Chapter three

A.Q. KHAN AND ONWARD PROLIFERATION FROM PAKISTAN

This chapter examines the known cases of nuclear exports undertaken by the A.Q. Khan network (and, in the case of North Korea, by Khan himself, independent of his foreign associates) and is intended to enable a fuller understanding of the involvement and responsibilities of each of the various actors at work: Khan, his foreign business partners and the relevant Pakistani authorities, military and civilian. After describing the conditions that allowed Khan to make the transition from importing for Pakistan's national nuclear programme to exporting to other states through his own independent network, the chapter examines, in chronological order, the interactions between Khan and Iran, Iraq, North Korea and Libya, and notes the unanswered questions about what Khan sold and to whom else he might have offered his nuclear wares.

Transition from imports to exports

From the outset, Pakistani government authorities provided A.Q. Khan with a remarkable degree of power and autonomy, partly because he demanded it, partly because of the very sensitive nature of his work, and partly because he was able to achieve tangible results faster than the Pakistani Atomic Energy Commission (PAEC), the rival scientific laboratory to Khan Research Laboratories (KRL). At first, President Zulfiqar Ali Bhutto directed the nuclear weapons programme personally, without much bureaucratic involvement. A small organisation was set up to troubleshoot security, finances and other issues that A.Q. Khan or PAEC Chairman Munir Ahmad Khan raised; its job was not to regulate the activities of either KRL or PAEC.

As A.Q. Khan began to make real progress with his centrifuge project at Kahuta, Bhutto's successor, General Zia ul-Haq, who did not particularly care for the PAEC chairman, provided A.Q. Khan with further sweeping responsibilities. Because of mounting concerns about US and other foreign intelligence penetration, Zia ordered increased secrecy and compartmentalisation of the nuclear weapons programme, thus allowing Khan to operate much more independently.

An unhealthy rivalry with PAEC propelled Khan towards even greater secrecy and opaque business practices. The Pakistani government encouraged the strategic laboratories' rivalry and was only interested in tangible results for the weapons programme. The fact that Khan operated beyond the remit of the vaguely stated laboratory guidelines surprised nobody, as every official involved in the nuclear programme recognised that improvisation of various sorts was required to circumvent foreign export controls and other international non-proliferation constraints. While PAEC was accountable to governmental authorities, KRL was not, and it expanded its responsibilities beyond its mandate into designing bombs, developing trigger mechanisms, reducing uranium gas into metal and working on design assembly itself. It is unclear whether this initiative had been officially sanctioned by the authorities or was a unilateral decision on Khan's part. Apparently, Zia had privately authorised the more results-oriented A.Q. Khan to continue activities that were parallel to programmes that PAEC was conducting. In turn, Zia encouraged M.A. Khan to report on A.Q. Khan. The bitter rivalry between the two organisations handicapped the safeguarding of Pakistan's nuclear secrets.

The PAEC–KRL rivalry was played out in three significant ways. The first was a public-relations battle waged by each organisation to win popularity by defaming the other. KRL employed at least 20 journalists in this vein, with PAEC following suit, but to a far lesser extent. The second aspect was fierce bureaucratic infighting. More generally, this rivalry stimulated Khan to operate beyond

the vague governmental guidelines and to undertake his procurement and production activities in extreme secrecy – partly so that PAEC officials could not discover what he was up to. PAEC's failure to procure a plutonium reprocessing facility was partially blamed on its hesitant leadership and outmoded bureaucracy. In contrast, A.Q. Khan's success in achieving his objectives confirmed the value of being freed from bureaucratic constraints. During the 1980s, Pakistan found itself immersed in clandestine activity. The covert war against the Soviets in Afghanistan made Pakistan a hub of covert supplies and transfers. This environment enabled Pakistan to bring in nuclear-related shipments under the guise of other clandestine weapons and equipment bound for Afghanistan's 'jihad'. Pakistani import- and export-control organisations (customs, immigration, etc.) became more inefficient and corrupt.

By the mid-1980s, A.Q. Khan had begun work on a second-generation centrifuge design, designated the P-2 (like the P-1, based on a Urenco design – see pages 18, 20), which had rotors made of maraging steel (an iron alloy that has superior strength without losing malleability), enabling it to spin at twice the speed of P-1 centrifuges and to enrich uranium more than twice as efficiently. As the acquisition priorities of KRL gradually shifted to materials required for the advanced P-2 designs, Khan was left with an surplus inventory of P-1 centrifuges and related components. This gave him and his foreign-based partners the opportunity for a more profitable business model by exploring export markets. In two notable instances, however – those of both Iran and Libya – it may have been a case of interested customers first reaching out to the network, rather than the other way around, although accounts differ on this and many other points. To meet the growing demand for its wares, the network established a nuclear supply line with a life of its own. Thus, instead of reducing the supply line after Pakistan had acquired the essential ingredients to produce weapons-grade material, the network redoubled its acquisition efforts to go after more advanced technologies (for the P-2 centrifuges), as well as greater quantities of materials which were not needed by Pakistan but could be resold to customers elsewhere in the market for P-1 centrifuges.

Khan's nuclear acquisition activities were largely unsupervised by Pakistani governmental authorities and his orders of many more components than Pakistan's own enrichment programme required apparently went undetected.[1] He had access to autonomous import and export privileges that no other organisation in the country possessed. It is unclear whether the excessive orders placed by Khan all arrived in Pakistan or went to Dubai for storage or dispatch to their final destination. Having expanded into other areas related to the manufacture of nuclear weapons and their associated delivery systems, Khan now had reason to seek more foreign shipments and to charter more aircraft to transport the goods. No one apart from the president had authority to question the contents or justification of Khan's imports or exports. This was owing to Zia's decision to give Khan a very long leash as long as he delivered the goods for Pakistan's own bomb programme – which he always did.

Most of Khan's onward proliferation deals were struck during a particular era of Pakistan's troubled political life. Between August 1988 (when Zia died) and October 1999 (when Pervez Musharraf took over), the structure of power in the country was diffuse and complex, with three different poles: the presidency, the army and the prime minister. The civilian leaders had little involvement in nuclear matters, policymaking was personalised and democratic institutions were weak. For over two decades, from 1976 onwards, Khan's foreign travels were not checked and his itinerary was a national secret, especially after the trial in the Netherlands, for which he was sentenced *in absentia* (see page 18). The Directorate of Inter-Services Intelligence (ISI) was the only other organisation that escaped governmental accountability, due to the covert nature of its role in the war in Afghanistan and in other intelligence and counter-intelligence operations.

The fact that Khan was privy to the highest national secrets meant that his activities could not be easily questioned. His security apparatus was not designed to monitor him, but rather to protect him and his organisation from external spies and anything that might compromise his foreign procurement for Pakistan's nuclear programme.[2] All KRL security personnel reported to him, and those military officers posted to him or other strategic organisations were appointed by the army after screening. Most were either retired or on the verge of retiring from military service, and a posting to guard the most coveted national organisation became a matter of pride. Security personnel were assured that there would be financial benefits and privileges so long as Khan considered them to be

indispensable to the security and advancement of the programme.

The network of brokers, financiers and front companies that Khan created to supply Pakistan's enrichment programme was also available to him for the new export opportunity that had become apparent. Khan's network initially consisted of a loosely connected set of intermediaries, which gradually evolved into a business enterprise. Contacts with Iran in 1987 represented the first known case of foreign associates working on Khan's behalf for purposes other than importing goods and technology for Pakistan.

B.S.A. Tahir (courtesy Royal Malaysian Police)

Iran

The Khan network's first known involvement in onward proliferation started with a discreet overture from Iran during the Zia regime in the mid-1980s. According to officials who were close to Zia, Iran approached the Pakistani government through official channels but did not receive the fuel-cycle technology it was seeking. Although the Pakistani press reported in November 1986 that Zia had given a green light to an Iranian request for nuclear cooperation, according to his aides he directed his nuclear programme managers just to 'play around' with the Iranians 'but not to yield anything substantial at any cost'.[3] Zia calculated that the initiation of civil nuclear cooperation with Iran was a prudent way to satisfy the political imperative of maintaining good relations with Tehran while at the same time not compromising Pakistan's own covert nuclear weapons effort. He did not want to invite even more international non-proliferation scrutiny and pressure at a time when Islamabad was attempting to manufacture nuclear weapons while simultaneously maintaining close military ties with the United States. Pakistani officials across the board insist that Zia did not approve any nuclear dealings with Iran that would involve the provision of sensitive technology. They argue that his strong Sunni beliefs and his strategy to increase the role of Sunni Islam throughout Pakistani society and official institutions put him at odds with Iran's Supreme Leader Ayatollah Ruhollah Khomeini and made any sensitive dealings with Iran very unlikely.

In 1987, the chairmen of the Pakistani and Iranian atomic energy commissions entered into a formal agreement on peaceful nuclear cooperation that emerged from official contacts beginning in February 1986 when Iran's President Seyyed Ali Khamenei (later supreme leader) visited Pakistan.[4] This deal included a provision for Pakistani scientists to train at least six Iranians at the Pakistan Institute of Nuclear Science and Technology (PINSTECH), training that was also offered to other Muslim countries. That month, A.Q. Khan reportedly visited Iran's Bushehr reactor to witness the damage caused by Iraqi bombing of the facility. In this and in subsequent visits he promoted centrifuges as a viable uranium enrichment technique,[5] a technology that Iran had begun to explore in 1985.

In early 1987 KRL scientists began to publish papers describing the construction of more advanced centrifuges with maraging steel. Because KRL was now openly boasting about its technical capabilities, foreign intelligence operatives started taking notice, and some entered into direct communications concerning possible business transactions with Khan and his cohorts.

1987 deal

After Zia parried Iran's request for sensitive nuclear cooperation, Iranian intelligence agents apparently set about trying to find another way of tapping into Pakistan's nuclear technology. The first confirmed contacts occurred in 1987. Which side initiated it is unclear; Iran was looking to buy and Khan had goods to sell. One contact was made in Switzerland, possibly through one of Khan's long-time associates and regular suppliers, German engineer Gotthard Lerch. The first substantial deal occurred in 1987 in Dubai, where Iranian officials reportedly met Indian-born businessman S. Mohamed Farouq, head of the family-run computer import–export company SMB

A.Q. Khan Network Onward Proliferation: Chronology

Mid-1980s

- Khan Research Laboratories (KRL) shifts its focus from P-1 t o P-2 centrifuge technology
- Iran begins to explore uranium enrichment technology
- Iran approaches Pakistan's Zia ul-Haq government for nuclear cooperation, but is reportedly rebuffed

1986

- Khan reportedly visits Iran's Bushehr reactor

1987

- Pakistani and Iranian atomic energy commissions conclude formal agreement on peaceful nuclear cooperation
- Iran approaches Khan network
- Khan network and Iran close $3 million deal for centrifuge technology

1989

- First deliveries of P-1 centrifuges to Iran

1990

- 6 October: Iraqi intelligence memo cites offer from Khan intermediary to help Iraq develop nuclear weapons

1991

- November: reported agreement between Pakistan's General Mirza Aslam Beg and Iran on nuclear and conventional cooperation in return for oil

1992

- North Korea begins to share missile expertise with Pakistan

1993

- Buhary Syed Ali Tahir offers Iran P-1 centrifuge components and drawings for more advanced P-2 machines
- December: Pakistani prime minister Benazir Bhutto initiates deal with North Korea for *No-dong* missile technology

1994

- March, May: Iran begins to receive components for 500 P-1 centrifuges and P-2 drawings

1995

- November: North Korea and Pakistan reportedly finalise *No-dong* deal

1996–97

- Pakistan begins to receive *No-dong* missiles from North Korea

1997

- Network sends three P-2 centrifuges to Iran, according to Tahir (unconfirmed)
- Libyan intelligence first contacts Khan
- Shipments to Libya begin (20 complete P-1 centrifuges, most components for another 200) and continue until late 2003

1998

- 6 April: Khan tests *Ghauri* missile

Late 1990s

- Khan reportedly begins delivery to North Korea of used centrifuges, drawings, depleted uranium hexafluoride (UF_6)

1999

- Last acknowledged meeting between Khan network and Iranians
- March: Saudi Arabian defence minister first foreign leader to visit KRL
- US intelligence report cites North Korean enrichment programme

2000

- September: Libya receives two P-2 centrifuges, places order for 10,000 more
- September: Libya receives 50kg of UF_6

2001

- Feb: Khan network sends Libya 1,750kg of UF_6
- March: Khan is removed from KRL
- December: Tahir signs $13m contract with Malaysian company SCOPE for 25,000 centrifuge parts
- Late (or early 2002): Khan network provides Libya with a design for a nuclear weapon

2002

- Iran procures magnets for P-2 centrifuges from other foreign suppliers and claims no P-2 design work before this year
- December: deliveries of P-2 components from SCOPE to Libya

2003

- March: US government places sanctions on KRL
- April: Interception of aluminium tubing shipment en route to North Korea
- August: Iran changes story that its enrichment programme was indigenous, acknowledges to IAEA that it obtained assistance from foreign intermediaries beginning in 1987.
- October: Interception of *BBC China*, ship headed to Libya with components for 1,000 centrifuges
- December: Libya renounces nuclear weapons programme

2004

- US–UK teams begin dismantlement of Libyan programme, taking out nuclear weapon designs, UF_6, centrifuges and other key equipment
- 4 February: Khan's public confession
- March: *BBC China* delivers P-2 centrifuge parts to Libya from Turkish workshops

Key Iran connection · Offer to Iraq · North Korea connection · Libya deal · Significant events

