



Institute for Science and International Security

ISIS Special Report:

Libya: A Major Sale at Last

David Albright

December 1, 2010

The Institute for Science and International Security

Table of Contents*

Bomb Inc.	2
Another Attempt	6
Turn-Key Centrifuge Plant	12
Dividing Up the Contract	14
Critical Classified Information	19
Transnational Supply Chain	22
Manufacturing Centrifuge Components	24
Malaysian Workshop	27
Aluminum Pre-Forms	29
Kirag	34
Centrifuge Rotor Tubes	38
Feed and Withdrawal System	40
Workshop 1001	42
Conclusion	47

* *Libya: A Major Sale at Last* is supplemental to the Libya chapter in *Peddling Peril: How the Secret Nuclear Trade Arms America's Enemies* by David Albright, released in March 2010. For more information about the Khan network and illicit nuclear trade, please refer to this book or to the ISIS web site.

LIBYA: A MAJOR SALE AT LAST

During the 1970s and 1980s, Libya's dictator Muammar Qaddafi sought nuclear weapons. He contributed money to Pakistan's nascent nuclear weapons effort to help cash-starved Pakistan. In return, A.Q. Khan, the leader of Pakistan's covert gas centrifuge effort, raised the possibility of selling Libya centrifuge technology in January 1984.¹ Qaddafi's scientists were startled by the offer, fearing that Libya did not have the physical or scientific infrastructure to take it up.² This may help explain why around that same time, Qaddafi recruited a European gas centrifuge expert to come to Libya and develop centrifuges.³ Fired from the German URENCO contractor MAN New Technologies in Munich,⁴ the expert brought his own equipment and designs to Tripoli in an effort to develop a gas centrifuge.⁵ He left Libya in 1992 without ever getting one to work.⁶

Qaddafi had always found it difficult to expand his ostensibly civil nuclear infrastructure. Many countries have relied on such a foundation to develop nuclear weapons. Although he managed to buy a small Russian nuclear reactor in the 1970s, few countries were willing to sell him additional nuclear facilities or train Libyans in the specialized arts of nuclear science and engineering. His military attacks on his neighbors, the 1988 downing of Pan Am flight 103 over Lockerbie, Scotland, and his broad support for terrorism united much of the world against him.

By 1989, Qaddafi had failed utterly to launch a nuclear weapons program. It was at this point that Khan and his international team once again stepped into the nuclear proliferation breach.

Bomb, Inc.

The details of the deal remain murky, according to a senior official close to the International Atomic Energy Agency (IAEA), who was unable to say who initiated the crucial meeting to establish the sale. The IAEA does know that Khan renewed his contacts with Libyan officials starting in the fall of 1989, five years after the initial offer.⁷ By early 1991, the sides had reached an agreement for the supply of P1 (Pakistan-1) centrifuges, the same ones sold to Iran (see figure 1).⁸ Khan's offer may have been

¹ Director General, *Implementation of the NPT Safeguards Agreement of the Socialist People's Libyan Arab Jamahiriya*, GOV/2008/39, September 12, 2008, Annex, p. 3.

² Interview with a senior official close to the IAEA, September 12, 2008; *Implementation of the NPT Safeguards Agreement*, September 12, 2008, op. cit.

³ Interview with a senior official close to the IAEA, January 6, 2004.

⁴ Interview with a senior official close to the IAEA, January 6, 2004.

⁵ Director General, *Implementation of the NPT Safeguards Agreement of the Socialist People's Libyan Arab Jamahiriya*, GOV/2004/12, February 20, 2004, par. 21.

⁶ *Implementation of the NPT Safeguards Agreement*, September 12, 2008, op. cit.

⁷ *Implementation of the NPT Safeguards Agreement*, September 12, 2008, op. cit., Annex, p. 3.

⁸ Interview with a senior official close to the IAEA, December 11, 2007.

similar in scope to the 1987 offer to Iran. Fairly quickly, Libya received a few P1 components and centrifuge designs.



Figure 1: P1 centrifuges in the Iranian pilot enrichment plant at Natanz. They are organized into cascades, each containing 164 P1 centrifuges connected by pipes. Photo credit: photo archive of the web site of the President of Iran, www.president.ir.

The earlier work on centrifuges by the German centrifuge expert was not a complete waste. It had at least prepared Libyan specialists for Khan's latest offer.

Like in the case of Iran, the P1 centrifuges would have come from Khan Research Laboratories (KRL), which was switching out the older P1 centrifuges and replacing them with the P2 model (see figure 2). Thousands of P1 centrifuges were retired, starting as early as in 1985. For Khan and his underlings at KRL, sneaking away hundreds or even a few thousand of these surplus machines was straightforward.

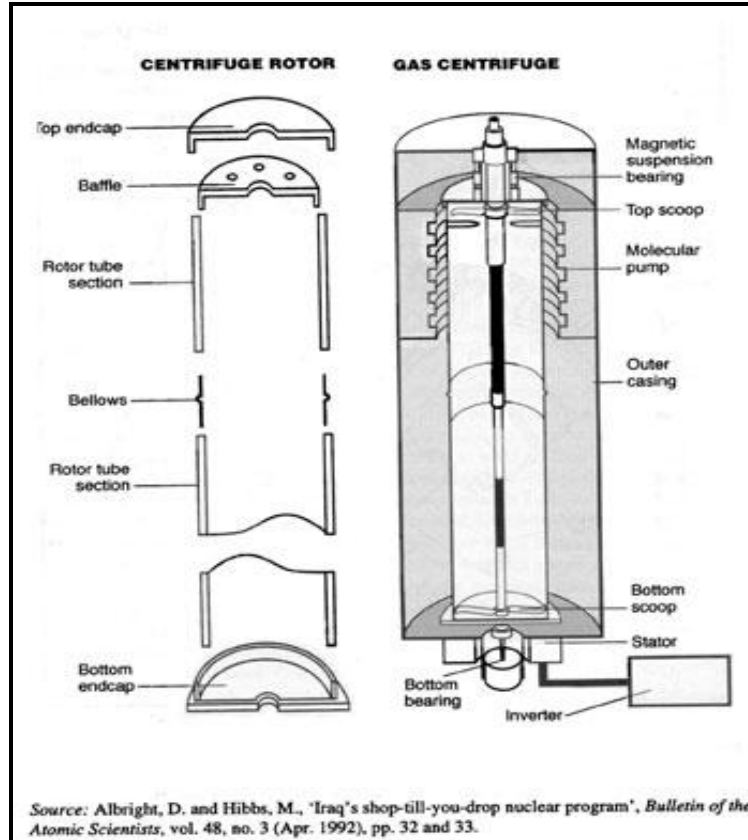


Figure 2: Generic drawing of an early URENCO-type centrifuge. In the case of Libya, the two rotor tubes and the bellows were combined into one piece.

The sale involved several other members of the Khan network. Friedrich Tinner, Khan's old colleague and a supplier in Switzerland, contracted to manufacture a few "test modules," or small-scale feed and withdrawal systems.⁹ He may have used the same designs Khan had given him in the 1970s when Tinner worked with Cora Engineering to provide feed and withdrawal equipment to Pakistan. These test modules were needed for the operation of a single P1 centrifuge and cascades of 9, 19, and 64 P1 centrifuges. Libya needed to operate these cascades to develop the experience to operate a centrifuge plant comprised of thousands of centrifuges. Khan's old colleague, Selim Alguadis, who headed 3E Endustriyel and its subsidiary EKA Elektronik Kontrol in Istanbul, agreed to produce six frequency converters, each of which could power many centrifuges. Gunes Cire, Khan's old university classmate and a close business associate of the Tinner who headed ETI Elektronik and its subsidiary, Techno

⁹ Interview with a senior official close to the IAEA, December 11, 2007. Each test module contained a vacuum pump, control and measuring equipment, a small feed autoclave, and two withdrawal stations, including "cold traps," filled with liquid nitrogen.

Elektrik in Istanbul, ordered a large number of P1 magnets from Western suppliers that were part of the upper bearing of the P1 centrifuge.¹⁰

Khan's sale to Libya stalled when the United Nations Security Council imposed a total air and arms embargo on Libya in 1992 for refusing to extradite two Libyans accused of carrying out the bombing of Pan Am flight 103.¹¹ In 1993, the Security Council banned the sale of petroleum equipment to Libya. Faced with such harsh sanctions, the network was stymied for several years.

By 1992, when the sanctions took effect, Khan had yet not delivered any P1 centrifuges or equipment to Libya. But network members had already fulfilled a portion of their contracts before the start of the U.N. embargo. They wanted their payments, but Libya was not going to pay for goods that were unlikely to be delivered. Tinner had finished one test module and sent it to Dubai, where it awaited shipment to Libya. He had also built a nine-machine test module that remained in Switzerland. Cire and Alguadis had likewise acquired ring magnets and made frequency converters.

Under pressure from his contractors and unable to get money from Libya, the Khan network devised a way to sell at least some of this equipment to Iran and KRL. When Iran decided to buy more centrifuges from the network in 1993, a network representative told them that centrifuge equipment stored in Dubai was for sale.¹² Based on member state information and interviews with Libyan officials and supply network members, the IAEA concluded that most of the centrifuge equipment offered to Iran by the network in 1993 had originally been ordered by Libya.¹³ This equipment was in addition to the 500 P1 centrifuges bought by Iran that had come directly from KRL.

Iran bought all the P1 magnets and one frequency converter. It did not buy Tinner's test modules. Khan's enrichment program bought the other five frequency converters. Iran again showed its resistance to buying very much from the network. As in the past, it bought "bits and pieces" and then tried to use its own smuggling network to create an indigenous centrifuge capability.¹⁴

After several years of trying, the Khan network appeared unable to seal a major deal. Libya was ensconced in sanctions and Iran was cherry-picking its offers. Iraq was bombed during the 1990 Gulf War before a nuclear weapons deal could develop. North Korea was a potential customer, although large

¹⁰ *Nuclear Proliferation Network, Technology and Equipment Procurement*, undated chart produced by the IAEA. Other sources list the names of Cire's and Alguadis' companies somewhat differently.

¹¹ UNSC Resolution 748.

¹² Interview with a senior official close to the IAEA, December 11, 2007.

¹³ Director General, *Implementation of the NPT Safeguards Agreement and Relevant Portions of Security Council Resolutions 1737 (2006) and 1747 (2007) in the Islamic Republic of Iran*, GOV/2007/58, November 15, 2007, p. 4.

¹⁴ Interview with a senior official close to the IAEA, January 6, 2004.

sales would never develop. Other countries that Khan is believed to have approached prior to the early 1990s, such as Egypt, are not believed to have bought centrifuges.¹⁵

Surprisingly, proliferating was harder than most would imagine. Many of these countries had nuclear complexes and could afford to turn down Khan or take only part of what he offered. Others likely suspected that the Khan network could not be trusted on such a sensitive issue.

Yet, Libya was in a tight spot. It needed to buy turn-key sites, having failed to develop its own nuclear facilities. It was thus determined to try again to buy from the Khan network.

