Director of the Civilian Affairs Committee, NATO Assembly, Brussels from 1990 to 1993. In 1993, he joined the *Délégation aux Affaires Stratégiques* (Policy Division) of the French Ministry of Defense. From 1995 to 1996, he was a Visiting Fellow at the RAND Corporation, Santa Monica, California. From October 1996 until August 2001, he was Special Assistant to the Director of Strategic Affairs at the French Ministry of Defense. Dr. Tertrais is now a Senior Research Fellow at the *Fondation pour la Recherche Stratégique* (FRS), as well as an Associate Researcher at the *Centres d'Etudes et de Recherches Internationales* (CERI). He is also a member of the International Institute for Strategic Studies (IISS), a contributing editor to *Survival*, a member of the editorial board of the *Washington Quarterly*, and a member of the Gerson Lehman Group Policy Council of Advisors. His latest book in English is *War Without End* (New-York: The New Press, 2005). Dr. Tertrais graduated from the *Institut d'Etudes Politiques de Paris* in 1984. He also holds

a Master's degree in Public Law from the University of Paris (1985), and a Doctorate in Political Science from the *Institut d'Etudes Politiques de Paris* (1994).