Group, and his Sri Lankan nephew Buhary Syed Ali Tahir. (S. Mohamed Farouq should not be confused with Muhammad Farooq, a centrifuge expert at KRL, who was involved extensively with Khan's nuclear smuggling.) SMB had sold computers to Khan and continued to operate a legitimate computer business until at least 2004, but by 1987 Farouq and Tahir were also ready to act as Khan's agents in marketing P-1 centrifuge components. The reported presence in some of the 1987 Dubai meetings of German engineer Heinz Mebus[6] (who died in 1992), another long-time friend and supplier to Khan, is further evidence that the Khan network was already developing into a multinational import–export organisation. A key Iranian interlocutor in the 1987 meetings was reportedly Mohammad Eslami, representing an Iranian military front company. Eslami is now a senior commander in the Iranian Revolutionary Guard; his involvement indicates the military orientation of the Iranian nuclear research and development programme from as far back as 1987.[7]

In a meeting in 1987, the Khan network submitted a one-page handwritten offer, consisting of a menu from which the Iranian buyers could choose, with prices reportedly ranging from millions to hundreds of millions of dollars. In what was cast as a five-point phased development plan, Iran was offered: a disassembled sample of P-1 centrifuge machines; drawings, descriptions and specifications for production; drawings, specifications and calculations for a complete plant; materials for 2,000-centrifuge machines; and auxiliary vacuum and electric drive equipment. The Iranians reportedly closed a deal for $3 million in Dubai in 1987.[8] They did not buy everything on the list, instead deciding to procure some items on their own, using the supplier information that Khan had also provided as a 'buyer's guide'.[9]

At a 1987 meeting in Dubai, or perhaps later (Iran has not been forthcoming to the International Atomic Energy Agency (IAEA) about the details), the network provided a 15-page document describing procedures for the re-conversion and casting of uranium metal into hemispheres, which IAEA Director General Mohamed ElBaradei later characterised as 'related to the fabrication of nuclear weapons components' and a 'matter of concern'.[10] Iran's claim that the Khan network provided the document on its own initiative is not consistent with what is known about the exchange of price lists.[11] The IAEA has not reported any evidence to contradict Iran's claims that it did not purchase the uranium re-conversion and casting equipment or do anything else with the document. In 2005, Iran showed both the one-page handwritten offer and the 15-page design document to the IAEA, but, as of April 2007, has not allowed it to take the originals back to Vienna, where they could be subject to forensic examination to provide further clues as to their origin. In 2005, Iran also showed the IAEA other documents relating to the 1987 offer, including: drawings of components and assemblies of P-1 centrifuges; technical documents describing manufacturing, assembly and operational procedures; diagrams of research centrifuge cascades; and a design layout for six cascades of 168 machines each.[12] Iran later built a pilot plant at Natanz designed to hold six cascades of 164 machines each.

Pakistani government attitudes

After the deaths of Zia in 1988 and Khomeini in 1989, new leaderships emerged in each country that were much more inclined towards mutual cooperation on a wide range of issues. In Pakistan, General Mirza Aslam Beg, the new chief of army staff, openly supported Iran's cause and suggested that Pakistan cooperate with Iran, Afghanistan and any new Islamic republics that emerged from the dissolution of the Soviet Union, in an alliance of sorts organised around 'strategic defiance' of the United States and its Western allies. Beg has also been an ardent supporter of Iran's bid to acquire nuclear weapons. Although his direct involvement is unconfirmed and he denies it, he is widely suspected of having been an accomplice of A.Q. Khan at least in terms of awareness, if not encouragement or even outright direction. According to US Ambassador to Pakistan Robert Oakley and Assistant Secretary of Defense Henry Rowen, Beg threatened to transfer nuclear technology to Iran if Washington cut off arms sales to Pakistan.[13]

Two unnamed former high-level Pakistani officials were reported as saying that in 1989 President Hashemi Rafsanjani sought Pakistani prime minister Benazir Bhutto's consent regarding a deal for nuclear weapons technology that Beg had initiated. The two officials say she told both Rafsanjani and Beg that she did not approve.[14] For his part, Beg was quoted as saying that, by Bhutto's own account, it was she who had been approached by the Iranians with a similar proposition for a $4 billion transfer. Beg also said Iran was willing to pay $6bn or more.[15] This price, however, seems exaggerated as it is very

much higher than Khan's 1987 and 1993 enrichment deals with Iran.

Although Beg denies having authorised any onward proliferation from Pakistan to Iran, he has confirmed that serious nuclear discussions took place between the nations at that time. According to an unnamed former cabinet minister, these talks continued after Benazir Bhutto's departure from office in 1990.[16] Several sources have reported that an agreement was reached in 1991 between General Asif Nawaz, Beg's successor as chief of army staff, Rafsanjani and General Mohsen Rezai, head of the Revolutionary Guard, which involved Pakistani nuclear weapons-related technology in return for Iranian oil.[17] Oakley claimed that Beg agreed to abandon the deal at his urging, and that Nawaz Sharif (the new prime minister) and Ghulam Ishaq Khan (Zia's successor as president and a trusted insider since the days of Prime Minister Zulfiqar Ali Bhutto) told Rafsanjani that the deal had not been approved by the president or the parliament and that Pakistan would not implement it. Western intelligence officials worried at the time that a deal might have involved a nuclear weapon design that Pakistan had originally obtained from China (which later turned out to be the case for Khan's deal with Libya).

G.I. Khan provided continuity in the direction of the nuclear weapons programme and protected A.Q. Khan from government oversight (see chapter four). Several of Benazir Bhutto's advisers, including her security affairs adviser, Major General Imtiaz Ali, and her military secretary, Zulfiqar Ali, reportedly encouraged meetings between Khan and Iran.[18] Bhutto was reportedly aware of the nuclear discussions during both of her terms of office (1988–90 and 1993–96).[19] These individual leaders may all have been inclined to help Iran, especially after the autumn of 1990. The US reaction to the Iraqi invasion of Kuwait (2 August) and the first-ever refusal by the White House to certify to Congress that Pakistan did not have a military nuclear programme because of the incontrovertible evidence to the contrary (1 October) gave ammunition to those, such as Beg, who urged defiance of the West.

However, no evidence has emerged that a clear directive was ever given to Khan to provide nuclear technology to Iran. In any case, the onward proliferation not only continued after the departure of G.I. Khan, B. Bhutto and Beg from power, but also expanded, from 1994. The diffusion of domestic political power among the troika of the president, prime minister and army chief obscured the command and control authority over the covert nuclear weapons programme. Further, as these power centres jockeyed for supremacy, each undermined the standing of the other. This situation provided Khan with a relatively free rein as long as he did not alienate the collective leadership and continued to produce the desired results for the nation's nuclear weapons programme.

1993–94 deal

Iran received more from A.Q. Khan than nuclear designs and equipment. The equipment supply documents the Khan network provided the Iranians allowed them to contact suppliers in Europe, Russia and Asia to acquire nuclear-related equipment and technologies. However, officials in Tehran realised that mere shopping was not enough, and they again turned to Khan for assistance. Iran claims that there were no contacts with the network between 1987 and mid-1993, when it says Tahir offered to supply an Iranian company with P-1 designs and components for 500 P-1 machines, as well as drawings for the more advanced P-2 centrifuges. After the preliminary contacts, Rafsanjani sent Iranian officials to Dubai to meet with Tahir and Farouq.[20] A deal was struck, an initial payment of $3m was made, and the first deliveries started in early 1994 using Iranian merchant ships.[21] The total amount of money Iran paid and to whom it went is unknown. Whether Iran obtained more than the 500 unassembled centrifuges it admitted to receiving from the Khan network is also unknown. Iran told the IAEA in 2003 that the centrifuges in its possession were domestically produced. But because the components had been used in Pakistan's own enrichment work, they had traces of highly enriched uranium (HEU) particles. When the IAEA inspectors produced evidence of those particles, Iran acknowledged the foreign origin of the centrifuges.

Some of the old centrifuge machines were reportedly damaged when the Iranians unpacked and tried to assemble them. Iranian scientists found it difficult to advance from research to operational enrichment, and blamed their lack of progress on the 'poor-quality components' provided by the Khan network.[22] Acquiring the components, their specifications and detailed drawings, however, allowed Iran to skip many research steps, in both centrifuge operations and component manufacturing. It was able to embark on a strategy to make thousands of centrifuges on its own and to order parts from

companies in the Khan network. Iran continued to draw on the advice of network intermediaries, by its own admission meeting with them 13 times between 1994 and 1999.[23]

As Pakistan–Iran relations began to deteriorate over the mounting proxy war and sectarian tensions in Afghanistan, business with the Khan network continued, although the Iranians did not entirely trust A.Q. Khan because of the troubles they were experiencing with his centrifuges. Diversifying away from its reliance on Khan, Iran sought other suppliers for the components and materials it required. An Iranian contractor acknowledged seeking to procure 4,000 magnets for use in P-2 centrifuges from a European intermediary. Iran claims that none were delivered from the intermediary in question, but that other magnets relevant to P-2 centrifuges were procured from other foreign suppliers in 2002.[24]

In 2006, when the IAEA was able to interview Tahir for a second time (following up an initial 2004 interview), he claimed, with no hint of purposeful exaggeration, that three complete P-2 centrifuges were sent to Iran in 1997 as a model for manufacturing more. However, he provided no supporting documentation.[25] Iran also admits to having received P-2 designs from the Khan network, but claims it obtained no P-2 centrifuges from abroad and that no work was carried out on the P-2 design prior to 2002. The IAEA has found inconsistencies in Iran's story about the P-2s, which, in 2007, remained one of the key outstanding questions for the agency. IAEA officials suspect Iran may have a parallel, undeclared P-2 development programme.

Over time, Iran gained experience in manufacturing its own centrifuge components and constructed two facilities in Natanz, an aboveground pilot plant designed for 1,000 centrifuges and a much larger underground facility planned to hold 54,000 centrifuges. A facility this size would give Iran the capability to produce approximately 20 bombs' worth of HEU per year if it chose to break out of the Nuclear Non-Proliferation Treaty (NPT) and acquire a nuclear weapons arsenal.[26] Iran apparently only has the parts for several thousand centrifuges, however, and to meet its industrial-level goal it would have to rely on additional black market procurement of maraging steel, and possibly other materials, in which it is not self-sufficient. Nuclear Supplier Group export controls and Security Council sanctions make that a difficult proposition for Iran.

By the beginning of 2007, Iran had about 370 centrifuges running intermittently with uranium hexafluoride (UF_6) in the pilot plant and was beginning to install the first of what it said would be 3,000 centrifuges in the underground facility. Although Iran had not yet demonstrated an ability to run the cascades continuously, it had proven that it could produce centrifuges, balance and spin them for months at a time, and enrich uranium in small amounts to reactor-grade levels (3.5–5%). If Iran is able to install 3,000 centrifuges and bring them into operation (a goal it ambitiously set for May 2007), and if it were to throw caution to the wind and withdraw from the NPT, continuous operation of a facility this size would, theoretically, enable Iran to produce one weapon's worth of HEU in 9–11 months.[27]

Iraq

Given Khan's budding business with Iran, it is somewhat surprising that in 1990 the network next sought to expand its international business by selling enrichment technology to Iraq, with which Iran had just fought a bitter eight-year war. At the time, Iraq had a very advanced clandestine programme to produce nuclear weapons. The full extent of Iraq's widespread and sophisticated nuclear procurement activities was not well known until it came to light after the 1991 Gulf War and the subsequent weapons inspection and dismantlement campaign of the United Nations Special Commission on Iraq. Yet Western governments and policy analysts – and certainly Khan and his European colleagues – were aware that Baghdad was renewing its efforts to build nuclear bombs in the aftermath of the 1981 Israeli attack on Iraq's Osirak reactor at Tuwaitha. Iraq gave priority to the development of electromagnetic isotopic separation techniques to enrich uranium, but also pursued gas centrifuge and other enrichment technologies.[28] Media accounts revealed Iraqi attempts to acquire maraging steel, vacuum pumps and other specialised machinery, all necessary for the production of uranium enrichment centrifuges. There were unconfirmed press reports that Iraq acquired uranium melting information from Pakistan in the late 1980s.[29]

The project had been given the code name 'A-B', which IAEA investigators took to mean 'atomic bomb'

A.Q. Khan and his associates apparently believed that Iraq's interest in uranium enrichment provided a business opportunity that was too potentially lucrative to pass up. Information that Khan had promoted a deal with Iraq emerged in 1995 with the defection of Saddam Hussein's son-in-law, Hussein Kamel, who directed UN weapons inspectors to a chicken farm he owned. There, inspectors found thousands of documents on paper and microfiche related to Iraq's nuclear, biological and chemical weapons development programmes. Included among these documents was a 1990 memo labelled 'top secret' and 'personal', which described a meeting in Baghdad between Iraqi intelligence officers and an intermediary for Khan believed to have used the name 'Malik'. The intermediary told the Iraqis that Khan was prepared to provide enrichment technology and project designs for a nuclear bomb and to 'ensure any requirements or materials from Western Europe [were transported] via a company he owns in Dubai'. The memo said 'the project has been given the code name "A-B"', which IAEA investigators took to mean 'atomic bomb'.[30] The asking price was $5m in advance, with an additional 10% commission to be paid on all procurements.

Another document obtained by inspectors indicated that Jafar Dhia Jafar, the former head of Iraq's nuclear agency, had responded positively, telling the intelligence service to explore the offer, although with the caveat that it could be a sting operation orchestrated by Western intelligence agencies. There was little other evidence of the offer or any other follow up, which in any case would have been impossible after the initiation of *Operation Desert Storm* in January 1991 and the subsequent intrusive inspection operations conducted by the UN. IAEA efforts to investigate the matter in the mid-1990s, and again in 2004 following Libya's revelation that it had received a bomb design from Khan, reached an impasse because all the individuals involved were either deceased or refused to be interviewed. IAEA officials were nevertheless fully convinced that the offer was genuine and unsolicited.