Another Attempt

Libya decided to reinvigorate its bomb efforts in July 1995, although sanctions would delay the actual restart.¹⁶ According to the Sri Lankan Seyed Abu Tahir Bin Bukhary, Khan's chief aid in his proliferation deals, Libya formally asked Khan to supply a gas centrifuge plant in 1997 at a meeting in a café in Istanbul, Turkey.¹⁷ In that meeting, Khan, accompanied by Tahir, met with Mohamed Matuq Mohamed, the senior Libyan government official heading the nuclear weapons effort, and Karim, the head of the gas centrifuge program.¹⁸ Matuq was Secretary of the General People's Committee and Secretary of the National Board of Scientific Research, which provided a convenient cover for Libya's nuclear weapons program.¹⁹

By this time, the 37-year-old Tahir was firmly in control of the Khan network's daily operations.²⁰ According to a senior official close to the IAEA, he had pushed his uncle, S. Mohammed Farooq, out of their Dubai business, Bin Belailah Enterprises (BBE). Farooq had resisted but settled for a cash buyout, and he moved to Singapore in 1992 where he has lived ever since.²¹ Khan tells a different story to the media. He says that in 1991 or 1992, Farooq cheated Tahir and fled to Singapore with all the money in their bank accounts and later blackmailed Tahir.²² Whatever the exact circumstances of Tahir taking

¹⁵ Interview with anonymous source, October 21, 2004. The assistance was offered several years prior to 1992.

¹⁶ *Implementation of the NPT Safeguards Agreement*, February 20, 2004, op. cit., par. 22.

¹⁷ “[Extract from Statement of Sayed Abu Tahir Bin Bukhary](#),” (Tahir Statement) Managing Director of SMB Group of Companies, Kuala Lumpur, Malaysia, June 7, 2006. Annexure L in *Plea and Sentence Agreement, State vs. Geiges, Wisser, and Krisch Engineering*, Pretoria, South Africa, Case No. CC332/2005, September 2007. See also *Press Release by Inspector General of Police in Relation to Investigation of the Alleged Production of Components for Libya's Uranium Enrichment Program*, February 20, 2004, accessed at http://www.rmp.gov.my/rmp03/040220scomi_eng.ht

¹⁸ Tahir statement, op. cit.

¹⁹ *Implementation of the NPT Safeguards Agreement*, February 20, 2004, op. cit., par. 6.

²⁰ Tahir was born April 17, 1959.

²¹ Interviews with senior officials close to the IAEA, 2006 and 2007. As part of the IAEA's investigations into Khan, Heinonen visited Farooq unannounced a few years ago at his home. Farooq was unwilling to cooperate with Heinonen, providing the IAEA inspector with only limited information about the network.

²² E-mail interview with Khan by Urs Gehrigler, *Weltwoche*, Published January 2009, <http://www.weltwoche.ch/ausgaben/2009-04/artikel-2009-04-interview-khan-english-version.html>.

over, he ran the business differently than his uncle. Unlike Farooq, who was like a “servant” to Khan, according to a senior official close to the IAEA, Tahir had a stronger, more personal relationship with Khan. He sought a more powerful role in the network, increasingly using his own family’s Dubai computer business, SMB Group, which included SMB Computers and SMB Traders Computers Division, as his base of smuggling operations. He injected new blood into the network and had the trust of Khan.

By 1997, a few countries started to unilaterally loosen sanctions against Libya, and Qaddafi started to send signals that he was interested in resolving the Lockerbie bombing. In April 1999, U.N. Security Council sanctions were suspended after Libya delivered two Lockerbie bombing suspects to The Hague in the Netherlands to stand trial. The door was finally open to implementing the Khan network’s sale to Libya.

The orders resumed in 1997, and the network sent 20 pre-assembled P1 centrifuges to Libya, renaming them the L-1 centrifuge, for Libya-1. The Khan network also sold Libya another 200 P1 unassembled centrifuges, uranium hexafluoride cylinders, and frequency converters, sometimes called inverters (see figure 2, page 3).²³ Despite Libya receiving the P1 centrifuges ordered in the early 1990s, Matuq had by then realized that the P2 centrifuge was a better machine.²⁴ Moreover, Khan no longer had surplus P1 centrifuges, so he would need to find an off-shore manufacturer to provide these centrifuges. When he met with Khan, Matuq placed an order for a P2 centrifuge plant. He still wanted the order of 200 P1 centrifuges because the Libyans could use them while waiting for the manufacture of the P2 machines to build up their expertise and experience in running centrifuges.

In 1998 or 1999, the Libyans received the two P1 test modules that Tinner had made in the early 1990s but which he was unable to sell to someone else. Tinner also sent two larger modules that he manufactured under the new order. According to Swiss investigators, Tinner contracted for most of the items from other companies, which were oblivious of the true end use of the items. Sometime in the mid-to-late 1990s, his sons, Urs and Marco, started working with him on the Libyan contract. They became known later in intelligence circles as the “Brothers.” Urs and his younger brother Marco began playing a more central role in the Tinner family’s day to day work on the Libyan deal, becoming more involved in operating the family businesses in Switzerland and Dubai. Neither had a university education, and Urs had trouble in school and reportedly got into trouble with the law after leaving home. Nonetheless, Urs became a very skilled technician. Marco was quiet and mentally quick. He studied electronics, but later

²³ *Implementation of Safeguards Agreement*, February 20, 2004, op cit.

²⁴ Interview with a senior official close to the IAEA, January 6, 2004.

developed expertise in financial management. Marco also served as an intermediary between suppliers and Khan. If a supplier had technical questions, he faxed Marco, who would in turn fax Khan for an answer, often using fake names and aliases. In this way, Marco answered the questions, while hiding Khan's presence.

One of the pre-assembled P1 centrifuges was set up in 2000 at Al Hashan, on the outskirts of Tripoli.²⁵ Libyan technicians then started to install progressively three small cascades of P1 centrifuges (see figure 3, page 9). None of the centrifuges enriched any uranium before Libya dismantled them in 2002.²⁶ Libyans told the IAEA that they did this for security reasons. Fearful that Western intelligence would discover the site, Libya designed its centrifuge program to be mobile to lessen the chance of detection. Any centrifuge building was also located far from Libya's declared nuclear research site at Tajura, outside Tripoli. Periodically, the IAEA inspected the Russian-supplied reactor at this site. Qaddafi deliberately refused to sign the IAEA's Additional Protocol for fear that its more intrusive inspections would expose his secret centrifuge efforts. Under the Additional Protocol, inspectors could more easily access Libyan sites and demand information if they had any suspicions of undeclared nuclear materials or facilities.



Figure 3: Inside the Al Hashan site that held P1 centrifuges, although Libya did not enrich any uranium before the program ended in 2003. On left, feed and withdrawal equipment, and on right, rows of unassembled P1 centrifuges. Photo credit: CBS 60 Minutes.

²⁵ *Implementation of the NPT Safeguards Agreement*, February 20, 2004, op. cit..

²⁶ *Implementation of the NPT Safeguards Agreement*, June 1, 2004, op. cit.; and *Implementation of Safeguards Agreement of Libya*, February 20, 2008, op. cit.

In 2000, as part of its switch to P2 centrifuges, Libya received two sample P2 centrifuges from Dubai (see figure 4).²⁷ These centrifuges were part of a set of as many as nine that network members received for distribution to actual or potential customers.²⁸ Any good salesman would want to carry a sample of his wares as he visited customers, but no one had ever offered such samples to a customer—those which could assist in the building of a nuclear weapons production complex.



Figure 4: Two P2 centrifuge rotor assemblies. The one on the left shows a bellows in the middle of the tube and the pin of the bottom bearing, provided to Libya by the Khan network and subsequently sent to the United States. Photo Credit: NHK

Urs Tinner allegedly received two centrifuges at the family-owned company, Desert Electrical Equipment (DEE) Factory in Dubai, for shipment to Libya.²⁹ These centrifuges were not designed to operate; some of them could not do so without undergoing additional manufacturing steps. However, they contained all the parts and provided a detailed look at this sophisticated and secret centrifuge.

After the network was discovered in 2003, network operatives told the IAEA that it destroyed four of the centrifuges to hide evidence, although the IAEA could not confirm their destruction. In 1997, Iran

²⁷ *Implementation of Safeguards Agreement*, February 20, 2008, op. cit.

²⁸ German Prosecutor, *Preliminary Proceedings Against Anonymous on Suspicion of Treason by Delivering Gas Ultracentrifuge Technology to Libya*, Interview of Olli Heinonen, Trevor Edwards, and Mrs. Yonemara, Karlsruhe, July 2, 2004; Interview with a senior official close to the IAEA, April 30, 2005.

²⁹ German Prosecutor, *Preliminary Proceedings Against Anonymous on Suspicion of Treason by Delivering Gas Ultracentrifuge Technology to Libya*, op. cit.

may have received three P2 centrifuges.³⁰ Urs Tinner sold two of the assemblies to the United States in 2003 or 2004.³¹ If the reports are accurate--two centrifuges to Libya via Urs, three to Iran, and four destroyed, the nine centrifuges are accounted for. But the reports about the sale to Iran and the destruction of others by the network remain unconfirmed. Thus, a complete accounting of the nine original P2 assemblies is unfinished.

Khan had finally landed a major sale. Matuq placed an initial order for 5,000 centrifuges and later expanded it to 10,000 centrifuges, enough to produce highly enriched uranium for a sizeable nuclear arsenal. Libya would pay \$100-200 million for these centrifuges and associated equipment and materials.³² Key members of the network profited enormously. The sale to Libya represented the pinnacle of the Khan network's achievements.

Khan's sale to Libya far outstripped what Iran purchased. He was planning to sell everything Qaddafi needed to build tens of nuclear weapons. In the mid-1950s, the Soviet Union committed to giving its communist ally China all it required to build nuclear weapons, but it cancelled the deal when their relationship soured a few years later. Until Khan, no other country had received a comparable offer.

Making the offer even more remarkable was that it came from Khan's transnational network of businessmen, smugglers, money manipulators, and engineers--white collar criminals held together by the allure of large profits and fidelity to their leader.

Nuclear weapons are so destructive that even a small Libyan arsenal would have deterred a country from attacking it. Even the United States, with all of its thousands of nuclear weapons, and which had bombed Libya in 1986, would need to think twice before it launched a military strike. Qaddafi would have also gained an immense amount of prestige in the Arab world and could threaten his neighbors with impunity, though likely sparking a nuclear arms race in the area. He also would have been capable of spreading centrifuge technology to other countries. A Libyan nuclear arsenal would have had a profoundly destabilizing effect in the Middle East and in Europe.

³⁰ Michael Adler, "Iran May Have Received Advanced Centrifuges: Diplomats," Agence France-Presse. January 20, 2006. This information was from diplomats familiar with the interrogations of Tahir in Malaysia, where he had been held since his arrest there in 2004.

³¹ For more on the Tinner's relationship to the U.S. government and the CIA, see the forthcoming ISIS report, *CIA Recruitment of the Three Tinner's: A Preliminary Assessment*.

