CHAPTER 4

PAKISTAN'S "MINIMUM DETERRENT" NUCLEAR FORCE REQUIREMENTS

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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 *Ghaznavi*/M-11 Fifteen to Twenty 1,300-1,500 km *Ghauri* Six 750 km *Shaheen 1* 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 km^2 in area. In contrast, Delhi is a city of 12.8 million people with an area of 1,055 km,^{2} 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 km^2 (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 km^2. 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 km^2. However, ground bursting these weapons would result in significant amounts of fallout. Potentially the fatality area from the fallout could be several times (10 km^2 to 20 km^2) 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 2*s 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 Indian'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 it 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 it 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., *Electrocchemical, 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.