North Korea

A.Q. Khan's nuclear export business took a new turn in the late 1990s when he provided North Korea with a number of gas centrifuges, associated material and technical assistance, expanding on deals in which North Korea provided *No-dong* missiles to Pakistan. His foreign network associates were not known to be involved in these transactions – only Khan and his fellow Pakistani collaborators. In his 2006 autobiography, Musharraf wrote that in early 1999, when he was serving as army chief, he discovered that some North Korean nuclear experts, operating under the guise of missile engineers, had been given secret briefings at KRL. As described below, North Korean interaction with KRL regarding ballistic missile exchanges was permitted as a secret government-to-government deal, but the Pakistani government claims that A.Q. Khan was not authorised to interact with the North Koreans on nuclear matters. Musharraf wrote that he summoned him to explain his interaction with the North Koreans on nuclear technology, but Khan flatly denied the charge.[31]

After Khan was arrested in 2004, Pakistani officials claimed that he had confessed to having transferred centrifuges and related technology to North Korea, beginning in the late 1990s.[32] The Clinton administration reportedly learnt of the transfers in 1998 or 1999. The first media claim of a North Korean enrichment programme came in March 1999, sourced to a US Department of Energy intelligence report.[33] The CIA concluded, however, that North Korea began its centrifuge-based uranium enrichment programme in 2000.[34] This conclusion derived in part from imagery analysis of unmarked containers loaded on Pakistani C-130 transport aircraft.

The most detailed account of the enrichment technology transfer comes from Musharraf's autobiography, in which he stated that 'A.Q. Khan transferred nearly two dozen P-1 and P-2 centrifuges to North Korea. He also provided North Korea with a flow meter, some special oils for centrifuges, and coaching on centrifuge technology, including visits to top-secret centrifuge plants.'[35] Musharraf's 2006 account is curious in two respects. Firstly, in 2005 he mentioned only half that number ('probably a dozen').[36] Western governments believe that the actual number was about 20. Secondly, it was the first reference to P-2s going to North Korea; previous reports about Khan's confessions mentioned only P-1 centrifuges. According to a government official who briefed the press after Khan's televised confession, Khan, in a 12-page signed confession, accepted full responsibility for 'supplying old and discarded centrifuge and enrichment machines together with sets of drawings, sketches, technical data and depleted hexafluoride (UF_6) gas to North Korea'.[37]

A dozen centrifuges would have been insufficient to produce enough HEU for a nuclear bomb. Along with the centrifuge designs Khan provided, however, they could be used as a template upon which North Korean scientists and engineers could base their own centrifuge production plans. As with Iran, Khan also reportedly provided a 'shopping list' to North Korea,[38] which enabled Pyongyang to purchase additional components directly from other foreign suppliers. In 2000, North Korea began to seek such materials in industrial-scale quantities, leading intelligence analysts to believe that it had progressed beyond the research and development stage in its uranium enrichment centrifuge programme. Such procurement attempts included equipment suitable for use in UF_6 feed and withdrawal systems, as well as high-strength aluminium tubes that matched the specifications of vacuum casings for Urenco centrifuges.[39] In April 2003, the French, German and Egyptian authorities intercepted a French cargo ship in the Suez Canal carrying a 22-tonne shipment of these tubes that North Korea had ordered from a German firm. This shipment was apparently part of a larger, 200-tonne consignment of aluminium tubes sought by North Korea, which would have been sufficient for 3,500–4,000 centrifuges. If North Korea were to construct 3,500 centrifuges based on the P-2 design, it would have the ability to produce almost 90kg of weapons-grade HEU annually.[40] North Korea attempted to circumvent German export controls by claiming that the tubes were intended for a Chinese company, Shenyang Aircraft Corporation.[41]

As is the case with some of Khan's other customers, which side initiated the centrifuge deal is unclear. As noted in chapter two, there were a few reports in the late 1980s of North Korean procurement of equipment useful for gas centrifuge enrichment. Until Khan provided centrifuges a decade later, however, North Korea's nuclear weapons programme was assumed to be limited to the plutonium route. North Korea froze the plutonium programme under the terms of the October 1994 Agreed Framework deal with the US. Seeking an alternative uranium enrichment path to nuclear weapons violated that agreement and, when the US confronted Pyongyang about the enrichment efforts, led to its demise. Whether North Korea nevertheless proactively sought the centrifuge technology or whether, as one former US negotiator privately surmised, it 'fell into their laps' through a Khan offer, is unknown.

Pakistan–North Korea connections

Khan's business dealings with North Korea were rooted in Pakistan's odd relationship with the Pyongyang regime, dating back to the early 1970s. At that time, Zulfiqar Ali Bhutto, whose original People's Party had strong socialist overtones, was impressed with the regimented government and economy of Kim Il Sung. Bhutto was known to be an admirer of many of the revolutionary leaders of the time, including Mao Zedong, Josip Broz Tito and Colonel Muammar Gadhafi, and had a material interest in improving ties with these leaders too. Ever since the United States had embargoed military sales to Pakistan after the 1965 Kashmir War, Pakistan looked to the East as an alternative source, and purchased a mix of Chinese and Russian weapons, equipment and transports. The military items produced by North Korea were compatible with other Soviet-bloc material and were considerably cheaper. Moreover, the North Koreans were easier to deal with than the Soviets, who had a far closer relationship with India. Bhutto approached North Korea in 1971 for assistance in replenishing Pakistan's depleted stock of military equipment and established full diplomatic relations in 1976, when he was accorded an elaborate welcome in Pyongyang. His daughter, Benazir Bhutto, received a similarly lavish state reception 17 years later, in December 1993. Like her father, she also secured an agreement to acquire missile technology.[42]

Whether North Korea proactively sought the centrifuge technology or whether it 'fell into their laps' is unknown

The 'Asian cooperation' policy forged by Zulfiqar Ali Bhutto in the 1970s, however, became less significant after his ouster in the July 1977 coup orchestrated by Zia, in his capacity as army chief. After the Soviet Union invaded Afghanistan in December 1979, and the new US government of President Ronald Reagan lifted all sanctions on Pakistan in 1981, Zia's priorities shifted to the jihad in Afghanistan and the acquisition of Western armaments to restore the military balance with India. North Korea had disappeared from Pakistan's radar screen. Within a few years, however, three factors brought North Korea and Pakistan back towards a strategic partnership. Firstly, Pakistan needed to match India's *Agni* and *Prithvi* ballistic-missile programmes, and North

Korea was known for its ballistic-missile production. Secondly, the Pakistani armed forces needed conventional weapons, including artillery and anti-aircraft guns, which North Korea had, while North Korea needed money and had a reputation for exporting military supplies at cheap rates. Thirdly, North Korea was developing expertise on the plutonium route to nuclear weapons production, and Pakistan was making rapid advances along the uranium enrichment route. Each country stood to gain much from the other.

In the 1990s, Pakistan's security predicament was compounded by new two factors, both involving India. The first had to do with the growing air-power imbalance with India and Pakistan's desire to obtain a reliable airborne nuclear delivery system. Washington's October 1990 implementation of the Pressler Amendment sanctions essentially froze Pakistan's air force procurement, save for some imports of low-technology aircraft from China. The delivery of F-16 aircraft that Islamabad had already purchased from the United States was stalled, and because of intense US pressure and their own non-proliferation concerns, European suppliers were reluctant to come to Pakistan's assistance.

The second factor that worried Pakistani defence planners was the rapid maturation of India's ballistic missile programme in the wake of a military crisis over Kashmir in 1990. India first test-fired its short-range *Prithvi* ballistic missile in February 1988 and introduced *Prithvi* missile batteries into service with the army in 1994.[43] Further, the two-stage intermediate-range *Agni*-1 ballistic missile, which the Indians considered a technology demonstrator and not a developed weapons system, underwent three test flights between 1994 and 2002. The emergence of an Indian ballistic-missile capability created a new missile gap for Pakistan, and also raised the prospect that India would have both missile and aircraft delivery systems for its covert nuclear arsenal, while Pakistan would not have much of either. To compound Pakistan's problems, the Missile Technology Control Regime (MTCR), which was originally established in 1987, was now operating rather effectively. Most European suppliers were members of the MTCR group and thus refused to supply Pakistan with the means to produce missile delivery systems.

Khan's contacts with Pyongyang

Just as A.Q. Khan filled a vital strategic need when US and French non-proliferation pressures blocked Pakistan's plutonium route to nuclear weapons in the 1970s, Khan stepped in once again to provide Pakistan with an alternative nuclear weapons delivery option by obtaining intermediate-range liquid-fuel ballistic missiles from North Korea. Prior to this development, Pakistan had obtained short-range, solid-fuel M-11 missiles and related technology from China, Pakistan's all-weather strategic ally, but KRL was not the recipient. The solid-fuel missile programme was the research and development responsibility of the National Defence Complex in conjunction with PAEC. KRL was responsible for the liquid-fuel missile programme. North Korea's 1,000–1,500km-range *No-dong* ballistic missile was well suited to Pakistan's pressing strategic requirement. (The range of the *No-dong*, like that of virtually all ballistic missiles, depends on the payload weight and other design configurations.) The sharing of missile expertise began in 1992, when Pakistani officials travelled to North Korea to view a prototype of the *No-dong*. In November 1995, North Korea and Pakistan apparently struck a deal for 12–25 *No-dong* missiles, and at least one transporter erector launcher or mobile erector launcher,[44] the delivery of which reportedly began in 1996–97.

It is widely assumed, but impossible to prove, that the provision of centrifuge technology was at least partly in exchange for the *No-dong* missiles, and that the deal was authorised by Pakistan's top leaders. According to North Korean Politburo defector Hwang Jang Yop, a *No-dong*–HEU deal was concluded in the summer of 1996.[45] Overhead imagery of Pakistani aircraft in Pyongyang is often cited as proof of official involvement in the nuclear deal.[46] It is likely that at least some of the centrifuges, parts, blueprints, designs and possibly UF_6 North Korea obtained were transported in C-130s belonging to the Pakistani air force or to charter companies connected to the air force. It was much easier for Khan to ship nuclear components to North Korea than to Iran because there was already an authorised trade in sensitive military equipment with Pyongyang dating from the early 1970s. Pakistani aircraft carried ballistic missiles and their components, surface-to-air missiles, artillery and other conventional military equipment from North Korea.[47] The business activities of KRL had grown over the years, involving much more than simply nuclear enrichment, and extending to the production of missiles, mines, electronics and artillery.[48] Khan also bought anti-tank missiles from North

Korea to help fulfil KRL's orders from the Pakistani army. This conventional trade could have masked nuclear trafficking. Movements of military cargo in and out of Pakistan at that time were characterised by extreme secrecy and compartmentalisation. US arms shipments through Pakistan for anti-Soviet forces in Afghanistan contributed to a climate in which questions were not asked about arms imports and exports. In one incident in 2000, Pakistani intelligence authorities had obtained a foreign liaison tip-off that a chartered C-130 aircraft going to North Korea to pick up conventional missiles was carrying 'irregular cargo' on Khan's behalf. Pakistani intelligence operatives quietly raided the aircraft, but found nothing. Apparently, Khan had been tipped off (see pages 96–7).[49] The fact that there was an unannounced search suggests that such cargo was not regularly screened.[50] In sum, evidence of official Pakistani–North Korean sensitive technology transactions does not necessarily indicate official Pakistani–North Korean nuclear collaboration.

Pakistani policymakers knew, of course, about the cooperation with North Korea on missiles, many of them having been directly involved in its continuation. It seems unlikely that they would have been unaware of the nuclear cooperation that was occurring at the same time. Although Khan and his KRL team were able to make many decisions independently, they had no authority on national security decisions. According to an unconfirmed press report, Khan claimed that three different army chiefs of staff – Abdul Waheed (1994–96), Jehangir Karamat (1996–98) and Pervez Musharraf (1998–present) – were aware of his nuclear deals with Pyongyang.[51] Current and former military officers strongly deny this accusation, but the military's dominant role in nuclear oversight since 1977 is reason to believe that Khan would not have traded the centrifuge technology without the army's approval. The armed forces certainly would have been privy to any discussions concerning the acquisition of the *No-dong*, a system carrying serious implications for any military force posture. Transferring nuclear technology to the North Korean pariah state would also have had severe consequences for the nation's foreign policy and international reputation. The claim that Khan could not have sold his country's nuclear secrets without the expressed approval of Pakistani civilian and military leaders is supported by an economic rationale, in the sense that many analysts doubt Pakistan could have paid for the missiles outright. In 1996, Pakistan was in a financial crisis, with its foreign exchange reserves equivalent to only three weeks of imports. The country was only able to avoid default with help from the International Monetary Fund and by borrowing $500m from domestic banks.[52]

Beginning with Benazir Bhutto, successive Pakistani governments have insisted that the ballistic missile cooperation with North Korea was based on a cash payment, rather than a quid pro quo exchange for Pakistani nuclear technology. Pakistan claims it paid a total of $210m to North Korea for the entire missile package, including the transfer of technology.[53] It is difficult to corroborate this claim through publicly available information. The figure is low in comparison with the $3bn Saudi Arabia reportedly paid for 36–40 Chinese CSS-2 ballistic missiles in the late 1980s. On the other hand, $210m for the *No-dong* package is in line with estimates that the shorter range *Hwasong*-5 and -6 missiles cost around $1.5–2m each and that the longer-range *Taepo-dong* has been priced at $6m.[54] Given the enormous strategic importance of *No-dong* missiles to national defence, $210m would have been within Pakistan's financial means. Despite its low foreign reserves, Pakistan's arms imports during the 1995–96 timeframe were valued at $819m.[55] The overall defence budget in the mid-1990s was around $3bn annually.[56]

Evidence of official sensitive technology transactions does not necessarily indicate official nuclear collaboration

A difficulty in assessing the Pakistani government claim is that there is little public evidence of monetary payments from North Korea to Khan or his associates for the centrifuges. The Islamabad government would have an incentive to disclose any such transactions that might have come to light in its investigations of Khan because this would help to distance the government from Khan's transactions. But to date no such evidence has surfaced.