³² George Tenet, *At the Center of the Storm* (New York: HarperCollins Publishers, 2007), p. 296.

Khan had truly become one of the most dangerous men in the world. Or as George Tenet, former director of the Central Intelligence Agency (CIA), said, Khan was “at least as dangerous as Osama bin Laden.”³³

Turn-Key Centrifuge Plant

The Khan network needed to focus on providing Libya with a turn-key gas centrifuge facility, something typically reserved for states or large corporations in industrialized nations with full government support and knowledge.

In this case, Khan did not have the approval of the Pakistani government or military. Moreover, he lost his position at KRL in early 2001 over suspicion of proliferating. Even Khan in his own private and public confessions has not tried to claim government approval for the later endeavor.³⁴ Instead, Khan has sought to blame Tahir and others in the network, downplaying his own role to that of a distant observer. However, network members uniformly state, and evidence collected by the IAEA shows, that Khan played a leading role in the Libyan deal.

Some have raised Khan’s shipment of most of the P1 centrifuge components to Libya on Pakistani Air Force C-130 cargo aircraft as evidence of Pakistani governmental approval of Khan’s activities.³⁵ However, because of Khan’s special role using smuggling operations to develop Pakistan’s nuclear weapons, he had acquired tremendous autonomy to carry out official smuggling to supply the Pakistani nuclear program, allowing him to use the same resources to conduct his unauthorized proliferation deals.

Although Libya ordered 10,000 centrifuges, the planned centrifuge plant was designed to hold less than two-thirds of them; the rest were intended to be spares. This was not a wasteful strategy given the likelihood that Libyan technicians would break many of the centrifuges once the plant began operating.

³³ Douglas Jehl, “CIA Says Pakistanis Gave Iran Nuclear Aid,” *The New York Times*, November 24, 2004.

³⁴ In his confessions, Khan has claimed that the initial discussions and deliveries to Libya, dating back to the late 1980s and early 1990s, were carried out with the approval of Prime Minister Benazir Bhutto in conjunction with her aide, General Imtiaz, Bhutto’s former defense minister, and Dr. Z.K. Niazi, a confidante of both. All three individuals are deceased, and little reliable information exists on the origins of the Libyan deal. However, Khan’s efforts to act as if he was just following orders initiated at the highest levels of government should be viewed with a great deal of skepticism. He has also tried to implicate all three individuals in ordering the transfer of centrifuges to Iran. However, in this case, Khan’s claims contain major discrepancies at odds with both Iranian statements and documents given to the IAEA and IAEA findings about those transfers. This does not mean that Niazi’s involvement is excluded in the initial transfer of centrifuges to Iran in 1987, although Bhutto became Prime Minister only in 1988, after the initial transfers. More likely, Khan is the one who initiated and organized the centrifuge transfer to Iran in conjunction with European members of his procurement network, and similarly, for the centrifuge transfers to Iran in the 1990s and to Libya in the late 1990s and again in the mid-1990s.

³⁵ Interview with a senior official close to the IAEA, April 1, 2005.

The plant itself was designed to hold 5,832 P2 centrifuges in 38 individual cascades, all run by computers.³⁶ The plant would have four sets of cascades producing enriched uranium in stages up to weapon-grade:

- Twenty-four “C” cascades, each containing 164 centrifuges, for a total of 3,936 centrifuges, would in parallel enrich natural uranium to 3.5 percent enriched uranium.
- Eight “HC-01” cascades each containing 164 centrifuges, for a total of 1,312 centrifuges, would enrich the 3.5 percent uranium to 20 percent.
- Four “HC-02” cascades, each containing 114 centrifuges, for a total of 546 centrifuges, would in parallel enrich from 20 percent to 60 percent material.
- Finally, two “HC-03” cascades, each containing 64 centrifuges, for a total of 128 centrifuges, would enrich the 60 percent material to 90 percent, or weapon-grade.

The bulk of the enrichment effort goes into making the 3.5 percent enriched uranium, requiring 67 percent of the centrifuges. Each of these blocks of cascades has its own feed and withdrawal system. A small fleet of vehicles carries the canisters of uranium hexafluoride between the various stations.

This plant was designed to produce enough nuclear material for several nuclear weapons per year. A U.S. government expert on enrichment stated that the plant was designed to produce approximately 100 kilograms of weapon-grade uranium a year.³⁷ A simplistic estimate would lead to an annual production of about 150 kilograms of weapon-grade uranium per year.³⁸ This difference in estimates would result from choices made in the operation of the plant or from losses and inefficiencies in this particular design.

The amount of weapon-grade uranium Libya intended to use in each nuclear weapon can only be surmised. One indication was found in a Pakistani document seized by authorities from Khan network members. The document related to the manufacture of nuclear weapons. It detailed the rough casting of weapon-grade uranium metal hemispheres and the machining of the cast material into smooth, polished hemispheres.³⁹ These are the basic components of the core of an implosion-type nuclear weapon. Each rough hemisphere contained 15 kilograms of weapon-grade uranium, for a total of 30 kilograms. Once

³⁶ *Plea and Sentence Agreement, State vs. Geiges, Wisser, Krisch Engineering*, op. cit.

³⁷ *Affidavit of William Tobey*, U.S. Department of Energy, who represented the views of the U.S. enrichment expert, *Plea and Sentence Agreement, State vs. Geiges, Wisser, Krisch Engineering*, op. cit.

³⁸ This estimate assumes that each P2 centrifuge achieves about 5 separative work units (swu)/year, for a total of about 29,000 swu/year for all the centrifuges. Assuming the need for about 200 swu per kilogram of weapon-grade uranium, that size facility could produce about 145 kilograms of weapon-grade uranium per year.

³⁹ Interview with senior official close to the IAEA, November 18, 2005.

finished, the final two hemispheres would have 25 kilograms, the rest removed during machining and polishing.⁴⁰ This quantity is very similar to the amount of weapon-grade uranium, or 24 kilograms, in the nuclear warhead design supplied to Libya by Khan. Nuclear bombs can require less weapon-grade uranium; Iraq's 1990 design called for 15 kilograms of weapon-grade uranium. Thus, the Libyan program appeared sized to produce at least four nuclear weapons per year. For a country like Libya, this production rate was enough to create a formidable, albeit small, nuclear arsenal.

Dividing Up the Contract

After the initial agreement between Khan and Matuq in the Istanbul café in 1997, Khan called together the leaders of the network to divide up the enormous work of supplying the large centrifuge plant. Friedrich Tinner, Khan's long-time German colleague, Gotthard Lerch, Tahir, and Khan, agreed on who would supply various parts of the order.⁴¹ The exact date of this meeting is unknown, and Swiss court documents also mention a key meeting in 1998 in Dubai in which Khan "initiated another project with the purpose of helping Libya develop nuclear weapons."⁴²

Tahir, based in Dubai and Malaysia, was the coordinator of the project and key point of contact. If Khan was the president of this endeavor, Tahir was its managing director.⁴³ He often stated to investigators that he was not an engineer; instead, he administered the project and controlled its financing. He served as the contact between Khan, the main network contractors, and the Libyans, principally Matuq and Karim. He had the responsibility of managing this group of contractors, often not an easy feat.⁴⁴ When necessary, Tahir would go about contacting Khan for a decision.⁴⁵ Tahir would then relay the decision to the Libyans and contractors. The contractors sent progress reports to Khan and requested payments for their work. After approving the payments, Khan passed details to Tahir for making payments to the contractors. Tahir then contacted Matuq for payment.

Tinner was the principal contractor to produce the centrifuge components. Khan had spent years establishing an indigenous capability to make P2 components. Lacking government authority for the deal, he could not use this manufacturing infrastructure to supply P2 centrifuges to Libya. To fulfill this contract, Tinner involved his close knit family in this endeavor. Nonetheless, they would encounter

⁴⁰ Knowledgeable source who has seen the document, August 2006.

⁴¹ The division of responsibilities for supplying the Libyan order is from Tahir's statement, *op. cit.* and interviews with senior officials close to the IAEA.

⁴² Swiss Federal Court (Supreme Court), *Judgment*, Lausanne, October 9, 2007, translated from German.

⁴³ Interview with a senior official close to the IAEA, December 14, 2004.

⁴⁴ Interview with a senior official close to the IAEA, February 8, 2005.

⁴⁵ Interview with a senior official close to the IAEA, December 14, 2004.

numerous difficulties in filling this part of the order. The network made many modifications as it struggled to provide the more sensitive centrifuge components, and other members had to get involved in acquiring centrifuge components.

Lerch agreed to produce the feed and withdrawal units of the main centrifuge plant. He subcontracted this work to his experienced South African colleagues, Gerhard Wisser, Daniel Geiges and Johan A.M. Meyer.

Alguadis agreed to produce the frequency converters, and each was capable of powering about 200 centrifuges.⁴⁶ Gunes Cire, who was by then aided by his son Kursad, contracted to produce the centrifuge motors using designs supplied by Tahir.⁴⁷ He and his son agreed to obtain centrifuge ring magnets from European companies. Because of Turkey's proximity to Europe and its close economic relationship, the Cires had easy access to raw materials from European suppliers.

That Cire and Alguadis were still in business in the late 1990s was a surprise and a testament to the network's resiliency. It also reflected the failure of U.S. administrations in the 1980s and 1990s to stop them, rarely making a top priority the halting of the Khan network's illicit procurement efforts for Pakistan's nuclear weapons program. Cire and Alguadis were the target of the Reagan administration while they were supplying Pakistan's nuclear weapons effort in the 1980s. In the late 1980s, the Reagan administration threatened to cut off military and economic assistance to Turkey because of Cire's and Alguadis' exports to Pakistan's nuclear weapons program. Such a cutoff was required under the Glenn-Symington amendments, unless the sales stopped or the president issued a waiver. According to a former U.S. official, there was a tremendous fight over pressuring Turkey to stop the two men inside the U.S. government. Turkey was a key ally in the fight in Afghanistan against the Soviet Union, and many did not want to threaten that cooperation over Khan. Nonetheless, President Ronald Reagan raised the issue in 1988 in a tête-à-tête with Turkish President Kenan Evren, who admitted that "there had been nuclear enrichment exports from Turkey to Pakistan."⁴⁸ Evren added that his government had "decided to prohibit the export of such materials." Many U.S. officials chose to believe that the Turkish government stopped Cire's and Alguadis' sales to Pakistan's enrichment program.⁴⁹ However, that attempt failed, like so many others aimed at stopping Khan and his network, because the Turkish government did not follow

⁴⁶ Interview with a senior official close to the IAEA, May 13, 2004.

⁴⁷ Ilhan Tasci, "Nuclear Services to the Islamic World," *Cumhuriyet*, July 6, 2004.

⁴⁸ The White House, "Memorandum of Conversation, Meeting with President Evren of Turkey," June 27, 1988.

⁴⁹ See for example, Leon Fuerth, "Turkey, Nuclear Choices Amongst Dangerous Neighbors," *The Nuclear Tipping Point*, edited by Kurt Campbell, Robert Einhorn, and Mitchell Reiss (Washington, DC: Brookings Institution Press, 2004).

through on its commitment, and subsequent U.S. administrations had little interest in verifying that commitment.

Because centrifuges break and must be replaced, the Khan network also agreed to sell Libya the capability to make centrifuges. According to Tahir, Peter Griffin and his son Paul, of Gulf Technical Industries (GTI) in Dubai's Al Quoz Industrial Estate, were in charge of acquiring machines for a precision manufacturing workshop that would allow Libya to make its own P2 centrifuge components, variously called "Workshop 1001," or the "Machine Shop." Griffin has admitted that he was asked by Tahir to specify and supply machine tools for a general maintenance workshop in Dubai for the manufacture of spare parts and components for the oil and gas industry, but denies he knew it was for making centrifuge components. He says that he learned from Tahir only in 2002 that the workshop was actually for Libya. Tahir's statement in the South African court case states that all these contractors, including Griffin, "were fully aware that the equipment that they were supplying was for the Libyan gas centrifuge program."⁵⁰

In a brilliant stroke, Khan placed the network's logistical hub for the Libyan order in Dubai, thus leveraging its Jebel Ali Free Trade Zone.⁵¹ For years, this picturesque port had served as an important intermediate stop for Khan's illegal purchases for his own centrifuge program. Khan was a frequent visitor, maintaining an apartment in Dubai.

Any item in this zone was considered in transit and local authorities could search a facility in the zone only if they believed a crime had been committed.⁵² By using Dubai companies as false end users for an order, the Khan network complicated the ability of the authorities or suppliers to figure out the actual destination, which if discovered, would surely be grounds to deny a sale. Moreover, using Dubai as the end destination provided valuable deniability to the network's members. Today, Dubai is far less of a smuggler's free-for-all zone than prior to the arrest of Khan. Under U.S. pressure, the United Arab Emirates (UAE) has in recent years created trade control laws and significantly tightened their implementation.

Because of its importance, several Khan network members maintained companies in Dubai. Tahir's SMB Computers was a flourishing wholesale computer company that Tahir ran with his brother. Tahir's warehouse of computers was one hectare (100 meters by 100 meters).⁵³ His business was also a

⁵⁰ *Tahir statement*, op. cit., p. 7.

⁵¹ Interview with a senior official close to the IAEA, February 1, 2004.

⁵² Interview with a senior official close to the IAEA, June 26, 2004.

⁵³ Interview with a senior official close to the IAEA, November 3, 2004.

cover for illegal activities; a separate warehouse held the network's orders before Tahir re-routed them to Libya. Tahir was connected to a number of Dubai companies that would serve as false end users for the network's purchases. Once an order arrived at one of these companies, Tahir could take control of the goods and send them onward to Libya, Pakistan, or other countries. Tahir used a variety of companies to ship proscribed nuclear-related equipment to Dubai and then onward to Libya and other destinations. The IAEA identified at least six such companies.⁵⁴ A special benefit of operating in Dubai, network operatives faced almost no risk of being arrested by UAE authorities.

Other network operatives maintained companies in Dubai. As mentioned earlier, the close-knit Tinner family owned Desert Electrical Equipment Factory. Urs Tinner supervised operations there during the late 1990s and early 2000s. This small workshop was involved in manufacturing centrifuge components and in assembling and testing centrifuge parts.⁵⁵ The company further received goods, serving as a false end user, and arranged their transfer to Libya.⁵⁶ DEE also organized the training of Libyans in the manufacturing of centrifuge components and the balancing of centrifuge rotors.⁵⁷ Urs Tinner set up a test centrifuge component production facility that he also used to train Libyans.⁵⁸

One of Tahir's major responsibilities was paying members of the network, while hiding cash transfers from the authorities. He favored using third parties to make payments, reducing paper trails to Tahir and Khan. Tahir testified that he convinced two of his friends, Syed Fareed al Habshi and the Malaysian Shah Hakim Shahnazim Zai, to use their off-shore accounts to receive funds from the Libyans and then transfer the money to contractors.⁵⁹ According to Tahir, these accounts were located at a variety of financial companies, including Aisha Investments, Al-Hayat Investments, and Shorthill Capital, in Labuan, Malaysia, an international off-shore financial center. Other accounts were located at Perfect International and City Investment Off-Shore in Hong Kong, Shahzenin, at Oryz Trading in Dubai, and in Singapore. For an account that Johan Meyer opened at Credit Suisse in Switzerland, he assigned the Libyan project the code name "E-Projects." Tahir's two friends made deposits into this account from their off-shore accounts, listing this code name as the transfer's purpose. In what may have been a slip, a Libyan entity called National for Industrial Safety also made a payment into this account in its own name.

⁵⁴ Interview with a senior official close to the IAEA, June 26, 2004.

⁵⁵ Interview with a senior official close to the IAEA, June 26, 2004.

⁵⁶ *Nuclear Proliferation Network, Technology and Equipment Procurement*, undated chart produced by the IAEA.

⁵⁷ Interviews with a senior official close to the IAEA, May 13 and June 26, 2004.

⁵⁸ Interview with a senior official close to the IAEA, June 26, 2004; Swiss Supreme Court. *Judgment*, op. cit.

⁵⁹ *Tahir Statement*, op. cit.

Critical Classified Information

The secret to Khan's success was the detailed knowledge and deep experience he possessed. His personal library of centrifuge designs, detailed manufacturing manuals, and nuclear weapon designs was unprecedented.

At the heart of the Libyan centrifuge deal was a set of detailed centrifuge plans and drawings. These were based on Leybold Heraeus drawings and documentation of the enrichment process, combined with Pakistani centrifuge drawings and documentation, test results, experience, and calculations.⁶⁰ In total, they embodied highly classified information and years of experience. The architectural plans for the centrifuge plant were so complete that they contained instructions not only for where to put machines, but even where to put toilet paper in the bathrooms.⁶¹

Khan and his network associates realized that they needed to digitize key drawings and documents, making manufacturing and dissemination more practical. Unfortunately, this act greatly simplified the further proliferation of this dangerous knowledge. Because digital files are easy to hide and copy, few today believe that investigators have retrieved all these files.

Because Libya would put the centrifuges together, operate the plant, and build more centrifuges, it received an extensive set of centrifuge drawings and documents for both the P1 and P2 centrifuges. Libya received this information in electronic format, on a hard drive and compact discs, which it later turned over to the IAEA. One disc contained a full set of P1 centrifuge drawings, together with manufacturing, assembly, and test instruction manuals. A second disc contained similar data for the P2 centrifuge plant.

Despite receiving extensive centrifuge information, the Libyans still had many technical questions. To shield Khan and his Pakistani centrifuge experts, the network reportedly assigned Friedrich Tinner to collect the Libyans' technical questions and relay them to Khan for answers. This arrangement was not entirely satisfactory. Karim complained to the IAEA inspectors that he "never had a straight talk with real experts."⁶²

To give Libya a preview of the facilities it had purchased, Khan provided a KRL promotional video. I watched this video at IAEA headquarters in Vienna with a former URENCO centrifuge expert. The video showed a large cascade hall at KRL, which the expert estimated held between eight and ten thousand glistening P2 centrifuges. He thought these centrifuges were in cascades dedicated to making low enriched uranium, like the "C" cascades in the Libyan order.

⁶⁰ *Plea and Sentence Agreement, State vs. Geiges, Wisser, Krisch Engineering*, op. cit., p. 16.

⁶¹ Interview with a senior official close to the IAEA, February 28, 2004.

⁶² Interview with a senior official close to the IAEA, March 9, 2004.

Much of the video showed the manufacture of P2 centrifuge components in KRL workshops. The video showed skilled workers manufacturing thin-walled maraging steel rotors with a length of about 1,100 millimeters and then creating a bellows by crimping the rotor at its midpoint. Many specialized, computerized machine tools were making other high-precision centrifuge components. Additional computerized machines measured the parts to ensure that they had been machined precisely enough. The narrator said that the workshops could achieve an accuracy of one-tenth of a micron, which is roughly 100 times smaller than the diameter of a human hair. The centrifuge expert thought that most equipment looked like it was purchased in the early 1990s. Its age would mean that Pakistan would have needed to replace or upgrade it by now. Undoubtedly, Khan and KRL had acquired much of this equipment under false pretenses from abroad.

Transnational Supply Chain

Obtaining their first major order was one thing. For the A.Q. Khan network, filling the Libyan order was another. Building a centrifuge plant with 10,000 centrifuges required the production of more than one million high-precision components, many with subcomponents—a huge undertaking. The plant needed an elaborate feed and withdrawal system with miles of piping operating under vacuum, where even a small hole could cause immense damage to the centrifuges.

For the Khan network to even try this colossal endeavor required hubris. They would have to accomplish a feat similar to that of building a centrifuge plant comparable to an early URENCO facility, but in secret and with a complicated set of suppliers and manufacturers stretched out over several continents. From the order, through procurement and production, to shipment, members of the Khan network had to collaborate closely. They had to oversee the movement and storage of raw materials, equipment, and manufactured items in Asia, Africa, and Europe, while managing a complex network of businesses and people.

Because of the immense task involved in such an effort, many experts and government officials concluded falsely that a Khan-type transnational network could never build an enrichment plant. In the 1980s and 1990s, this disbelief gave Khan an advantage as he created the wherewithal to defy official expectations.

Financial resources were no obstacle; Libya had essentially unlimited funds to buy the facility. The Tinnors referred to the deal as a “cash cow.” If the quoted price suddenly increased, or major delays in finalizing the project occurred, Qaddafi was not in a strong position to complain. In the off chance Qaddafi sought to retaliate against a few of the Khan people, the others could reveal the program to the world, with likely dire consequences for Libya. Qaddafi would have to accept delays and changes in the offer, all at a high financial cost.

On balance, the Khan network had a realistic chance of succeeding in supplying Libya. It was well-seasoned in working together to supply Pakistan’s centrifuge program, with many of its manufacturing operations located off-shore. Khan had created this supply chain in the 1970s, and by the late 1990s, its members had accumulated extraordinary nuclear trafficking skills. They had also weathered many investigations and prosecutions, making them more confident that they could succeed. Finally, the Libyan order was for a plant that was a duplicate of what they had already created at KRL. They could make the plant the second time around more easily, and likely with an increased profit.

Easing its task, the Khan network benefited from technology's continuing improvement and its spread throughout the world by the late 1990s. It was becoming easier to obtain the materials, components, and equipment for a centrifuge plant. More countries, many of which were dismissed as developing nations, had sophisticated manufacturing and machine tool capabilities that Khan's experts could exploit to fill the Libyan order in secret. John M. McConnell, then-Director of National Intelligence, testified before the Senate Armed Service Committee on February 27, 2007: "The time when only a few states had access to the most dangerous technologies has been over for many years. Dual-use technologies circulate easily in our globalized economy, as do the scientific personnel who design and use them."⁶³ The Khan network was one of the first to recognize this new reality and exploit it at a time when few understood the threat it posed to world security.