One other possible explanation for Khan's nuclear assistance to North Korea was that he acted largely of his own volition, for his own profit. As already noted, Khan had broad autonomy as head of KRL. There appears to have been poor state control of critical nuclear technologies and components, including centrifuges. Khan could ship large

consignments in and out of the country with little oversight, particularly before the creation of the military's Strategic Plans Division in 1999. In this scenario, Khan could have begun to assist North Korea in the late 1990s for personal gain. At this time, his own importance was diminishing because PAEC, not KRL, was responsible for weaponising Pakistan's deterrent. He would also have had a motivation to spur North Korea to speed up deliveries of *No-dong* missile technology, allowing Khan to test the *Ghauri* in 1998, a full year before PAEC could field a solid-fuel alternative.[57] The broad cooperation between Pyongyang and Islamabad, however, is significant reason to suspect state complicity, at least in terms of having knowledge of and thereby implicitly condoning the centrifuge deal.

Libya

In 1997, the Khan network began what became an extensive nuclear export business with Libya, involving nuclear specialists, middlemen and supplier companies from three continents. Of all Khan's deals, the most is known about the Libya connection because of Tripoli's disclosures and its cooperation with inspectors after Gadhafi decided in 2003 to renounce and dismantle his nuclear and chemical weapons programmes and to restrict its ballistic-missile capacity. Following on from secret negotiations with the US and UK to lift sanctions implemented in response to the Lockerbie bombing, Libya contacted MI6, the UK intelligence service, in mid-March 2003 to initiate talks on dismantling strategic weapons programmes in exchange for removing other sanctions and normalising relations. Secret talks then expanded to include the US. Libya was reluctant to acknowledge the full extent of its nuclear programme, however, until the German-registered vessel, *BBC China*, bound for Libya with centrifuge equipment from the Khan network, was diverted to Italy in a joint US–UK–Germany–Italy operation. This interdiction demonstrated to Tripoli that its clandestine supply network had been compromised. The US and UK intelligence officials involved in the highly confidential negotiations provided additional evidence of what they knew and, in December 2003, Libya revealed even more. During a trip by MI6 and CIA officers to Libya early that month, Libya handed over a copy of a nuclear weapon design that it had received from the Khan network,[58] as detailed below.

Libya's unrelenting interest in nuclear weapons

Gadhafi's aspirations for acquiring weapons of mass destruction had been widely known ever since he overthrew King Idris I in 1969. In the 1970s, Gadhafi's endeavours to buy nuclear weapons off the shelf took him to China, France, India and the Soviet Union. These efforts did not yield any results; however, Gadhafi did succeed in acquiring 2,263 tonnes of yellowcake (uranium oxide concentrate) from Niger in 1978 and 1981.[59] In the same period, Gadhafi befriended Zulfiqar Ali Bhutto, who was vigorously pursuing nuclear weapons in response to India's May 1974 nuclear explosive test. Bhutto was in desperate need of finances, as well as raw materials, for a crash programme that Pakistan had embarked upon with very little prior infrastructure. During 1973–82, Gadhafi reportedly provided financial assistance and passed 450 tonnes of the yellowcake Libya had obtained from Niger to Pakistan.[60] In return, Libya apparently sought assistance from Pakistan with 'hot cells' for extracting plutonium from irradiated uranium.[61] Libya had hoped that Pakistan would provide weapons-related technology in return for aid. Libya reportedly gave $100–500m to Bhutto, whose Islamic rhetoric about the programme excited many revolutionary leaders of the time.[62] However, on the government-to-government level Pakistan agreed only to offer training for Libyan personnel at PINSTECH and no more. The Pakistan–Libya nuclear cooperation at the government-to-government level ended once Bhutto was overthrown.

For a decade from the mid-1980s onwards, the Libyan nuclear programme was largely frustrated by the unwillingness of potential nuclear suppliers to deal with the regime.[63] Libya acknowledged that, in July 1995, it made a strategic decision to reinvigorate its nuclear activities, including gas centrifuge enrichment.[64] At this point, Libya tried to set up a two-track programme. The first track involved a plutonium route for which it unsuccessfully sought assistance from Argentina, the Soviet Union, Bulgaria and Japan. Its second track was to follow the uranium enrichment route to fissile-material production. In the early 1990s Libya had managed only to operate a single centrifuge, which it had obtained from Germany. In 1997, Libyan intelligence initiated contact with Khan, and followed up with a meeting in Istanbul among Libyan intelligence agency head Matooq Mohammed Matooq, A.Q. Khan and Tahir, to conclude a deal for the wherewithal for a uranium-centrifuge enrichment programme.

Selected companies reported to have manufactured, supplied or attempted to supply Libya with gas centrifuge components or relevant machinery

Ring magnets
KRL, Pakistan

Non-corrosive pipes and valves
KRL, Pakistan
TradeFin, South Africa
CETEC, Switzerland
SMB Computers, Dubai

Aluminium or maraging steel
KRL, Pakistan
SCOPE, Malaysia
Bikar Mettale Asia, Singapore

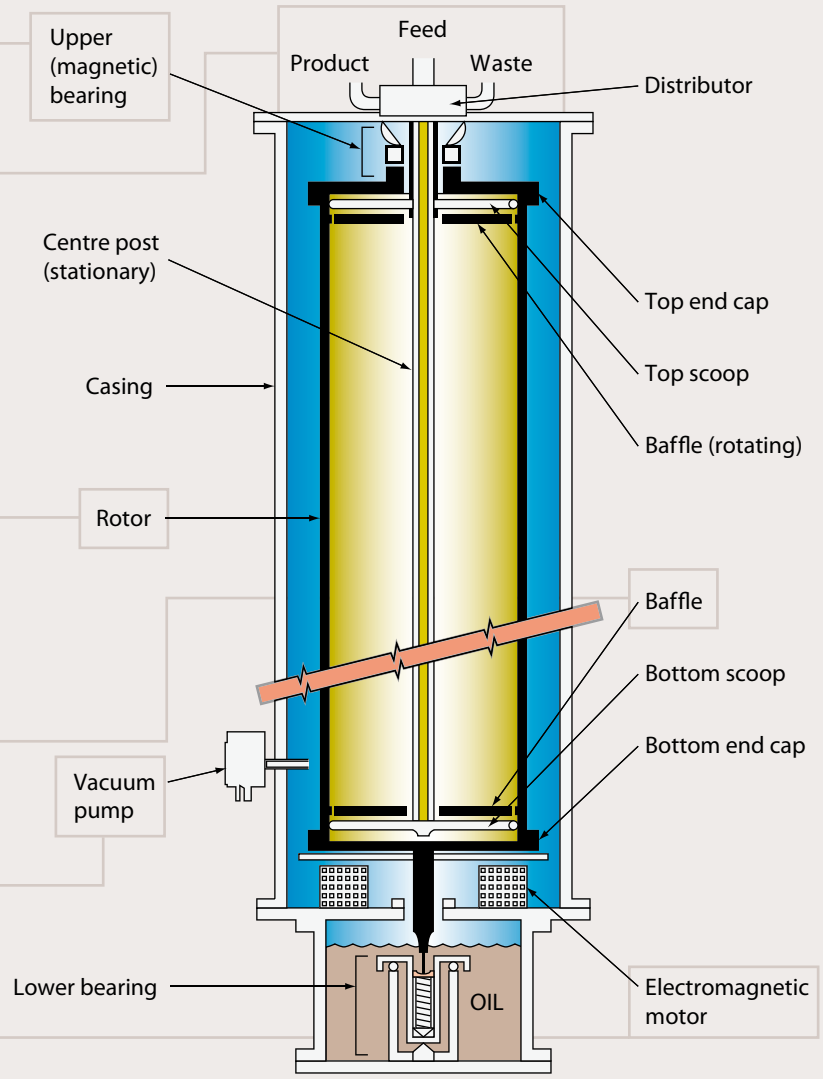
Flow-forming or balancing equipment
KRL, Pakistan
TradeFin, South Africa
Traco, Switzerland
De Young Engineering, South Korea

End-cap and baffle
KRL, Pakistan
SCOPE, Malaysia
SMB Computers, Dubai

Vacuum pumps
KRL, Pakistan
Krisch Engineering, South Africa
TradeFin, South Africa

Power supply
KRL, Pakistan
SMB Computers, Dubai
ETI Elektroteknik, Turkey
EKA, Turkey

Three-dimensional measuring machine
Mitutoyo, Japan



This image is adapted from a chart first produced by the **Center for Nonproliferation Studies** in January 2005. Some more recent information has been added. Not all of these companies were aware of the end use of the components or machinery that they supplied or manufactured.

Centrifuge enrichment equipment

Shortly after Libya's initial contact with Khan in 1997, the Khan network started to send Libya 20 complete P-1 aluminium rotor centrifuges (re-designated as L-1s for 'Libya-1'), along with most of the components for an additional 200 centrifuges. The aluminium rotors and ring magnets were mysteriously missing. In 2000, Khan sent Libya two test P-2 (renamed L-2) maraging steel centrifuges. Both of these centrifuges had been used in the Pakistani nuclear programme, and both were contaminated with HEU particles. Gadhafi then ordered 10,000 additional P-2 centrifuges, enough to produce significant quantities of weapons-grade uranium after they were installed and operating effectively. The first deliveries were made in December 2002. The focal point of the Libyan research and development activities was a facility named Al Hashan on the outskirts of Tripoli. By April 2002, one nine-machine cascade had reportedly been completed and was under vacuum with all the pipes, electrical connections and processing equipment set up. But for

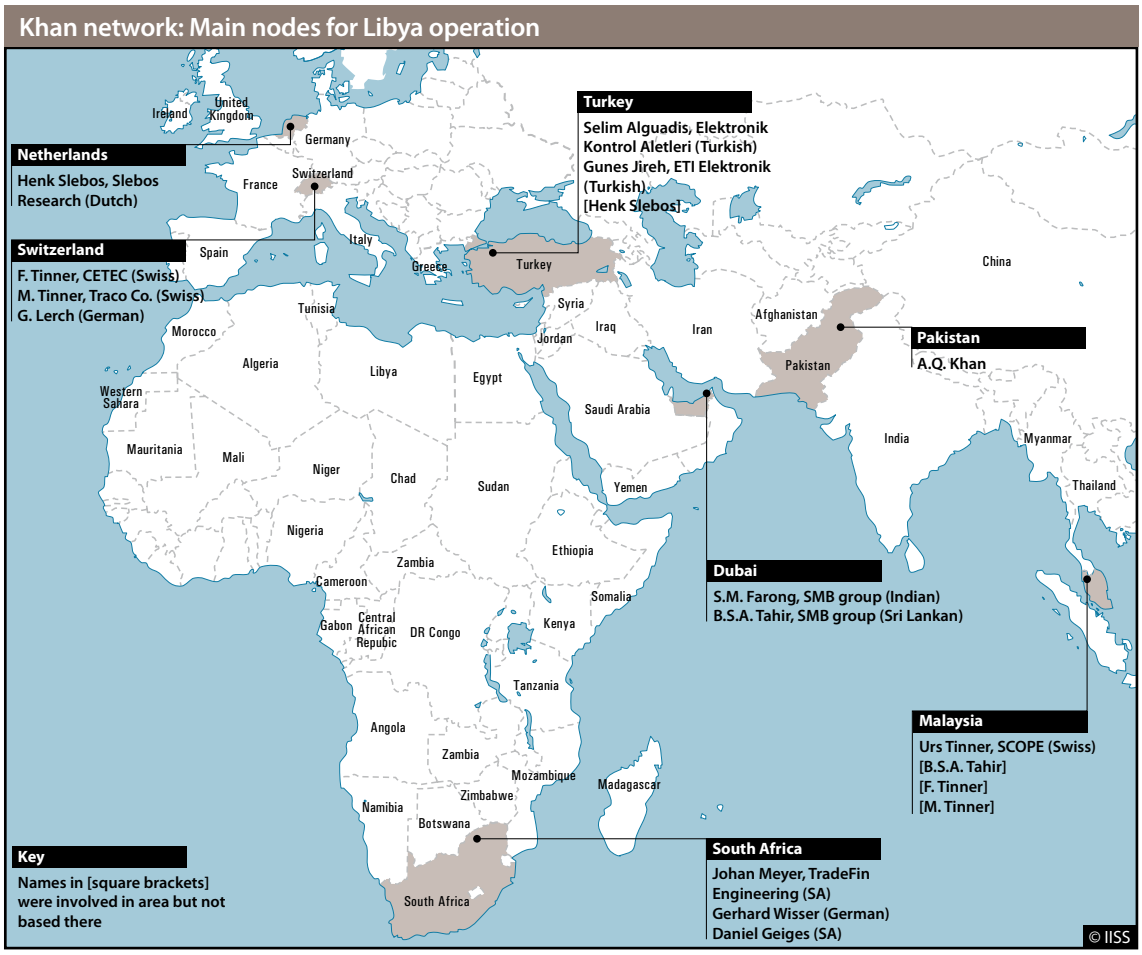
unknown reasons Libya then decided to dismantle the cascades and to move them to Al Fallah. By the end of 2003, the Gadhafi regime had acquired a significant number of L-2 components, but again, no rotating parts were delivered, apparently because of difficulties manufacturing them in the network's overseas facilities. The network considered making them in Dubai, South Africa, Turkey and Malaysia, but for reasons that remain unclear ultimately decided to produce the rotors in Libya itself. When US and UK officials and IAEA inspectors arrived in late December 2003 and January 2004 to begin the dismantlement process that Libya had pledged, the components were still unassembled and were found in unopened boxes. Libya also received computer compact disks containing a full set of P-1 and P-2 centrifuge drawings together with assembly and test instruction manuals. The network arranged training in Europe, Africa, the Middle East and Southeast Asia for Libyan technical personnel.[65] To manufacture centrifuge components that were difficult to procure elsewhere, particularly the maraging steel rotors, and to repair damaged centrifuges, the network established a workshop at Janzour, Libya, code-named *Project Machine Shop 1001*, and purchased the necessary machining equipment.