By the time the Khan network was finally disrupted in 2003, it had not finished providing Libya with a gas centrifuge plant. Yet what they had already accomplished was impressive and should serve as a warning. To better understand their accomplishments, the network's step-by-step progress is charted here. The details show the porous nature of export controls on parts and equipment acquired by the network, and the difficulty of detecting Khan-type networks. Unfortunately, despite some reform, export controls remain woefully inadequate and the detection of new networks uncertain.

⁶³ Statement of John M. McConnell, Director of National Intelligence, Senate Armed Services Committee, February 27, 2007.

Manufacturing Centrifuge Components

The network's priority was organizing the manufacture of the P2 centrifuge components. As mentioned earlier, Khan could not order them ready-made in KRL's workshops, and surplus P2 centrifuges did not exist. To supply the Libyan order, the network had to make the centrifuge components outside Pakistan.

Top members of the network had many discussions about making the components, leading to troubleshooting and modifications as problems developed. Although others would play important roles in making components, according to Tahir's testimony, the three Tinners had primary responsibility for manufacturing them. Over the years, Khan had often visited the Tinner family at their home and developed a high regard for Friedrich. He trusted the close-knit family to produce this key part of the Libyan order.

A centrifuge is composed of rotating and non-rotating parts. Although the non-rotating components require precise machining and have stringent tolerances, they are easier to make than those that rotate. These components, such as the rotor and bellows, must withstand spinning at high speeds and be precisely machined and balanced (see figure 2, page 3). In addition, many components are actually comprised of several smaller pieces that must be carefully assembled. Sometimes assembly is complicated and requires the creation of final assembly workshops. This in turn necessitates coordination among those responsible for each subcomponent.

Overall, the IAEA thought that the network had a well-organized, sophisticated plan to produce the non-rotating components, but not a proven plan to make the critical rotating components.⁶⁴ One shortcoming in the entire effort was the schedule of delivery of the parts. It was more of an aspiration than a fixed schedule, according to a senior official close to the IAEA. Many parts arrived late in Libya, but the delays did not cause much friction. Libya was delayed in setting up its P1 centrifuges, and thus was not yet ready to start assembling the P2 centrifuge plant.⁶⁵

To make many of the components, the Tinners used their family-owned companies, including PhiTec AG, Cemeq AG, and Traco Schweiz AG, based in eastern Switzerland. Friedrich was the unchallenged patriarch of the family; Urs and Marco carried out most of their family's obligations under

⁶⁴ Interview with a senior official close to the IAEA, February 28, 2004.

⁶⁵ Interview with a senior official close to the IAEA, February 28, 2004.

the Libyan deal. Friedrich's wife, daughter, and her husband, also worked in the family businesses.⁶⁶ They were mostly involved in the more routine day-to-day operations of the companies.⁶⁷

Friedrich operated PhiTec, which sold engineering services, vacuum valves, and vacuum systems, according to its website. Cemeq was a partner company of PhiTec. In addition to helping outfit Libya's and Pakistan's nuclear programs, in the 1980s and early 1990s, Friedrich filled orders for the Iraqi gas centrifuge program, selling piping and valves. He even sold some goods after Iraq's invasion of Kuwait in August 1990 and the imposition of a U.N. Security Council embargo. According to Mahdi Obeidi, the former head of Iraq's gas centrifuge program, Tinner provided valves and piping for a 50-machine cascade that Iraq was building as part of its secret program to build nuclear weapons. But because of the embargo and the war, these items were detained in Jordan, where U.N. inspectors eventually discovered them. Friedrich was never prosecuted since the items did not reach Iraq.

Marco, based in Switzerland, focused on the deliveries and financial aspects of the order for the family. He ensured that payments were made and goods dispatched. He himself ran Traco Schweiz and Traco Group International, which were mainly import/export businesses.

Urs was a competent technician. His father asked him to go to the United Arab Emirates in 1998 to help with the family business. He settled in Ajmaan, the emirate next to Dubai, where he began running the family's overseas operations to supply Libya.

Because family members were dispersed and often traveled, they needed a secure way to communicate. They became adept at encrypting their electronic communications, even double coding their messages.⁶⁸ Olli Heinonen, the IAEA's lead investigator of the Khan network, learned of the Tinnert's encryption methods while he was interviewing them in early 2004; he contacted many members of the Khan network and the Tinnert were cooperative. During an early meeting in Malaysia, the Tinnert asked him to encrypt his communications with them. They told him to buy a new novel by Robert Goddard, *Play to the End*, a crime novel set in Brighton, Britain about a local businessman whose wealth might be from shady, past practices conducted by his family business. Heinonen received instructions to go to a certain page, line, and character in the book, and build up an encryption key. This method, which dates to World War II, led to the first level of encryption. Then, the text was further coded using well-known, commercially available PGP (pretty good protection) encryption software.

⁶⁶ Interview with a senior official close to the IAEA, January 20, 2006.

⁶⁷ Interview with a senior official close to the IAEA, January 20, 2006.

⁶⁸ Interview with a senior official close to the IAEA, August 2008

The Tinnars were early users of the Internet to store secret data, placing important documents and files on remote Internet servers. They also used complicated passwords and account names to further disguise their data.

To order parts, the Tinnars received complete sets of centrifuge drawings and manufacturing manuals from Tahir.⁶⁹ They digitized these drawings in order to produce computer-aided design (CAD) drawings. This step allowed the Tinnars to produce digital engineering drawings, which were easier to change and share among themselves and manufacturers. Because modern machine tools are automatic and depend on computers programmed with precise instructions, the Tinnars also needed to produce digitized engineering drawings for the manufacturers of the components. These digitized drawings had other advantages—storage and dissemination was far easier, and the Tinnars could also more easily change the drawings. They erased any traces on the original drawings that could expose Pakistan or Khan as the source. Between 1998 and 2000, Marco’s company made modifications to the drawings aimed at making the manufacture of specific parts easier.⁷⁰ In the process, the Tinnars created their own numbering system for each set of drawings, which also served to hide the true purpose of the components from manufacturers. Yet, the Tinnars were not centrifuge experts. They likely had an incomplete understanding of centrifuges, although they possessed the knowledge and skills to make individual components. As a result, each time they changed a centrifuge drawing, they sent the new drawing to Khan for approval.⁷¹

The Tinnars made some of the centrifuge components in Switzerland, but many of them could not be made there without undue risk of detection. The network needed to find a workshop in another, more amenable country.

Malaysian Workshop

An opportunity developed in Malaysia, a stable country without export controls and an ambitious and growing high-tech sector.⁷² Beginning in the mid-1990s, Khan’s associate Tahir had cultivated key social and business relations in Malaysia. In late June 1998, he married the daughter of a former Malaysian diplomat in a lavish wedding, and Khan, who often treated Tahir as a son, was an honored

⁶⁹ Interviews with senior officials close to the IAEA, February 20, 2004 and August 21, 2008.

⁷⁰ German Prosecutor, *Preliminary Proceedings Against Anonymous on Suspicion of Treason by Delivering Gas Ultracentrifuge Technology to Libya*, op. cit.

⁷¹ Interview with a senior official close to the IAEA, August 21, 2008.

⁷² Alan Sipress, “Key Player in Nuclear Trade Ring Found Hospitable Base in Malaysia,” *The Washington Post*, February 24, 2004.

guest and a celebrity in the wake of Pakistan's nuclear tests just one month earlier.⁷³ Important members of the network, including Dutch colleague Henk Slebos, Griffin, and several senior KRL officials, also attended the wedding and were feted for several days by Tahir.

Tahir mixed with Malaysia's elite, growing close to Kamaluddin Abdullah, the son of future Prime Minister Abdullah Ahmad Badawi. Kamaluddin appointed Tahir as director of his privately held investment company. Later, Tahir's wife replaced her husband on the board. Kamaluddin's investment company, in turn, controlled the majority share of Scomi Group, a respected Malaysian chemical, oil, and gas trading and manufacturing company poised to expand its business in Thailand, Myanmar, Qatar, and the UAE. Its Chief Executive Officer was Shah Hakim Shahnazim Zai, Kamaluddin's school classmate, and the other major shareholder and co-founder of Scomi Group. Tahir said that Shah Hakim later helped him disguise payments from Libya to the network's contractors.

In the first half of 2001, Tahir brokered a two-year, \$3.42 million contract with Scomi Group for the manufacture of 14 centrifuge components. This contract represented, at the time, 26 percent of Scomi's total turnover; another 12 percent was for Malaysia's Ministry of Defense.⁷⁴ The contract was ostensibly between the Scomi Group and Gulf Technical Industries, although Griffin says he was unaware of the order. Khan has said that Tahir and Griffin had an earlier falling out in the late 1990s.⁷⁵ It is likely that Tahir surreptitiously used GTI's logo to hide his or the actual customer's involvement.

Scomi did not have the facilities to make all 14 of the components, and it needed to create a new workshop. The company obtained a single story, 33,000-square foot production facility in an industrial park in Shah Alam, twelve miles southwest of Kuala Lumpur.⁷⁶ The company was initially called Prisma Wibawa Sdn. Bhd., before being renamed Scomi Precision Engineering Sdn. Bhd., or SCOPE for short, in December 2001. SCOPE's roughly 30-strong workforce, under General Manager Shamsul Bahrin Rukiban, was excited about the contract and optimistic that more work would follow the initial contract.

Urs moved to Malaysia in 2001 to help set up the workshop. Tahir remained active at SCOPE, making key decisions about orders and authorizing payments. He also oversaw the production of the components, becoming a full-time technical consultant to SCOPE in April 2002.⁷⁷ Urs contractors

⁷³ Abdul Mabood Siddiqui, *Timbuktu, City in the Middle of Nowhere* (Islamabad: Hurmat Publications, undated), p. 16 and pp. 48-50.

⁷⁴ Isa Ismail, "28 April 03: Brokers' Digest," *The Edge Daily*, web site, assessed November 3, 2005, www.theledgedaily.com.

⁷⁵ E-mail interview with A.Q. Khan by Urs Gehrigler, *Weltwoche*, Published January 2009, <http://www.weltwoche.ch/ausgaben/2009-04/artikel-2009-04-interview-khan-english-version.html>.

⁷⁶ Raymond Bonner and Wayne Arnold, "Business as Usual at Plant That Tenet Says was Shut," *The New York Times*, February 7, 2004.

⁷⁷ Testimony of Thorsten Heise, Gotthard Lerch Trial, Summary of testimony, 11th day, Mannheim, Germany, June 20, 2006.

referred to Tahir as the “sponsor.” According to one contractor, Tahir and Urs did not get along, and Tahir treated Urs in a condescending manner.⁷⁸

Urs had to procure high-precision machine tools for the new workshop, preferring well-known European and Japanese suppliers.⁷⁹ Swiss investigators learned in 2004 that Traco Schweiz sent SCOPE several pieces of manufacturing equipment in 2001 and 2002. The Japanese company Mitutoyo sold SCOPE six precision measurement machines, at least one of which ended up in Libya’s gas centrifuge program.⁸⁰ The machines from Traco Schweiz were used to cut and shape parts, while the Mitutoyo machines would measure the dimensions of a piece with great accuracy, ensuring that the part was acceptable to use in a centrifuge.