Supplying 10,000 centrifuges, each of which has approximately 100 parts, meant that the supplier network would have to procure or manufacture over a million components and ship them all to Libya. Some of these components must have been difficult for Khan to procure through the network's traditional means. Khan's supply to Iran and North Korea of designs, mostly used centrifuges and components, and UF_6 was bold enough (although the full extent of Khan's sale to both countries is unknown). The enormous Libyan project posed problems that were vastly more complicated. To meet the challenge, the Khan network increased the capacity of front companies in Malaysia, Turkey and South Africa (as described below) to manufacture certain products and, in Khan's biggest innovation, to establish factories in non-traditional supplier countries to procure, assemble and manufacture the components for the enrichment process.[66]

Uranium hexafluoride

As part of the 2000 deal to supply 10,000 P-2 centrifuges, the Khan network agreed to sell Libya 20 tonnes of UF_6 (enough, when enriched to 93%, for about three implosion-type weapons). Probably because of difficulties obtaining that amount, less than 2 tonnes were delivered: two small cylinders in September 2000, one containing 25kg of unenriched UF_6 and one with the same amount of UF_6 with depleted uranium (.03% U^{235}); and in February 2001, 1,700kg of UF_6 slightly enriched to 1%. The origin of the uranium has not been definitively established, but the evidence points to North Korea with Pakistan and Dubai as transit points. Tahir told Malaysian investigators that the UF_6 was shipped on Pakistani planes, although Pakistan says it came from North Korea. Suspect bank transactions preceding the UF_6 transfers include a payment made by Libya, and a North Korean receipt of a similar amount, although not necessarily enough to cover that amount of UF_6.[67] There seems to be no doubt that the cask containing the 25kg of UF_6 originated in Pakistan.[68] It is not confirmed where the cask had been and what was the origin of the material inside it. US experts detected plutonium traces on the container that were identical to traces previously found at North Korea's Yongbyon complex, which indicates that the container was as some point in proximity to that site.[69] IAEA tests on the same container did not yield the same plutonium traces,[70] although the IAEA swipe samples were not as extensive as those taken by the US of the entire container. The isotopic composition of the UF_6 itself did not match known samples of uranium from anywhere else in the world.[71] By a process of elimination, and in connection with the plutonium particles and the suspect bank accounts, US intelligence analysts deduced that it came from North Korea. This analytical conclusion, however, does not conclusively rule out other countries as the source of the UF_6. And there is no other evidence that North Korea has a uranium-conversion facility capable of producing the uranium gas.

One additional possibility is that North Korea sent natural yellowcake to Pakistan, which Pakistan then converted and shipped to Libya,[72] but this hypothesis is flawed. While KRL almost certainly had the means to convert uranium gas into uranium metal, there is no evidence that Khan had the expertise and equipment to turn yellowcake into uranium tetrafluoride and then into UF_6. If Khan had such a capability, it seems likely that he would have offered it to other countries, but there is no evidence that Khan offered any country assistance with uranium conversion. Libya did import (but never used) a modular uranium-conversion facility in 1986 from a Japanese company that was not known to be linked with the Khan network (the name of the company has not been disclosed). If Pakistan were assisting



North Korea in making UF_6, it would point to official state involvement through PAEC, the organisation responsible for Pakistan's uranium-conversion capability. To date, there has been no allegation of PAEC involvement with Libya.

Bomb design

Libya claimed that the documents for a nuclear weapon design and fabrication that it received from the Khan network in late 2001 or 2002 had been provided as a 'bonus' for $20–50m and that it took no steps to assess the credibility or to explore the practical utility of the information – an assertion viewed with scepticism by the IAEA.[73] The documentation included assembly drawings and manufacturing instructions for components of the 'physics package': explosive parts of the weapon, the detonator and fissile materials. It did not include the associated electronics, cabling and firing sets. Also missing were some of the key scale drawings of the explosive lenses. The bomb design was about 95% complete and was far more detailed than what has been available on the internet or through other unclassified sources. The material laid out a step-by-step process of casting uranium into a metal bomb core and building the explosive lenses to compress the core.[74] The designs were for a ten-kilotonne implosion device following a late 1960s Chinese design, weighing 453kg. It was too large to fit on any missiles in Libya's arsenal. Many of the bomb design documents were described as copies of copies, and included handwritten notes from lectures by Chinese weapons experts, that seemed to confirm that they had been reviewed by KRL.[75] In January 2004, Libya turned over to the US and UK (through the IAEA) the design documents in the form Libya said they had come, wrapped in the original Islamabad drycleaner's bag. (As noted above, Libya had already provided a copy to UK and US intelligence officials a month earlier.) Lacking trained personnel in the necessary fields, it is unlikely that Libya would have been able to fill in the missing drawings on its own to produce a workable bomb. On the other hand, if Iraq, North Korea or Iran, with their much larger industrial infrastructure and cadres of qualified engineers, had received the same

set of designs, they probably could have completed the missing pages indigenously. As discussed below, whether any other customer received a bomb design is unknown. That such a national security asset was included so casually in the deal with Libya is reason to believe that the Khan–Libya nuclear connection was not authorised by the Pakistani government.

The make-up of the Khan network

The Khan network was not a hierarchically structured enterprise, but rather a collection of connected nodes in various countries, which sometimes operated in league with Khan and at other times functioned independently. At least 30 companies and middlemen sold nuclear-related goods through the network.[76] The vast majority of individuals involved in the Khan proliferation network had a long history of procuring and selling items for the Pakistani nuclear weapons programme. And when Khan managed to shift his primary business operations from imports to much more lucrative exports, many of his European and South African accomplices stayed with him. The new 'business model' orientation offered the European members of the network much more money in comparison to what they had previously got from Pakistan's secret nuclear programme coffers, and they were asked to carry on with the very same expertise in manufacturing, logistics and finances that they had developed to such perfection in aiding the Pakistani (and, in some cases, Iraqi) nuclear weapons effort.

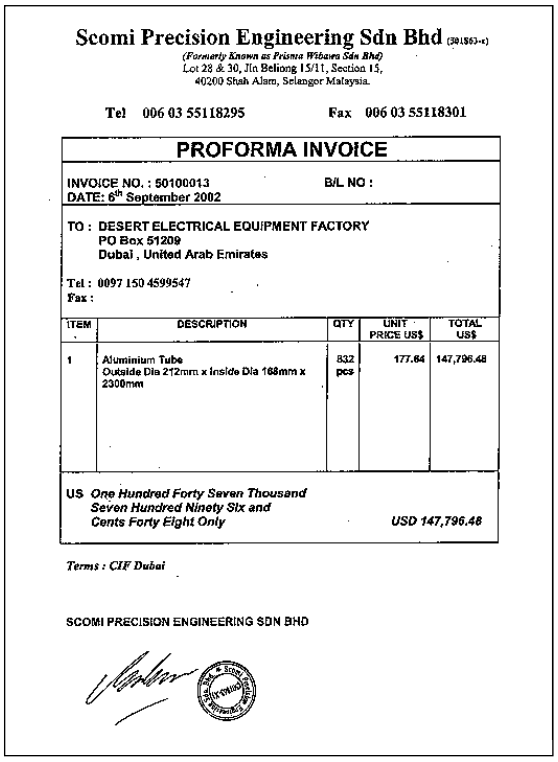
Libya had almost no pre-existing capability and wanted the Khan network to facilitate the entire enrichment process

The Libya deal showcased the organisation's complex and transnational nature and differed from the Khan network's transactions with Iran and North Korea in three important respects. Firstly, most of the proliferation occurred after Khan was removed from KRL in 2001 for defying government attempts to control his foreign dealings (see pages 96–8). Secondly, it was the first time the network had managed to produce outside any single country the entire panoply of materials, tools and technologies needed to fabricate gas centrifuges for uranium enrichment. Thirdly, the deal differed in scale from those involving Iran and North Korea because each of those countries already had a fair degree of technological expertise in the nuclear sciences. Libya had almost no pre-existing capability and wanted the Khan network to facilitate the entire enrichment process.

Libya contracted Khan to manufacture centrifuge components, to assemble them into workable centrifuges 'offsite', and then to install and operate them at a location outside Tripoli. The vast size and scope of the order broke new ground for the network, requiring Khan to transform both his organisation and its business practices to provide full service as a completely private sector entity. The Libyan case also reveals how sophisticated the network had become. Khan suggested, for example, that the Libyans build sheds for centrifuges that would look like goat or camel farms as a means of camouflage. The manner in which the business was conducted would have maximised profits for the network and kept the Libyan programme dependent on Khan for advice for many years into the future.

The Dubai hub: After Khan was removed from KRL in March 2001 (see chapter four) he moved his base of network operations to Dubai.[77] This was where components were stored and transhipped, and where his most important associate, Tahir, kept office, as managing director of the SMB Group, a position he took over from his uncle Farouq. Tahir was Khan's main intermediary with Tripoli when the Libya operation began in 1997. Other Dubai-based companies, such as the Aryash Trading Company and Gulf Technical Industries (GTI), often appear in reports on the Khan network as prominent links in the traffic in sensitive items. GTI was managed by British citizen Peter Griffin and his son Paul, both of whom deny any wrongdoing and against whom no charges have been filed.

The South African connection: In South Africa, the Khan network worked with companies and experts who had been involved with the South African nuclear weapons programme before it was abandoned in 1993. One such expert was Gerhard Wisser, a German living in South Africa, who had supplied vacuum pumps and other equipment to Pakistan in the 1980s in addition to doing work for the South African nuclear programme. In Dubai in 1999, Tahir offered Wisser a lucrative commission to arrange for the manufacture of 'certain pipework systems'. Wisser engaged a former associate who had also worked for the South African nuclear programme, Johan Meyer, owner of the engineering



Scomi Precision Engineering Sdn Bhd (301863-e)
(Formerly Known as Prisma Wibawa Sdn Bhd)
Lot 28 & 30, Jln Beliong 15/11, Section 15,
40200 Shah Alam, Selangor Malaysia.

Tel 006 03 55118295 Fax 006 03 55118301

PROFORMA INVOICE

INVOICE NO. : 50100013 B/L NO :
DATE: 6th September 2002

TO : DESERT ELECTRICAL EQUIPMENT FACTORY
PO Box 51209
Dubai , United Arab Emirates

Tel : 0097 150 4599547
Fax :

ITEM	DESCRIPTION	QTY	UNIT PRICE US$	TOTAL US$
1	Aluminium Tube Outside Dia 212mm x Inside Dia 168mm x 2300mm	832 pcs	177.64	147,796.48

US *One Hundred Forty Seven Thousand Seven Hundred Ninety Six and Cents Forty Eight Only* *USD 147,796.48*

Terms : CIF Dubai

SCOMI PRECISION ENGINEERING SDN BHD

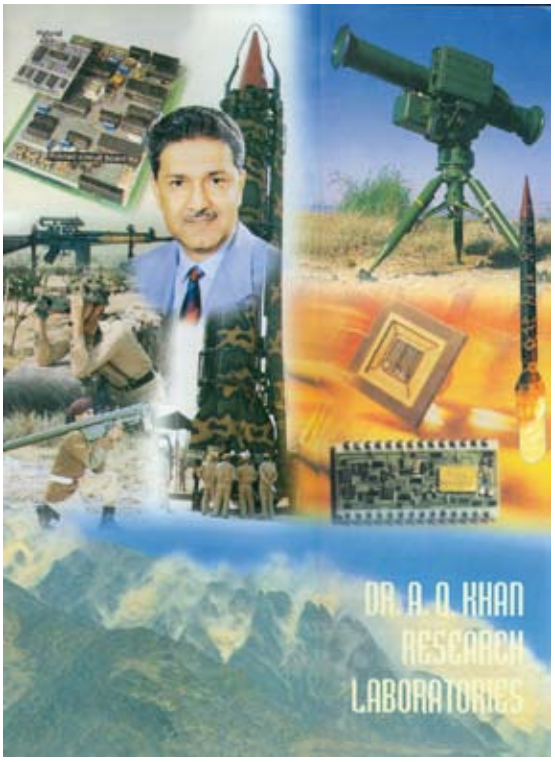
SCOPE invoice to Desert Electrical Equipment Factory, Dubai (courtesy Royal Malaysian Police)

firm TradeFin, based in Vanderbiljpark. Along with a third associate, Swiss citizen Daniel Geiges, they built a complex steel system to feed and withdraw UF_6 gas into a centrifuge cascade. The massive system filled 11 40-foot shipping containers and was estimated to be worth $33m. The network also asked TradeFin to manufacture maraging steel rotors for Libya's L-2 centrifuges. In late 2000, TradeFin ordered a specialised Spanish-made lathe from GTI but ultimately decided not to produce the rotors, either because of a price dispute or because they were unable to acquire the maraging steel that was needed. TradeFin consequently returned the lathe to GTI in December 2001. In 2004, inspectors discovered the lathe in Libya.[78]

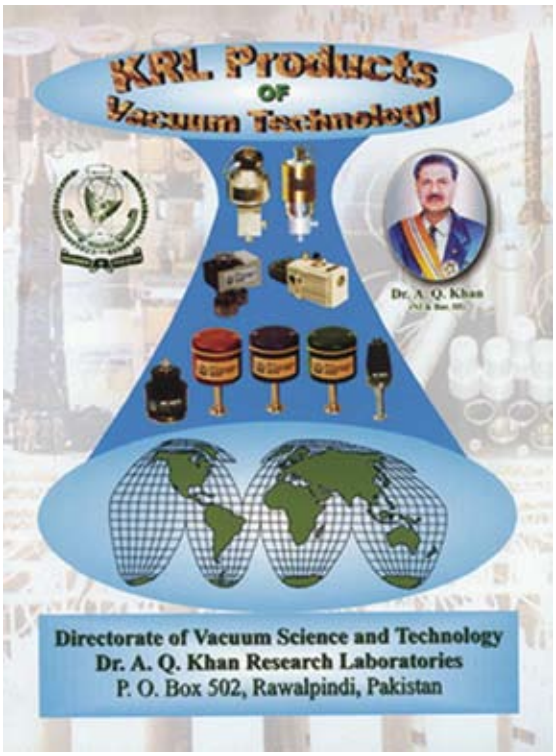
The Malaysian production plan: To evade export controls from members of the Nuclear Suppliers Group and to take advantage of his Malaysian wife's connections, Tahir contracted Scomi Group Berhad, a Malaysian oil and gas firm, to manufacture thousands of centrifuge components for the Libya operation. Scomi set up a subsidiary, Scomi Precision Engineering (SCOPE), with a 40-person facility in Shah Alam, Malaysia, but Scomi officials have been cleared of having known that the components were destined for a nuclear weapons programme in Libya.[79] The two-year $3.5m contract was signed in the name of GTI, though Peter Griffin denied any involvement, arguing that Tahir had forged the documents.[80] At Tahir's request, Urs Tinner, son of long-time Khan associate Friedrich Tinner, began consulting for the SCOPE factory and arranged to import lathes as well as cutting, turning and grinding machines. Between December 2002 and August 2003, SCOPE manufactured and sent 14 types of centrifuge components (of the approximately 100 components needed in total) to Dubai.