Aluminum Pre-Forms

To make these non-rotating components, Urs had to find a supplier for over one hundred thousand raw aluminum tubes and rods, or “pre-forms.” Each piece corresponds in length and width to the finished centrifuge part. The high-precision machines would cut and shape these pre-forms into their finished form.

Urs found a reliable aluminum supplier in Thorsten Heise, who had just established Bikar Metal Asia Pte Ltd, a Singapore subsidiary of the German metal dealer Bikar Metal. Urs believed that Bikar Metal would supply higher quality aluminum than Malaysian companies.⁸¹ In the fall of 2001, Rukiban and Urs, representing Prisma Wilbawa, signed a series of sales agreements worth over \$1.5 million with Bikar Metal Asia for a large order of pre-forms. Based on hundreds of pages of documents describing these deals seized by investigators and obtained by ISIS, many of the aluminum pre-forms came in lots of 10,100 pieces, corresponding closely to Libya’s order of 10,000 centrifuges.⁸² Several of the documents can be accessed [here](#). Bikar Metal Asia acquired these pre-forms from at least four companies: its German parent company, the Swiss sales agent Aluminum Silicon Mill Products (ASMP), representing the SUAL group of Russian aluminum producers, the Slovakian producer Impol, and an unknown Italian

⁷⁸ Testimony of Thorsten Heise, op. cit.

⁷⁹ German Prosecutor, *Preliminary Proceedings Against Anonymous on Suspicion of Treason by Delivering Gas Ultracentrifuge Technology to Libya*, op. cit.

⁸⁰ “Malaysian Firm Denies Nuclear Black Market Role,” *TodayOnline*, September 15, 2006; Kyodo, “Mitutoyo Exported 10,000 Devices Since 1995, Most of them Illegally,” August 31, 2006.

⁸¹ David Crawford, “How a Nuclear Ring Skirted Export Laws,” *The Wall Street Journal*, March 22, 2004.

⁸² Susan Basu, “Transactions of Bikar Metal Asia and Scomi Precision Engineering, 2001-2002,” ISIS memorandum, undated, based on internal Bikar Metal documents.

company.⁸³ Many of the shipments went to Singapore, some by airline but most by sea, and then were shipped by sea to Malaysia. A company called KUMZ, a member of SUAL, sold SCOPE about 300 tonnes of aluminum tubes slated for the outer casings, which was Urs' single biggest purchase. The tubes, valued at about \$1 million, traveled to Singapore and then to SCOPE during 2002.⁸⁴ The outer casing contains the spinning parts of a centrifuge, the rotor assembly. Spinning at speeds that exceed the speed of sound, a rotor that fails can explode into deadly shrapnel that must be kept inside the centrifuge to prevent injury to anyone nearby. The casing's nearly one-inch thick wall contains that shrapnel.

Urs wanted commissions from Bikar Metal for arranging these orders, in essence getting paid twice for making the components. First, he received money for making the parts and then again for arranging the supply of raw materials for these parts. In an office next to Bikar Metal Asia, Urs and Heise together founded the company Engineering-Trading-Asia-Consulting (ETAC).⁸⁵ Heise described that for a while, one purpose of ETAC was to funnel commission payments to Urs for his orders to Bikar Metal Asia.⁸⁶ Later, IAEA inspectors believed that ETAC started to make parts of vacuum valves.⁸⁷ Indeed, ETAC participated in a vacuum equipment sales exposition in Germany in 2004, sharing a booth with PhiTec.

After receiving the aluminum pre-forms, Urs used the digitized centrifuge drawings to program SCOPE's newly imported computerized machine tools. For security reasons, he removed any design information from the machine after the component was finished.⁸⁸ Figures 5 and 6 show the aluminum outer casing and the casing with a molecular pump inserted inside.

⁸³ "Transactions of Bikar," op. cit. ASMP is a marketing representative for a Russian group of companies.

⁸⁴ Bikar Metal Asia Pte Ltd, Transaction for Al tubes, Al 6061, 168 mm inner diameter, data table prepared by ISIS, undated.

⁸⁵ Summary of testimony of Thorsten Heise, op. cit.

⁸⁶ Summary of testimony of Thorsten Heise op. cit.

⁸⁷ Interview with a senior official close to the IAEA, December 11, 2007.

⁸⁸ 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, http://www.rmp.gov.my/rmp03/040220scomi_eng.htm.



Figure 5: Outer casing of P2 centrifuge made at SCOPE in Malaysia.

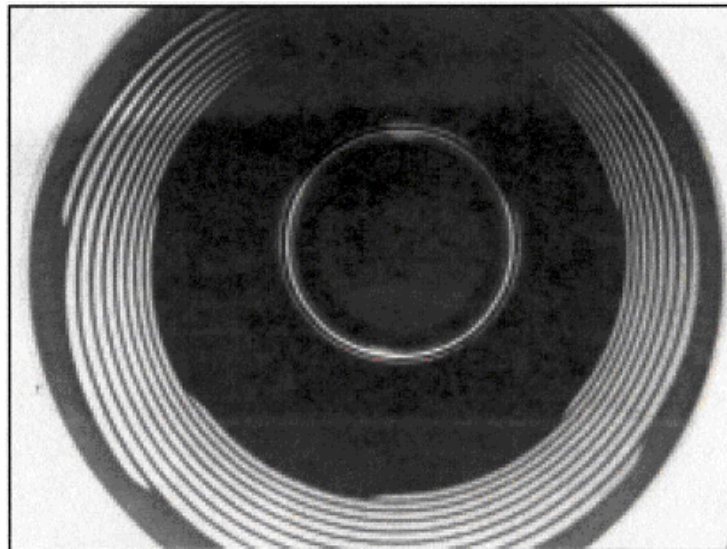


Figure 6: Bird's Eye View of the Interior of P2 Casing and Molecular Pump

Because each part was made to exacting standards, it had an ID number and underwent quality assurance to make sure that the part met the required standards.⁸⁹ The components were then carefully packed in boxes with a packing slip.⁹⁰ They were sent to Libya via Dubai in four separate shipments from December 2002 to August 2003.

Most of the aluminum is believed to have ended up in finished parts. However, questions remain about the fate of pre-forms not turned into components. A European intelligence agency that also obtained a copy of the seized documents concluded that investigators have not accounted for about 10,000 pieces, or about five to ten percent of the total. Were these leftover pre-forms destroyed by the network? Or did they end up in the hands of other customers?

Urs also contracted with Bikar Metal for other metals, such as copper-beryllium bar and stainless steel. The copper beryllium was intended for the cup used in the bottom bearing to hold the pin and ball assembly for a centrifuge. SCOPE did not make this part; it is unclear who was to make this component.

Urs also procured aluminum pre-forms from Bikar Metal for a nearby Malaysian company. In this case, the component was the rotor tube of the P1 centrifuge and required high strength aluminum normally subject to export controls. This order was part of Libya's order of 200 P1 centrifuges. (Each P1 centrifuge has four thin-walled rotor tubes connected by three bellows.) Because Pakistan had stopped making P1 centrifuges a decade earlier and scrapped most of them from its enrichment plants, it no longer had enough surplus ones to fill the Libyan order. In 2002, Bikar Metal sent 1,200 high-strength aluminum tubes, graded "7075-T6," to the Malaysian company to make 800 rotor tubes. The company used an inefficient process to thin the wall of the tubes, leading to large losses, explaining why so many extra tubes were ordered. The 800 finished rotors were delivered to Libya via Dubai; almost all the other P1 components arrived in Libya from Pakistan by airplane.⁹¹

Someone may have disguised the shipments of 7075 aluminum tubes to Malaysia. One likely reason is that depending on their origin, these tubes might have required an export permit, which could have increased official scrutiny. Internal Bikar Metal records from the collection in ISIS's possession suggest that documents required by customs may have been altered to hide the fact that the shipment involved controlled aluminum. An invoice from Bikar Metal Asia to Scomi lists these tubes as 7075 grade; another invoice, explicitly marked CUSTOMS, lists these tubes as grade 6082, a type that did not

⁸⁹ Interview with a senior official close to the IAEA, January 9, 2004.

⁹⁰ Interview with a senior official close to the IAEA, January 6, 2004.

⁹¹ Interview with a senior official close to the IAEA, April 1, 2005.

INSTITUTE FOR SCIENCE AND INTERNATIONAL SECURITY

require export approval.⁹² With this exception, all other items on this invoice have the same dimensions and alloy types as the main invoice. A typed packing list from Bikar Metal to Scomi matches the invoice marked CUSTOMS. An unknown person checked off each item on the list and hand wrote “7075” alongside each line that listed these tubes as 6082. Also, the same hand appears to have made an informal packing list and recorded these tubes as alloy 7075.

⁹² Susan Basu, “Bikar Metal Asia Pte Ltd, Transaction for Al tubes, 106mm OD, Alloys 6082 and 7075” ISIS, undated.

Kirag

Back in Switzerland, the Tinnens were organizing the production of another 30 centrifuge subcomponents. A document obtained by ISIS labeled an “order confirmation,” dated May 30, 2001, from Traco Schweiz to Gulf Technical Industries in Dubai, lists all of these parts. The invoice lists each part’s number ranging from 9001 to 9084, based on the Tinnens’ numerical identification of each drawing, the number required--typically 10,000--and a unit price for each part.⁹³ The total order was valued at 3.0 million Swiss francs, or about \$2.5 million at the time. Like in the case of the Scomi contract, GTI probably had little to do with this contract.

Each part is difficult to identify solely from the invoice, but another document obtained by ISIS, a statement by Marco to Swiss investigators, contains the drawings of each component and their part numbers. According to European centrifuge experts, these drawings included centrifuge feed and extraction system components, including the scoops, and subcomponents of the bottom bearing.

Almost all of the drawings are dated as to when someone modified or checked them. These dates range from January 2001 to January 2002. A majority of the drawings were checked or reviewed on September 20, 2001, as if they were finalized for manufacturing on that date. These notations also support that the Tinnens had digitized the drawings to ease the parts’ manufacture.

The Tinnens selected the Swiss firm Kirag, a machine workshop in Chur, to make most of these components. In late 2001 and early 2002, the Tinnens arranged for Bikar Metal Asia to ship aluminum pre-forms to Kirag.