The Turkish mini-hub: The Khan network relied on workshops in Turkey as mini-hubs to procure subcomponents from Europe and elsewhere, and to assemble centrifuge motors and frequency converters to spin the centrifuges at the high speeds necessary to separate different uranium isotopes.[81] Elektronik Kontrol Aletleri (president: Selim Alguadis) and ETI Elektroteknik (president: Gunes Jireh, company partly owned by Dutch businessman Henk Slebos) imported centrifuge motors and aluminium castings from Europe, assembled them, and sent them to Dubai. Alguadis contends that he did not know their destination was Libya. In 2003, a shipment of electrical components was sent with false end-user certificates to Dubai, and was loaded aboard the *BBC China*. When the ship was diverted to the southern Italian port of Taranto in October 2003 and Italian authorities removed a shipment of centrifuge components from Malaysia, the other components from Turkey were not discovered and continued on to Libya. The Libyan government alerted international inspectors to their arrival in Tripoli in March 2004 and they were subsequently removed by the US.[82]

Other manufacturing sites: The Khan network acquired specialist equipment and materials from companies or intermediaries in many other countries, including Spain, Italy, Germany, the Netherlands, Switzerland and the UK. In Asia, the network acquired specialist balancing machines made by Hanbando Balance, Inc., one of South Korea's most prestigious manufacturers of balancing technology. A small South Korean firm, De Young Engineering, purchased four of these machines and exported them to Libya in June 2002. It is likely that Hanbando was unaware of the final destination of its dual-use product. The Japanese company Mitutoyo falsified export documents for the specialised three-dimensional



KRL brochure distributed at 2000 Karachi arms fair (Andrew Koch/KRL)



KRL brochure (Andrew Koch/KRL)

measuring machines (needed to build uranium-enrichment centrifuges with the necessary precision) it sold to the network for the Libya programme.

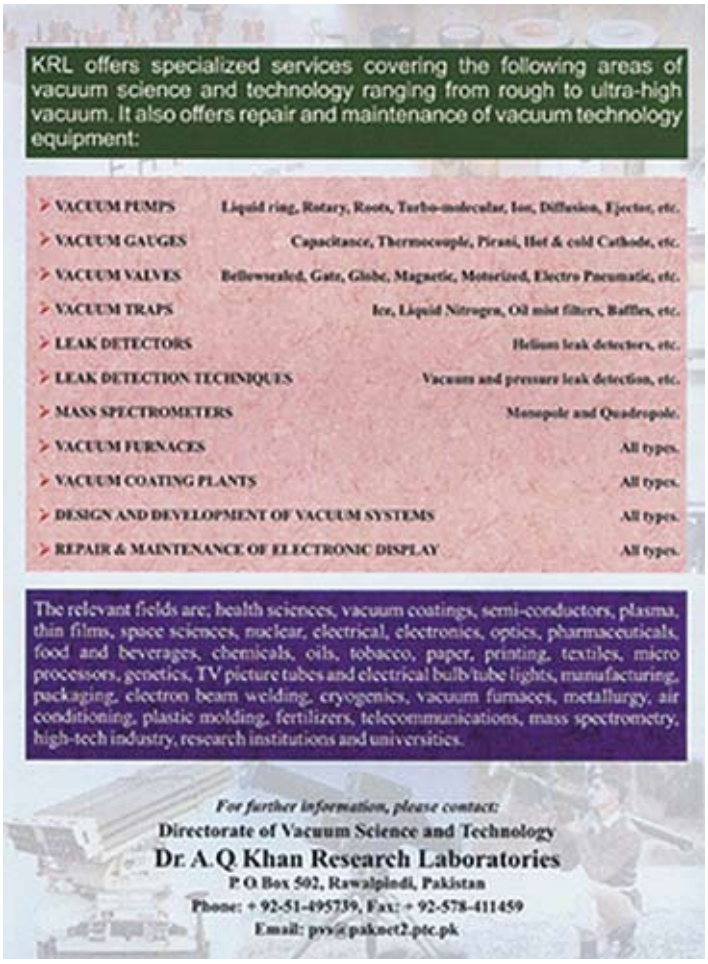
Soured Pakistan–Libya connections

The Pakistani nuclear connection with Iran and North Korea can be logically discerned, but the Khan network's cooperation with Libya is more puzzling, unless it is viewed as a straight business deal. In the case of neighbouring Iran, with whom Pakistan had previously had a strong relationship, there were still residual notions of ideological affinity. In particular, the strategic inclination of Beg, in his capacity as army chief, towards Iran, and the significance of his notion of strategic defiance could explain why he might have had some sympathy for Iran's quest for nuclear weapons. In the case of North Korea, the country-to-country strategic relationship was based on defence cooperation that had existed since the mid-1970s.[83] In the case of Libya, there was no ideological or military connection with Pakistan in 1997, when the initial contact with KRL was made. Nor had there been any government-to-government connection, except during the early 1970s when Gadhafi and Bhutto were close and Libya was interested not only in assisting Pakistan financially, but also in providing natural uranium for the Pakistani nuclear weapons effort. Pakistan's relations with Libya had soured owing to Bhutto's hanging by Zia in 1979. The relationship was only revived in the year 2000, when Musharraf visited Libya. Unlike with North Korea and Iran, there were no compelling reasons for Pakistan to engage in strategic cooperation with Libya, nor were there any peculiar personality inclinations. Nevertheless, the network struck up a profitable proliferation business.

Libya proved to be the network's biggest customer, paying the network at least $100m, according to the US.[84] At a time when Pakistan had become closely allied with the United States in the aftermath of the 11 September 2001 attacks, it is illogical that the government of Pakistan would have risked such a deal with a pariah country for such a meagre sum. The amount also seems insignificant compared to what other Arab countries with oil money were prepared to offer, such as the $3bn Saudi Arabia is said to have paid China for CSS-2 ballistic missiles in 1988.

Other potential customers

Whether the A.Q. Khan network had other customers has been a matter of intense interest to foreign analysts and investigative agencies. KRL openly advertised its enrichment wares, telling a



KRL brochure (Andrew Koch/KRL)

visitor at a Karachi trade fair in 2000, for example, that everything described in a glossy brochure – all the components to operate a uranium enrichment plant and support services – were available for purchase.[85] Khan is reported to have visited at least 18 countries in the years before his 2004 arrest: Afghanistan, Côte d'Ivoire, Egypt, Iran, Kazakhstan, Kenya, Mali, Mauritania, Morocco, Niger, Nigeria, North Korea, Saudi Arabia, Senegal, Sudan, Syria, Tunisia and the UAE.[86] The CIA monitors several of these countries for indications that they might harbour nuclear weapons ambitions, in part because of their reported past links with Khan.[87] Khan's repeated travel to Africa, sometimes accompanied by KRL scientists and Pakistani army officers, also raised questions. In trips to Nigeria, Niger, Mali and Sudan he might have been discussing uranium procurement, and, in Timbuktu, Mali, personal business related to his hotel investment there. Another possibility is that he was prospecting for additional customers. Some unconfirmed press reports have also claimed that Sudan was used as a warehouse between 1999 and 2001 to store advanced dual-use engineering equipment of European origin.[88]

Pakistan and Saudi Arabia have an alliance in which it is understood that Pakistan will come to the kingdom's aid if it is under dire threat. To firm up this alliance, Saudi Arabia has reportedly provided financial support for Pakistan's nuclear programme, dating from the 1980s.[89] In 1990, the Saudis were reportedly tempted to seek Pakistani nuclear warheads for the CSS-2 missiles they had acquired from China.[90] In May 1999, Saudi defence minister Prince Sultan bin Abdulaziz made a widely publicised visit to KRL facilities, the first foreign leader to do so. Pakistani officials assert that Khan's purpose was to market a missile, not nuclear technology. The Saudi defence minister reportedly toured KRL again in August 2002, although by this time Khan had been removed.[91] Khan, for his part, visited Saudi Arabia at least twice, in November 1999 and September 2000.[92] It is common for Pakistani officials to visit Saudi Arabia, for the hajj and other legitimate reasons, but Khan's visits bear scrutiny. An investigation of his front office in Dubai found records of telephone calls to Saudi Arabia (whether for legitimate or illicit business is unknown). According to US ambassador Chas Freeman, King Fahd bin Abdulaziz told high-level US officials on several occasions that Saudi Arabia would need a nuclear deterrent in case Iran developed an atomic bomb.[93] In 2003, several sources asserted, without firm evidence, that Pakistan and Saudi Arabia agreed on a 'nukes-for-oil' barter,[94] although in this case it would have been a strictly government-to-government deal, not involving the Khan network. There is no hard evidence of a formal offer or nuclear transfers from Pakistan to Saudi Arabia, and the aforementioned visits may just reflect the depth of the long-standing relationship between the two countries.

Reports of Khan discussing nuclear training assistance with the United Arab Emirates were also in a government-to-government context.[95]

Syria leads the list of countries suspected of having acquired nuclear technology illicitly through the Khan network, although the allegations have not been substantiated. The CIA's unclassified report to Congress on WMD technology transfers in 2004 expresses concern that expertise or technology could have been transferred to Syria, but attributes the intelligence only to reports in the Pakistani press that 'Pakistani investigators in late January 2004 said they had "confirmation" … that A.Q. offered nuclear technology and hardware to Syria'. The original press report adds that the deal never materialised.[96] One pair of experts claims that Khan offered nuclear technology to Egypt, which turned it down.[97] The South African government's indictment of Geiges and Wisser for unauthorised import and export of centrifuge equipment states that in 1988–90 they offered various kinds of centrifuge technology to an unnamed client, who ultimately declined the offer on the grounds that it was stolen property.

It is also possible that KRL exported nuclear materials as well as centrifuge technology and know-how to China, whose enrichment programme reportedly suffered difficulties.[98] Given the very close relationship that exists between the two countries in this and other fields, this would likely have been a government-sanctioned activity, if it occurred.

BBC China, run aground in 2004 (Captain Nicholas Sloane)

Other unknowns

What happened with the rest of the nuclear equipment Libya ordered from the Khan network but never received is another of the major questions remaining after the network was broken up. Investigators who compared Libya's records and interviewed network members say critical components disappeared in 2003, heightening suspicions about an unidentified 'fourth customer'. After the interdiction of the *BBC China* made it clear that the network had been compromised, those involved began to destroy evidence and to dispose of stockpiled equipment. Rotors and other centrifuge components, precision tools and parts for lathes disappeared. Additionally, the network had an unknown number of complete P-2 centrifuges in Dubai that it used as demonstration models. Two were transferred to Libya, leaving at least a handful unaccounted for. Although not in a complete state of readiness, these would present a significant proliferation risk if they were to fall into the wrong hands. Network intermediaries contacted by investigators claimed that they destroyed the machines in order to remove incriminating evidence, but it is more likely that they simply hid or sold these valuable commodities.[99]

A related question is whether other production facilities for the Khan network remain undisclosed. The 4,000 centrifuges that the US removed from Libya in 2004 were missing their most important parts – the fast-spinning rotors. Although the network set up a workshop to produce the rotors in Libya, it is questionable whether Tripoli could find enough technicians with the specialised skills needed for the assembly of these precision components. It remains possible that the rotors were ordered from an as-yet undisclosed factory elsewhere.

It is also unknown whether all members of the Khan network have been identified and put under at least some kind of law-enforcement watch. Approximately 50 individuals may have been actively involved in the network.[100] Worldwide, 38 individuals are known to have been investigated.[101] Certainly not everyone who assisted Khan in Pakistan has been named. It is likely that some of Khan's associates in other countries are still at large.

The unanswered question of greatest concern is which other countries or non-state actors might also have received copies of a nuclear weapon design besides Libya. If the designs were given to Libya

simply to sweeten the deal for centrifuges, it is logical to assume that Iran and North Korea, and any other customers, would have been offered copies as well. The uranium-casting documents Iran received from the Khan network have been described as 'part of the same recipe' as Libya's bomb design.[102] Libya denies having received any weaponisation information in electronic form (in contrast to the centrifuge drawings it did receive on compact disks). However, the bomb designs were reportedly digitised and copied onto computer disks at the Khan office in Dubai. According to testimony introduced in May 2006 at Lerch's trial in Mannheim, Urs Tinner admitted to having atomic bomb construction plans in his office that he had received from Tahir. Lerch's attorney said a customs agent memo quoted Tinner as saying that the designs were original drawings from the 1980s and that he had provided a copy to the IAEA.[103] The Swiss and American authorities, as well as the IAEA, have been trying to find out what other use the Tinners may have made of the bomb designs, including the nightmare scenario of whether they sold any copies to terrorist groups.

The IAEA and Western intelligence agencies are also still trying to confirm the extent and nature of the assistance Khan gave Iran and North Korea.

A.Q. Khan's personal motives and world view

In the beginning, Khan was working only for Pakistan's national interest, which was to procure nuclear weapons technology by any means. He was encouraged to engage in parallel business dealings so that KRL could decrease its reliance on state funding. He was not the first to benefit from the illicit trade in destructive technologies, but he accelerated the consolidation of the market and, in doing so, did much to spread nuclear weapons technology. He removed key obstacles in Pakistan's successful quest for nuclear weapons. Khan's personal and Pakistan's national motives came into conflict as soon as Khan was lured into lucrative clandestine dealings. In spite of his position as a nationally revered figure, Khan still harboured further personal ambition. His problem was that the secretive nature of the Pakistani nuclear programme meant his achievements had to be kept hidden from the rest of the world.

Khan aspired to defy the West, which had portrayed him as a villain and convicted him of stealing centrifuge designs (in the Netherlands). Khan felt his capabilities had been insulted. He may also have felt a genuine sense of injustice and a victim of hypocrisy given the high number of Western industrialists who were more than ready to do business with him. He had to prove he could deliver, and outwit the West and its hurdles. Combined with this was Khan's personal anger and Pakistan's sense of having been victimised owing to India's nuclear test (France, Germany and Canada reneged on contracts for nuclear facilities under intense US pressure after India's 1974 test, as noted in chapter one). Khan reportedly told his interrogators that he believed that 'the emergence of more nuclear states would ease Western attention on Pakistan',[104] an explanation that rings true.

Khan said that he believed he was 'helping the Muslim cause', but this is a less credible explanation since the recipients of his assistance included North Korea, a non-Muslim country. In fact, Khan was not quite spreading the Islamic bomb, but acting for those states that defied the West in their nuclear pursuits, and more generally, in their foreign policies. Explaining his actions through this religious dimension obscures the financial motivation that appears to have been behind his dealings with Iran. He may also have felt the need for revenge against Zia, who in 1987 had rebuked him (page 94). The Iran case can be explained by simple market mechanisms: there was a long-standing demand from Tehran, and there was now an available supply of discarded P-1 centrifuges. This provided an opportunity to expand the business of the network, giving profits to all collaborators, who included his business partners as well as those within KRL and some government officials who might have facilitated or overlooked the deal. The offer to Iraq in 1990 shows that there was no consistent political strategy behind the network's exports: it did not make sense to sell simultaneously to Saddam Hussein and to his arch-enemies in Tehran. Khan used the *No-dong* deal with North Korea to retain his value in competition with his PAEC rivals. As for Khan's motive for Libya – it seems that he simply wanted to make money and to satisfy his ego. He felt hurt that his authority had been called into question, and that he had been removed from KRL, and thus wanted to prove that he could deliver a nuclear capability anywhere in the world through the network, for which the Libya deal was an opportunity to 'go global', expanding from its original Pakistani roots. In sum, a constellation of different motivations explains the various deals made by the Khan network, varying in importance over time and according to circumstances: ego, profit, nationalism and Islamic identity.

Conclusions

For most of the deals it is hard to separate A.Q. Khan the individual from the global network he led. But neither were Khan and the network synonymous. Although Khan was the deal-maker, the network often appeared to act autonomously, driven as much by his foreign business partners as by his own ambitions. By the time of the Libya deal, the network was a 'globalised supply chain'. Production capabilities became widespread – with computer-controlled lathes, components could be made almost anywhere – and knowledge became diffuse.

The network's ability to satisfy its customers stems from its origins as a national procurement enterprise. It was the experience gained from working for the Pakistani programme that made the network so efficient when it turned to exports. The story is more complex, however, than a mere 'reversal of the flow'. Pakistan continued to import components for its own programme, in a manner that was largely insulated from the Khan network's exports. Also, Khan's foreign-based partners were not involved to the same degree in all cases: they appear not to have been involved in the North Korea case at all, except, for some perhaps, as direct component suppliers. By contrast, Khan's Swiss and Dubai-based partners were apparently the first to be involved in both the Iran and Libya cases.

Khan cannot be characterised strictly as either a government representative or a businessman acting independently. He was in fact both, in varying degrees according to the circumstances. The state's complicity in his proliferation ranged along a spectrum. At one end, his procurement for Pakistan's nuclear programme was state authorised, supported and funded, although he had great autonomy in making his own purchases. Khan's purported discussions with the Saudis were almost surely state authorised. At the other end of the spectrum, the Khan network's sales to Libya of centrifuge equipment produced in Malaysia, Turkey, Europe and South Africa and transshipped in Dubai were almost exclusively a private business transaction beyond state control. The same is likely to be true of his purported exploratory business trips to other countries in Africa. The offer to Iraq also appears to have been a private venture by the network, although the dearth of evidence makes it hard to draw conclusions.

The Pakistani government should have known what key officials, such as Khan, were up to in an area so fundamental to Pakistan's national security and international reputation, and it is logical to assume that the intelligence apparatus was aware of more than Pakistan has ever let on. While knowledge of a transaction denotes complicity, however, it does not necessarily imply authorisation. With Iran, North Korea and Libya, Khan operated in the context of on-going government-to-government cooperation in weapons programmes and exchanges that either involved nuclear technology (in the case of Iran), nuclear delivery systems (in the case of North Korea), or nuclear materials (in the case of Libya).

In downplaying the damage caused by Khan's onward proliferation, Pakistani officials stress that the centrifuge equipment he sold to Iran was used and deficient, as was probably true of the equipment he transferred to North Korea, and, in the case of Libya, that it was incomplete. None of these countries succeeded in constructing a nuclear weapon from the technology they obtained from the Khan network, although how close they got to a bomb as a result of the transfers is a matter of some debate. The nuclear device the North Koreans tested in October 2006 was based not on HEU but on the plutonium they had separated from the spent fuel rods from their research reactors. How much progress they made in their Khan-assisted centrifuge-procurement programme is simply unknown. There is no evidence that North Korea has any ability to produce HEU; but neither was there any evidence that it could produce UF_6 before it emerged as the most likely source of the UF_6 that Libya obtained from Khan. Iran has made the most widely documented progress in centrifuge technology with Khan's help, but as of the beginning of 2007, it was at least two or three years away from being able to produce enough HEU for one nuclear weapon. Libya produced no enriched uranium from the equipment it imported, and, assuming it would have received more help and the missing UF_6 and centrifuge parts, it was at least three or four years away from being able to produce a weapon when Gadhafi renounced the programme in December 2003. Even then Libya would have needed a suitable delivery vehicle.

The Khan network was not a nuclear weapons 'Wal-Mart', since its contributions to proliferation concerned only – so far as is known today – centrifuge technology and, in one instance at least, a weapon design. However, Khan's nuclear sales had other deleterious results. The transfer of enrichment technology to North Korea precipitated the breakdown of the US–North Korea Agreed Framework and Pyongyang's resumption of its plutonium

President George W. Bush looks over equipment obtained from Libya's former nuclear weapons programme at the Oak Ridge National Laboratory in Oak Ridge, Tennessee, USA, July 2004 (White House photo by Tina Hager)

Centrifuges from Libya on display at Oak Ridge National Laboratory, USA, March 2004 (Doug Mills/The New York Times/ Redux)

programme and weapons test, with as-yet unknown ripple effects. Khan's nuclear assistance to Iran led to a further breakdown in the global non-proliferation regime and an international crisis over a budding uranium enrichment capability that many fear could escalate to armed conflict. If Gadhafi had not made his wise choice in 2003, Libya could possibly be in possession of an atomic bomb by now, a development that would probably have set one or more of its neighbours on a similar path. These scenarios, alarming as they are, only encompass the known elements of Khan's black market dealings. By freely selling enrichment equipment and putting the designs on computer disks, Khan significantly lowered the technical barriers to nuclear weapons development. Who else might have access to the nuclear technology he and his network proliferated remains a haunting question.

Notes

1 William J. Broad, David E. Sanger and Raymond Bonner, 'A Tale of Nuclear Proliferation: How a Pakistani Built His Network', *New York Times*, 12 February 2004.

2 Feroz Hassan Khan, 'Nuclear Proliferation Motivations: Lessons from Pakistan', *Nonproliferation Review*, vol. 13, no. 3, November 2006, p. 511.

3 John Lancaster and Kamran Khan, 'Pakistanis Say Nuclear Scientists Aided Iran; Iran Nuclear Effort Said Aided in Secret '80s Deal', *Washington Post*, 24 January 2004.

4 Gordon Corera, *Shopping for Bombs: Nuclear Proliferation, Global Insecurity, and the Rise and Fall of the A.Q. Khan Network* (New York: Oxford University Press, 2006), p. 64.

5 Leonard S. Spector and Jacqueline R. Smith, *Nuclear Ambitions: The Spread of Nuclear Weapons 1989–1990* (Boulder, CO: Westview Press, 1990), p. 212; Kenneth Timmerman, *Countdown to Crisis: The Coming Nuclear Showdown with Iran* (New York: Crown Forum, 2005), pp. 38–9.

6 Stephen Fidler, 'Fresh Clues on Smuggling Network Could Lift Lid on Tehran's Secret Nuclear Program', *Financial Times*, 12 March 2005; Dafna Linzer, 'Iran Was Offered Nuclear Parts: Secret Meeting in 1987 May Have Begun Program', *Washington Post*, 27 February 2005.

7 'Iranian Dissident Fires Ukraine, Iran Charges on Tehran's Nuclear Program', Agence France Presse, 26 August 2005.

8 Corera, *Shopping for Bombs*, p. 60.

9 Dafna Linzer, 'Iran Was Offered Nuclear Parts'.

10 IAEA, 'Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran', GOV/2006/15, 27 February 2006, p. 5, paras 20 and 22.

11 Corera, *Shopping for Bombs*, p. 66.

12 IAEA, 'Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran', GOV/2005/87, 18 November 2005, p. 2, paras 5 and 6.

13 IISS communications, October 2005 and December 2006. See also Steve Coll, *Ghost Wars: The Secret History of the CIA, Afghanistan, and Bin Laden, from the Soviet Invasion to September 10, 2001* (New York: Penguin Press, 2004), pp. 220–21; Matt Kelley, 'Pakistan Threatened to Give Iran Nukes', Associated Press, 27 February 2004; Douglas Frantz, 'Pakistan's Role in Scientist's Nuclear Trafficking Debated', *Los Angeles Times*, 16 May 2005.

14 Frantz, 'Pakistan's Role in Scientist's Nuclear Trafficking Debated'.

15 Kathy Gannon, 'Iran Sought Advice in Pakistan on Attack', Associated Press, 12 May 2006; Kathy Gannon, 'Explosive Secrets from Pakistan', *Los Angeles Times*, 16 May 2005.

16 Bruno Tertrais, *Pakistan's Nuclear Exports: Was There a State Strategy?*, (Washington DC: The Non-Proliferation Policy Education Center, 20 October 2006), pp. 5–6, http://www.npec-web.org/Essays/20061023-Tertrais-Pakistan.pdf; David Rohde, 'Nuclear Inquiry Skips Pakistani Army', *New York Times*, 29 January 2004; Lancaster and Khan, 'Pakistanis Say Nuclear Scientists Aided Iran'; Gannon, 'Explosive Secrets from Pakistan'.

17 Coll, *Ghost Wars*, p. 221. Lancaster and Khan, 'Pakistanis Say Nuclear Scientists Aided Iran'; Udayan Namboodiri, 'Dr. Khan's Story: Thy Hand, Great Gen!', *Pioneer*, 6 February 2004; Timmerman, *Countdown to Crisis*, pp. 105–8.

18 Mubashir Zaida, 'Scientist Claimed Nuclear Equipment was Old, Officials Say', *Los Angeles Times*, 10 February 2004; David Armstrong, 'Friends Like These', *The New Republic*, 9 November 2004.

19 Corera, *Shopping for Bombs*, pp. 75–6.

20 *Ibid*.

21 Polis Diraja Malaysia, 'Press Release by Inspector-General of Police in Relation to Investigation on the Alleged Production of Components for Libya's Uranium Enrichment Programme', 20 February 2004, p. 3: http://www.rmp.gov.my/rmp03/040220scomi_eng.htm.

22 IAEA, 'Implementation of the NPT Safeguards Agreements in the Islamic Republic of Iran', report by the Director General to the Board of Governors, GOV/2003/75, 10 November 2003, Annex 1, p. 8, para 48.

23 IAEA, 'Implementation of the NPT Safeguards Agreements in the Islamic Republic of Iran', GOV/2004/83, 15 November 2004, p. 8, para 34.

24 IAEA, GOV/2004/83, p. 11, para 45.

25 'Iran May Have Received Advanced Centrifuges: Diplomats', Agence France Presse, 20 Jan 2006; Arms Control Association 'Questions Surround Iran's Nuclear Program', Arms Control Association Fact Sheets, 3 March 2006, http://www.armscontrol.org/factsheets/Iran-IAEA-Issues.asp; Dafna Linzer, 'Strong Leads and Dead Ends in Nuclear Case Against Iran', *Washington Post*, 8 February 2006.

26 IISS, *Iran's Strategic Weapons Programmes: A Net Assessment* (Abingdon: Routledge for IISS, 2005), p. 54, Table 1A.

27 *Ibid*.