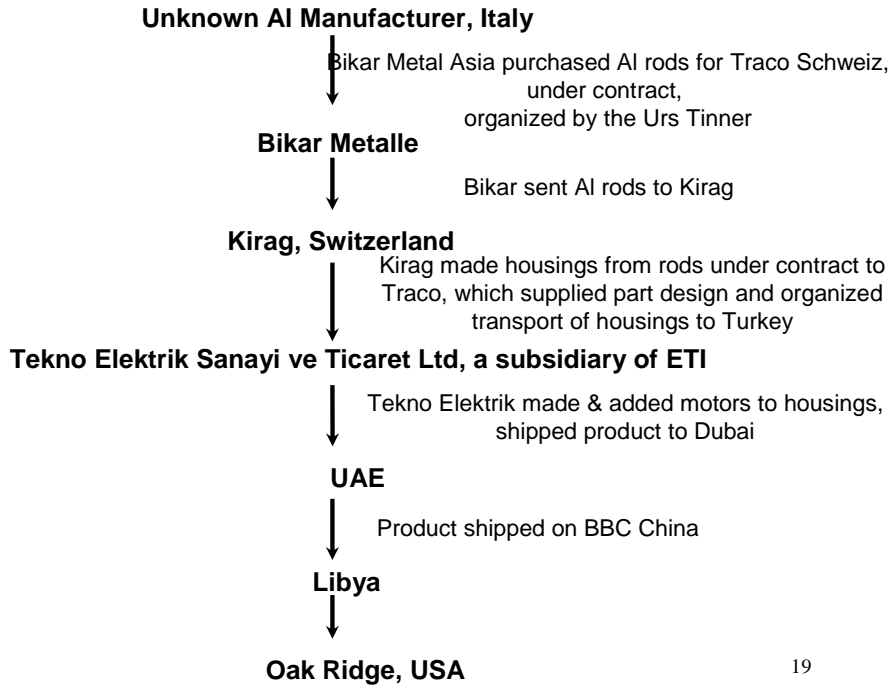
One major component made at Kirag was part 9003, called the motor housing (see figure 7). This part is in the bottom of the centrifuge and holds the motor that turns the centrifuge. Urs arranged for two shipments of about 1,000 of this part’s aluminum cylindrical pre-forms to Malaysia in November 2001. Subsequently, he ordered Bikar Metal Asia to send several more shipments with about 8,000 additional aluminum cylindrical pre-forms directly to Kirag through April 2002.⁹⁴ The source of the aluminum is difficult to determine from the seized documents, but it was likely from Russia.⁹⁵ Bikar Metal sent invoices for these pre-forms, totaling about \$270,000, to Marco at Traco Group International in Vaduz, Liechtenstein, a country with notoriously weak banking laws susceptible to exploitation by money launderers. The money had arrived earlier to pay for these deliveries. Between late May and the end of

⁹³ One drawing is numbered 200 015, which is an earlier number system used by the Tinnens. It became part 9015.

⁹⁴ Table prepared by ISIS from Bikar Metal Asia documents listing all quotations, invoices, and deliveries of the motor housing pre-form (210 mm outer diameter, height 105 mm).

⁹⁵ Memorandum from Bikar Metalle GmbH to Bikar Metal Asia, September 9, 2001; Martin Stoll, “On the Radar of the CIA,” *FACTS*, March 10, 2005 (translated from German).

Motor Housings and Motor for the Libyan Centrifuge Program



19

Figure 8: Supply chain of the motor housing and its associated motor produced by the Khan network.



Figure 9: President George W. Bush at Oak Ridge, Tennessee holding a finished motor in the aluminum housing which was turned over by Libya (motor is white object visible on the bottom of the housing). Source: White House website

Other components were shipped to SCOPE and Dubai. In late 2001, Traco sent several subcomponents to Al Khadar Technologies Est. in Dubai, according to Swiss investigations. One part, 9010, was a spring used in the bottom bearing. However, when Urs examined the part in Dubai, he discovered that an error had occurred during manufacturing and subsequently discarded the part. A replacement order was unfinished when the network's activities halted in 2003.

In July 2002, Traco Schweiz shipped by air freight to SCOPE twelve types of subcomponents. Some of the components looked like bottom bearing subcomponents. By the time the network was busted in late 2003, the Swiss order was unfinished.

The Tinnars did not make all the components of the centrifuges. Cire and Selim Alguadis obtained most of the magnets from the German firm Tridelta in Dortmund.⁹⁷ Media reports said that they bought 40,000 ring magnets, sending half to Dubai and the other half to Pakistan.⁹⁸ Two ring magnets are used in the centrifuge's upper bearing and help hold up the centrifuge rotor; thus each country obtained enough for 10,000 centrifuges. Before using them, someone would have had to magnetize them and put them into magnet holders. The magnets and a magnetizing device were delivered to Libya, implying that Libya would have needed to finish this upper bearing component itself.⁹⁹

Centrifuge Rotor Tubes

The Tinnars were having trouble manufacturing the rotating components of the centrifuge. In particular, they could not make the thin-walled maraging steel rotor tubes for the P2 centrifuge.

The network originally considered creating a workshop in Dubai to manufacture the rotors but dropped this proposal because the workers were not up to it, according to a senior official close to the IAEA.¹⁰⁰ Next, Turkish companies with easy access to raw materials from Europe and Russia were considered and rejected. Their work force was also not sufficiently skilled.

According to Tahir, Khan asked Lerch to try to make the rotors.¹⁰¹ In 2000, Griffin had purchased in Spain two specialized machine tools called Denn flow-forming machines that could make rotor tubes. Bought for Workshop 1001, these machines were shipped to Dubai. Lerch asked Tahir to obtain one of

⁹⁷ Ilhan Tasci, "Turkey Nuclear Bridge," *Cumhuriyet*, July 6, 2004.

⁹⁸ Public Affairs Office of U.S. Embassy Ankara, "PAO Ankara Turkish Press Summary 08 Dec 05," December 8, 2005. Original source, *Cumhuriyet*.

⁹⁹ Interview with a senior official close to the IAEA, February 23, 2005.

¹⁰⁰ Interview with a senior official close to the IAEA, December 11, 2007.

¹⁰¹ *Tahir Statement, op. cit.*

the machines from Griffin and ship it to South Africa, where Lerch's colleague Meyer, who owned the company Tradefin, had agreed to try to make the rotor tubes. Tahir shipped the other flow-forming machine to Libya. To deceive South African customs inspectors, Lerch provided Meyer's boss Wisser with export documents that undervalued the worth of the flow-forming machine tenfold and falsely called it a lathe.¹⁰² The machines arrived at Tradefin in late 2000. Wisser said that he received a hard drive from Lerch that contained information on making the P2 rotors.¹⁰³

Wisser or Meyer asked a former manufacturer of maraging steel rotor tubes for South Africa's centrifuge program to supply maraging steel and technical assistance in making the rotor tubes.¹⁰⁴ However, the expert turned them down. Undeterred, for four months, Meyer kept proposing various methods to make the rotor tubes. Lerch, however, indicated that Meyer was too expensive, and the project ended.

Lerch instructed Wisser to return the flow-forming machine to Dubai; it arrived in early 2002.¹⁰⁵ Before dispatching the operating documentation for the machine to Dubai, Wisser updated Tahir in code: "The gift has been dispatched with DHL."¹⁰⁶

Urs Tinner then wanted to try his hand at making the tubes; he considered making several other rotating components as well.¹⁰⁷ Tahir directed that the flow-forming machine be shipped to Malaysia. A senior official close to the IAEA believes that the machine tools already at SCOPE could have made many of the other rotating components, such as end caps. But Urs was also unsuccessful at making the rotor tubes, and he returned the flow-forming machine to Dubai. Afterwards, Tahir sent it to Libya.¹⁰⁸ By the end of the program in 2003, Libyan officials said that they had not made any rotors using the two machines.

¹⁰² *Plea and Sentence Agreement, State vs Geiges, Wisser, Krisch Engineering*, , op. cit., p. 19, Annexures P, Q, and R.

¹⁰³ In the High Court of South Africa, *Plea and Sentence Agreement, State vs Geiges, Wisser, Krisch Engineering*, op. cit., p. 19.

¹⁰⁴ Interview with a senior official close to the IAEA, August 22, 2006.

¹⁰⁵ *Plea and Sentence Agreement, State vs. Geiges, Wisser, Krisch Engineering*, op. cit., p. 19.

¹⁰⁶ In the High Court of South Africa, "Summary of Substantial Facts," *Indictment, The State vs. Geiges and Wisser*, undated.

¹⁰⁷ Interview with a senior official close to the IAEA, August 22, 2006.

¹⁰⁸ *Tahir Statement*, op. cit.

Feed and Withdrawal System

Khan appointed Lerch to make the feed and withdrawal system.¹⁰⁹ Lerch supplied Khan with progress reports and payment schedules. Lerch's profit from this project was at least 3.5 million Euros, or about \$3 million at current exchange rates.¹¹⁰

In July 1999, Lerch met Wisser in Dubai, informing him about the new project, although he did not tell him that the client was Libya until late 2001 or early 2002.¹¹¹ Wisser agreed to be the prime contractor responsible for procuring all the necessary goods and manufacturing the feed and withdrawal equipment for the enrichment plant.¹¹² Tahir provided Wisser with all the designs and data necessary to manufacture the systems. He sent centrifuge drawings, cascade designs, calculations on producing weapon-grade uranium, Pakistani data about the time necessary to produce a specified amount of weapon-grade uranium using P1 and P2 centrifuges, and information on converting weapon-grade uranium into nuclear weapon components. Some of the documents from Pakistan had Khan's signature.

Wisser appointed Meyer as his key manufacturer and assigned Geiges as the chief engineer of the project. As the work progressed, Wisser updated Lerch and Tahir, who informed Khan.

Meyer and Wisser obtained much of the equipment and materials locally. To obtain sensitive equipment overseas, Meyer established a front company in Switzerland. He bought vacuum pumps from the Spanish company Telstar and measuring equipment in Germany.¹¹³

Wisser involved Len Harvey, a consultant to Krisch Engineering, in initial designs of the feed and withdrawal system. Later, Harvey agreed to make specialized measurement equipment for use in these centrifuge cascades.¹¹⁴ Wisser and Geiges had both failed in their attempts to buy this equipment overseas. The price was higher than budgeted for this equipment. They also were unprepared to risk discovery by asking for an export permit, something that the supplier insisted upon. Requests for this type of measurement equipment, namely flow meters and pirani gauges suitable for use with gas centrifuge cascades, can lead to probing questions from supplier governments.

Meyer contracted Andre Smit, a local engineer, to make equipment to allow the computerized control of the plant. But they needed to create the electronic interface between their system and the

¹⁰⁹ *Plea and Sentence Agreement, State vs. Geiges, Wisser, Krisch Engineering*, op. cit., p. 11.

¹¹⁰ Judge Juergen Niemeyer, "Oral Summary of Judge in the Sentencing of Gotthard Lerch," October 16, 2008.

¹¹¹ *Plea and Sentence Agreement, State vs. Geiges, Wisser, Krisch Engineering*, op. cit., p. 11 and 13.

¹¹² *Plea and Sentence Agreement, State vs. Geiges, Wisser, Krisch Engineering*, op. cit., p. 11.

¹¹³ *Plea and Sentence Agreement, State vs. Geiges, Wisser, Krisch Engineering*, op. cit., p. 15.

¹¹⁴ "Summary of Substantial Facts," *Indictment, The State vs. Geiges and Wisser*, op. cit.

centrifuges themselves, particularly the electrical equipment powering the centrifuges.¹¹⁵ In February 2002, Lerch and Wisser sent Geiges and Smit to Turkey where they inspected the electrical equipment being made by Alguadis.¹¹⁶

The feed and withdrawal system developed by Lerch and Khan was originally designed for P1 centrifuges, but it could be modified for P2 centrifuges. Although P1 and P2 centrifuges are different, they have similar performance characteristics that allowed them to be used with the same feed and withdrawal system with only straightforward modifications.¹¹⁷ One obvious modification was to account for the height difference; the P2 is about half as tall as the P1. As a result, the piping from the overhead piping arrangement had to be lengthened to reach the P2 centrifuges.