28 Joseph F. Pilat, 'Iraq and the Future of Nuclear Proliferation: The Roles of Inspections and Treaties', *Science*, new series 1225, no. 5049, 6 March 1992, p. 1225.

29 'Agencies Trace Some Iraqi URENCO Know-How to Pakistan Re-Export', *Nucleonics Week*, 28 November 1991, pp. 1, 7–8.

30 For the IAEA's English translation of the memo, see David Albright and Corey Hinderstein, 'Documents Indicate A.Q. Khan Offered Nuclear Weapons Designs to Iraq in 1990: Did He Approach Other Countries?', Institute for Science and International Security, 4 February 2004, http://www.isis-online.org/publications/southasia/khan_memo_scan.pdf.

31 Pervez Musharraf, *In the Line of Fire: A Memoir* (New York: Free Press, 2006), p. 289.

32 David E. Sanger, 'Pakistani Says He Saw North Korean Nuclear Devices', *New York Times*, 13 April 2004.

33 Bill Gertz, 'Pyongyang Working to Make Fuel for Nukes', *Washington Times*, 11 March 1999.

34 Richard P. Cronin, K. Alan Kronstadt and Sharon Squassoni, 'Pakistan's Nuclear Proliferation Activities and the Recommendations of the 9/11 Commission: US Policy Constraints and Options', CRS Report to Congress, RL32745 (Washington DC: Congressional Research Service, updated 24 May 2005, p. 22).

35 *Ibid*., p. 296.

36 David E. Sanger, 'Pakistan Leader Confirms Nuclear Exports', *New York Times*, 13 September 2005.

37 'Re-imposition of Sanctions Feared,' *Dawn*, 5 February 2004.

38 Sanger, 'Pakistani Says He Saw North Korean Nuclear Devices'.

39 Central Intelligence Agency (CIA) Report to Congress, 19 November 2005.

40 Mark Hibbs, 'Customs Intelligence Data Suggest DPRK Aimed At G-2 TYPE Centrifuge', *NuclearFuel*, 26 May 2003.

41 Joby Warrick, 'N. Korea Shops Stealthily for Nuclear Arms Gear', *Washington Post*, 15 August 2003.

42 Eishiro Takeishi, 'We Bought Missile Technology', *Asahi Shimbun*, 19 July 2004; Gary Thomas, 'Former Prime Minister Says Pakistan Had Nuclear Capability Long Before Nuclear Tests', Voice of America, 3 March 2005, http://www.voanews.com/english/2005-03-03-voa4.cfm.

43 By March 2003 India had conducted 16 known test flights of *Prithvi*-1 missiles. Zahid Hussain, 'Missile Tests Raise Indo-Pakistan Fears', *The Times*, 27 March 2003.

44 Joseph Bermudez, *A History of Ballistic Missile Development in the DPRK*, Occasional Paper No. 2 (Monterey, CA: Center for Nonproliferation Studies, Monterey Institute of International Studies, 1999), p. 28.

45 Larry A. Niksch, 'North Korea's Nuclear Weapons Program', CRS Issue Brief for Congress, IB91141 (Washington DC: Congressional Research Service, updated 21 February 2006, pp. 9–10).

46 Gaurav Kampani, 'Second Tier Proliferation: The Case of Pakistan and North Korea', *Nonproliferation Review*, vol. 9, no. 3, Fall–Winter 2002, p. 110.

47 Shahid-ur-Rehman and Aroosa Alam, 'Musharraf Says Khan Offered Centrifuges, Designs To N. Korea', Kyodo News Service, 24 August 2005.

48 S. Shabbir Hussain and Mujahid Kamran (eds), 'Dr. A.Q. Khan Research Laboratories, Kahuta: Twenty Years of Excellence and National Service', in *Dr. A.Q. Khan on Science and Education* (Lahore: Sang-E-Meel, 1997), pp. 222–9.

49 Lancaster and Khan, 'Musharraf Named in Nuclear Probe'; 'Re-Imposition of Sanctions Feared'; Musharraf, *In the Line of Fire,* pp. 289–90.

50 Christopher O. Clary, 'The A.Q. Khan Network: Causes and Implications', M.A. thesis, Naval Postgraduate School, Monterey, CA, 2005, p. 65.

51 Lancaster and Khan, 'Musharraf Named in Nuclear Probe'; Clary, 'The A.Q. Khan Network', p. 63.

52 Sharon Squassoni, 'Weapons of Mass Destruction: Trade between North Korea and Pakistan', RL31900 (Washington DC: Congressional Research Service, 28 November 2006), p.15.

53 Presentation by Pakistan Strategic Plans Division officials at the Naval Postgraduate School in Monterey, CA, 27 October 2006.

54 Clary, 'The A.Q. Khan Network', p. 64.

55 'Arms Transfers to India and Pakistan, 1994–2004', Stockholm International Peace Research Institute

(SIPRI) Arms Transfers Database, http://www.sipri.org/contents/armstrad/atind_pakdata.html.

56 'Pakistan', SIPRI Military Expenditure Database, http://www.sipri.org/contents/milap/milex/mex_database1.html.

57 For additional analysis of the explanation that Khan acted alone, see Clary, pp. 63–6.

58 Corera, *Shopping for Bombs*, p. 190.

59 IAEA, 'Implementation of the NPT Safeguards Agreement of the Socialist People's Libyan Arab Jamahiriya', GOV/2004/33, 28 May 2004, p. 2, para 15.

60 W.P.S. Sidhu, 'Pakistan's Bomb: A Quest for Credibility', *Jane's Intelligence Review*, vol. 8, no. 6, June 1996, p. 278.

61 Shyam Bhatia, *Nuclear Rivals in the Middle East* (New York: Routledge, 1988), pp. 64–71; Spector and Smith, *Nuclear Ambitions,* pp. 175–85.

62 Wyn Q. Bowen, *Libya and Nuclear Proliferation: Stepping Back from the Brink*, Adelphi Paper 380 (London: Routledge for IISS, 2006), pp. 30–31.

63 *Ibid*., p. 36.

64 IAEA, 'Implementation of the NPT Safeguards Agreement of the Socialist People's Libyan Arab Jamahiriya', report by the Director General to the Board of Governors, GOV/2004/12, 20 February 2004, p. 5, para. 22.

65 IAEA, GOV/2004/33, Annex I, pp. 5-7.

66 Clary, 'The A.Q. Khan Network', p. 77.

67 Communication with investigative official, Europe, October 2006; Corera, *Shopping for Bombs*, pp. 236–7.

68 Glenn Kessler and Dafna Linzer, 'Nuclear Evidence Could Point to Pakistan', *Washington Post*, 3 February 2005.

69 *Ibid*.; Glenn Kessler, 'North Korea May Have Sent Libya Nuclear Material, US Tells Allies', *Washington Post*, 2 February 2005.

70 Kessler and Linzer, 'Nuclear Evidence Could Point to Pakistan'.

71 David E. Sanger and William J. Broad, 'Tests Said to Tie Deal on Uranium to North Korea', *New York Times*, 2 February 2005.

72 Kessler and Linzer, 'Nuclear Evidence Could Point to Pakistan'.

73 William J. Broad, 'Libya's Crude Bomb Design Eases Western Experts' Fears', *New York Times*, 9 February 2004; Douglas Frantz, 'A High-Risk Nuclear Stakeout', *Los Angeles Times*, 27 February 2005; IAEA, GOV/2004/33, Annex I, p. 7.

74 Bowen, *Libya and Nuclear Proliferation*, p. 43.

75 Joby Warrick and Peter Slevin, 'Libyan Arms Designs Traced Back to China; Pakistanis Resold Chinese-Provided Plans', *Washington Post*, 15 Feb 2004; David Albright and Corey Hinderstein, 'Unraveling the A.Q. Khan and Future Proliferation Networks', *Washington Quarterly*, vol. 28, no. 2, Spring 2005, p. 114.

76 Douglas Frantz, 'Vital Nuclear Parts are Missing', *Los Angeles Times*, 22 April 2005.

77 Report of a Committee of Privy Councillors chaired by the Rt Hon. the Lord Butler of Brockwell, KG GCB CVO, *Review of Intelligence on Weapons of Mass Destruction*, HC 898 (London: The Stationery Office, 14 July 2004), http://www.factcheck.org/UploadedFiles/Butler%20Report.pdf, p. 18.

78 Douglas Frantz and William C. Rempel, 'New Find in a Nuclear Network', *Los Angeles Times*, 28 November 2004; Albright and Hinderstein, 'Unraveling the A.Q. Khan and Future Proliferation Networks', p. 118.

79 Scomi Group Berhad, 'SCOPE's Press Statement on its Contract in Dubai', news release, 4 February 2004: http://www.scomigroup.com.my/publish/04news008.shtml; Raymond Bonner and Wayne Arnold, 'Business as Usual in Plant that Tenet Said was Shut', *New York Times*, 7 February 2004.

80 Steve Coll, 'The Atomic Emporium', *The New Yorker*, 7–14 August 2006.

81 Polis Diraja Malaysia, 'Press Release by Inspector-General of Police'; David Albright and Corey Hinderstein, 'Libya's Gas Centrifuge Procurement: Much Remains Undiscovered, Institute for Science and International Security (ISIS) 'ISIS Issue Brief, 1 March, 2004: http://www.isis-online.org/publications/libya/cent_procure.html; David Albright, 'International Smuggling Networks: Weapons of Mass Destruction Counterproliferation Initiatives', statement to the Senate Committee on Government Affairs, 23 June 2004.

82 William J. Broad and David E. Sanger, 'After Ending Arms Program, Libya Receives a Surprise', *New York Times*, 29 May 2004; Ian Traynor, 'Western Agents Let Nuclear Equipment Slip Past to Libya', *Guardian*, 29 May 2004.

83 Clary, 'The A.Q. Khan Network', p. 80.

84 Matt Kelley, 'Nuclear Weapons Cost Libya $100 Million', Associated Press, 16 March 2004.

85 Andrew Koch, 'AQ Khan Network: Case Closed', testimony to Subcommittee on International Terrorism and Nonproliferation of the House International Relations Committee, 25 May 2006, pp. 17–19.

86 William J. Broad and David E. Sanger, 'As Nuclear Secrets Emerge in Khan Inquiry, More Are Suspected', *New York Times*, 26 December 2004.

87 John D. Negroponte, 'Annual Threat Assessment of the Director of National Intelligence', Senate Select Committee on Intelligence, 11 January 2007.

88 Ian Traynor and Ian Cobain, 'Clandestine Nuclear Deals Traced to Sudan', *Guardian*, 5 January 2006.

89 'Saudi Nuclear Pact', *Washington Post*, 18 January 1981; 'Mohammed Al-Khilewi: Saudi Arabia is Trying to Kill Me', *Middle East Quarterly*, vol. 5, no. 3, September 1998, p. 74.

90 Mansoor Ijaz, 'Pakistan's Nuclear Metastasis: How Widespread is the Cancer?', *The Weekly Standard*, 8 January 2004; Ronen Bergman, 'El-Sulayil Missile Base – Saudi Desert', *Yediot Ahronot*, 27 March 2002, http://www.globalsecurity.org/org/news/2002/020327-saudi.htm.

91 Selig S. Harrison, 'US Must Clamp Down on Pakistan Nuke Dealing', *San José Mercury News*, 30 May 2003.

92 Tertrais, 'Pakistan's Nuclear Exports', p. 11.

93 Harrison, 'US Must Clamp Down on Pakistan Nuke Dealing'. However, according to Harrison, Ambassador Freeman understood at that time that 'the King envisaged a US nuclear umbrella'.

94 David R. Sands, 'Israeli General Says Saudis Seek to Buy Nukes', *Washington Times*, 23 October 2003; Uri Dan, 'Israeli: Saudis Trying to Buy Nuke Warheads', *New York Post*, 22 October 2003; Arnaud de Borchgrave, 'Pakistan–Saudi Trade Nuke Tech for Oil', United Press International, 20 October 2003.

95 'Government Offers UAE Nuclear Training But Not Atomic Bomb on Platter', *Jasarat*, 26 May 1999.

96 'Unclassified Report to Congress on the Acquisition of Technology Relating to Weapons of Mass Destruction and Advanced Conventional Munitions, 1 January through 31 December 2004', May 2006, p. 5; Kamran Khan, 'Pakistanis Exploited Nuclear Network; Iran, Libya Aided Via Black Market, Investigation Finds', *Washington Post*, 28 January 2004.

97 Albright and Hinderstein, 'Unraveling the A.Q. Khan and Future Proliferation Networks', p. 113.

98 See David Albright and Mark Hibbs, 'Pakistan's Bomb: Out of the Closet', *Bulletin of the Atomic Scientists*, vol. 48, no. 6, July–August 1992; and Corera, *Shopping for Bombs*, p. 45.

99 IISS interview with David Albright, January 2007. Frantz, 'Vital Nuclear Parts Missing'.

100 David Albright, 'A.Q. Khan Network: The Case is Not Closed', testimony before the Subcommittee on International Terrorism and Nonproliferation of the House International Relations Committee, 25 May 2006, p. 8.

101 Kenley Butler, Sammy Salema and Leonard S. Spector, 'Where is the Justice?', *Bulletin of the Atomic Scientists*, vol. 62, no. 6, November–December 2006, pp. 25–34. As of the publication date, the authors said five individuals had been convicted, 14 were known to be under investigation, and at least 19 others had been cleared of wrongdoing, released from detention or pardoned.

102 Anton La Guardia, 'Tailor's Bag that Put West on the Trail of Iran's Nuclear Secrets', *Daily Telegraph*, 22 March 2006.

103 Wolfgang Frey, 'Angeklagter im Atomprozess schwer belastet' ('Defendant in Atom case severely incriminated'), *Der Spiegel*, 17 May 2006.

104 David Rohde and David E. Sanger, 'Key Pakistani is Said to Admit Atom Transfers', *New York Times*, 2 February 2004.