Any major changes in the original design required Khan's approval. For example, to compensate for being unable to bend stainless steel at Tradefin, Meyer requested some design changes in the piping, which Wisser sent to Dubai for approval. The changes were accepted in Libya and Pakistan, although this modification meant that Libya would need to do considerably more welding during set-up, further delaying the start-up of the plant.¹¹⁸

Libya sent two engineers, identified only as Abdul and Ali, to inspect the feed and withdrawal systems at Tradefin. They appeared to have a comprehensive knowledge of gas centrifuges.

Meyer was able to complete the entire project, except for certain valves. The Tinnens were responsible for supplying these valves, and PhiTec had sent one in June 2002 for Smit to use in his work, but the Tinnens refused to supply the rest of the valves. They were dissatisfied with Tahir's method of payments. Tahir said that a substantial number of the valves were later sent to Libya or remained in Switzerland.¹¹⁹

To hide the true purpose of the equipment, the Libyans selected a phony purchaser in Jordan. Tahir gave Wisser a draft contract for a water purification plant with the Jordanian company Contracting and Trading Organization.¹²⁰ The contract was signed by a "Professor Jabir," who was president of this company. The contract, signed on May 20, 2001, had an estimated completion date of November 2002. The actual shipping date would have been about a year later.

¹¹⁵ Andre Smit, *Affidavit*, Pretoria, South Africa, September 18, 2004, in the court case of Gerhard Wisser and Daniel Geiges.

¹¹⁶ *Plea and Sentence Agreement, State vs. Geiges, Wisser, Krisch Engineering*, op. cit., p. 15; *Tahir Statement*, op. cit.

¹¹⁷ Interview with a senior official close to the IAEA, August 22, 2006.

¹¹⁸ Interview with a senior official close to the IAEA, August 22, 2006.

¹¹⁹ *Tahir Statement*, op. cit.

¹²⁰ *Plea and Sentence Agreement, State vs. Geiges, Wisser, Krisch Engineering*, op. cit., pp. 17-18; and *Tahir Statement*, op. cit. The full contract is included in the *Tahir Statement* on the ISIS web site.

Workshop 1001

The Libyan deal called for the supply of a complete centrifuge plant, but Libya also needed the manufacturing capability for making additional centrifuges to replace broken ones and expand the size of the plant. As the order progressed, however, it became apparent that the Khan network could not make all the components and that Libya would need to make several of them itself.

The network sent the bulk of the equipment for the workshop to Libya. In 2004, the IAEA inspectors found all of this equipment still in their shipping crates in a large warehouse in Janzour, Libya, west of Tripoli, which was slated to hold the workshop.¹²¹

Tahir says that Peter Griffin was tasked with obtaining most of the necessary machine tools and materials for the workshop.¹²² Griffin denies that he knew initially that the goods were destined for Libya. He says that Tahir asked him to specify and supply machine tools for a general maintenance workshop in Dubai for spare parts for the oil and gas industry. Griffin also arranged training for engineers in operating the equipment. According to Griffin, only when Libyan technicians arrived in Spain for training in the summer of 2002 did Tahir indicate to him that the workshop was planned for Libya instead of Dubai.

The expertise necessary to design this workshop undoubtedly came from Pakistan, and this information was given to Libya. Libya also received from an unknown source, possibly Tahir, detailed instruction manuals on making centrifuge components.¹²³ The instructions for each component included the equipment required, the specific skills needed by the technicians to make that part, a description of each step in the production of that piece, and the length of time needed to accomplish each step.¹²⁴

Griffin obtained much of the equipment in Spain. Part of the reason for this could have been the difficulties he would have faced in his own country in obtaining the items. Over the years, Griffin, who was British, had provided many items to Khan.¹²⁵ As a result, he was well-known to British authorities. In 1995, the British Security Service MI5 warned British companies to avoid doing business with Griffin, his son Paul, and his companies.

Because of his notoriety, Griffin could have anticipated facing scrutiny if he approached British suppliers. The companies could become suspicious of the end-use of the equipment and report his contact with them to national authorities.

¹²¹ *Implementation of the NPT Safeguards Agreement*, February 20, 2004, op. cit.

¹²² *Tahir Statement*, op. cit.

¹²³ Interview with a senior official close to the IAEA, June 4, 2004.

¹²⁴ Interview with a senior official close to the IAEA, October 28, 2004.

¹²⁵ Interview with a senior official close to the IAEA, October 28, 2004.

In 1998 or 1999, Griffin reportedly approached a Spanish trading company, Commercial Nork L.L., in San Sebastian in the Basque region to buy a list of equipment for the workshop. According to *El Pais*, Griffin attended the “Feria de Maquinaria,” or the Machine Fair, in Bilbao.¹²⁶ It is plausible that Griffin first made contact here with Commercial Nork. Griffin’s use of Nork as a procurement intermediary increased the efficiency of the order, minimized the number of suppliers that would have direct contact with him, and further ensured the free flow of goods to Dubai with Nork being a local intermediary.

According to ISIS interviews with a senior Nork official, Griffin asked Nork to procure a shopping list of tens of pieces of equipment.¹²⁷ The Nork employee listed several of the machines procured for Peter Griffin. Nork obtained the two DENN model RL-400/2 flow-forming machines from Industrias Puigjaner S/A in Barcelona. Nork also obtained a machine for bending small tubes, an engraving machine, four milling machines, a drilling machine, a cutting machine, horizontal and vertical cutting saws, one large CNC lathe, one smaller CNC lathe and another smaller lathe, and an electric discharge machine. This equipment is the type needed in a centrifuge manufacturing plant.

Nork employees insist that they did not know that the ultimate destination of these machines was Libya. Furthermore, the senior employee interviewed by ISIS stressed that, except for one case, they believed the machines did not require authorization from Spanish authorities.

However, Ronald Miskell, a U.S. government expert, differed in his assessment with respect to the two Denn flow-forming machines. He examined these machines at Oak Ridge, Tennessee and testified in the South African prosecution of Wisser. Miskell’s expert testimony was key in convicting Wisser of illegally importing and exporting the flow forming machines from South Africa back to Dubai. He found that these machines could be readily equipped with a computer control unit that would allow the production of centrifuge rotors.¹²⁸ The ability to convert such a unit in a “relatively straight forward” manner, he concluded, meant that the machines were subject to dual-use export controls under the Nuclear Suppliers Group (NSG).¹²⁹ Spain is a member of the NSG and thus should have required Nork to obtain an export license for these machines.

¹²⁶ Isabel Piquer, Miguel Gonzalez, “Técnicos libios supuestamente vinculados al programa nuclear se formaron en España,” *El Pais*, 24 February 2004.

¹²⁷ Paul Brannan, *Conversation with NORC Official*, ISIS Memo, November 15, 2005; Brannan, *Conversation with NORC Official*, ISIS Memo, October 20, 2005; Brannan, *Conversation with NORC Official*, ISIS Memo, December 19, 2005

¹²⁸ *Affidavit, Dr. Ronald Vincent Miskell*, consultant to the U.S. Department of Energy with expertise on machine tools on multinational export controls, *Plea and Sentence Agreement, State vs. Geiges, Wisser, Krisch Engineering*, op. cit.

¹²⁹ *Affidavit, Dr. Ronald Vincent Miskell*, op. cit. The controls are NSG Part 2 controls.

Spanish authorities conducted an investigation of Nork. They visited its office in 2004 and removed and copied documents. The results of the official Spanish investigation into the activities of Nork are unknown, although the Nork official said in 2005 that the company did not expect any prosecutions.

The Nork employee explained that the most sophisticated machine Nork ordered for Griffin was a high-precision boring and grinding machine from a Swiss company, Société des Instruments de Précision (SIP), based in Geneva. This machine, the SIP-5000, could be legally sold to Nork without an export license as long as it remained in Spain. However, since it was intended for export to Dubai, Griffin submitted a re-export request with Swiss authorities on August 30, 2001.¹³⁰ According to a knowledgeable Swiss official, the authorities recognized Griffin's name but in an apparent mistake, decided that the name of the individual was too common to warrant the Swiss government denying the export without further evidence. A Swiss government official said that the government contacted Griffin's country of origin (likely Britain) for more information, but the government took months to respond to the Swiss government's request. By then, under pressure to approve the export, Swiss government authorities decided to allow the shipment. However, given suspicions about Griffin and Dubai's well-known role as a transit country, the government imposed the unusual condition that SIP had to provide a report that the machine was installed in the declared Dubai facility. Further placating authorities, SIP officials told the authorities that the machine required its assistance to install.¹³¹ However, SIP never provided the installation report, and it declared bankruptcy, the first of two before it was taken over by another tool manufacturer. Meanwhile, Tahir sent the machine to Libya, where it was eventually found by the IAEA.

Training on many of the machines occurred in Spain. As reported in *El Pais*, Griffin and Nork officials settled on a contract in which Nork would aid in the training of Libyan scientists in Spain during the period 2000 to 2002.¹³² One employee told *El Pais*: "It surprised us...that, being a company from Dubai, all the technicians were Libyan. We asked GTI and they answered that in the Gulf it was normal to use foreign workers."¹³³

¹³⁰ Erik Reumann, "The Swiss Give a Boost to the Manufacture of Kahfafi's Bomb," *La Liberté*, May 12 2008 (original in French).

¹³¹ "The Swiss Give a Boost," op. cit.

¹³² Isabel Piquer, Miguel Gonzalez, "Técnicos libios supuestamente vinculados al programa nuclear se formaron en España," *El Pais*, 24 February 2004.

¹³³ Piquer and Gonzalez, "Técnicos libios supuestamente."

According to a Libyan who attended a training session on flow-forming metals, this session was more about familiarization than making equipment.¹³⁴ He was personally disappointed that he received little useful training in actually making the rotor tubes.

¹³⁴ Interview with a senior official close to the IAEA, February 26, 2008.

Conclusion

Despite several problems that would have likely delayed the start of the Libyan centrifuge plant, the Khan network established an impressive transnational supply operation aimed at providing Libya with the ability to make nuclear weapons. IAEA and U.S. experts who have reviewed the evidence judge that the network would have succeeded if the network had not been exposed and Libya had continued to pursue its nuclear ambitions.

IAEA inspectors who examined all the evidence concluded that Libya was still about three to four years from starting the centrifuge plant when it ended its nuclear weapons program in late 2003.¹³⁵ Libya also would have needed to train engineers and technicians to operate the large centrifuge plant.¹³⁶ Yet, the fact that a band of traffickers and proliferators could organize this effort is a disturbing reminder of just how dangerous Khan and his network became in their efforts to proliferate.

¹³⁵ Interview with a senior official close to the IAEA, February 26, 2004.

¹³⁶ Interview with a senior official close to the IAEA, February 28 and March 24, 2004.