

Nuclear

*Keep nuclear scientists together at IAEC
in order to pool their skills and have
them available when needed . . .*

Saddam Husayn

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Key Findings

Iraq Survey Group (ISG) discovered further evidence of the maturity and significance of the pre-1991 Iraqi Nuclear Program but found that Iraq's ability to reconstitute a nuclear weapons program progressively decayed after that date.

- Saddam Husayn ended the nuclear program in 1991 following the Gulf war. ISG found no evidence to suggest concerted efforts to restart the program.
- Although Saddam clearly assigned a high value to the nuclear progress and talent that had been developed up to the 1991 war, the program ended and the intellectual capital decayed in the succeeding years.

Nevertheless, after 1991, Saddam did express his intent to retain the intellectual capital developed during the Iraqi Nuclear Program. Senior Iraqis—several of them from the Regime's inner circle—told ISG they assumed Saddam would restart a nuclear program once UN sanctions ended.

- Saddam indicated that he would develop the weapons necessary to counter any Iranian threat.

Initially, Saddam chose to conceal his nuclear program in its entirety, as he did with Iraq's BW program. Aggressive UN inspections after Desert Storm forced Saddam to admit the existence of the program and destroy or surrender components of the program.

In the wake of Desert Storm, Iraq took steps to conceal key elements of its program and to preserve what it could of the professional capabilities of its nuclear scientific community.

- Baghdad undertook a variety of measures to conceal key elements of its nuclear program from successive UN inspectors, including specific direction by Saddam Husayn to hide and preserve documentation associated with Iraq's nuclear program.
- ISG, for example, uncovered two specific instances in which scientists involved in uranium enrichment kept documents and technology. Although apparently acting on their own, they did so with the belief and anticipation of resuming uranium enrichment efforts in the future.
- Starting around 1992, in a bid to retain the intellectual core of the former weapons program, Baghdad transferred many nuclear scientists to related jobs in the Military Industrial Commission (MIC). The work undertaken by these scientists at the MIC helped them maintain their weapons knowledge base.

As with other WMD areas, Saddam's ambitions in the nuclear area were secondary to his prime objective of ending UN sanctions.

- Iraq, especially after the defection of Husayn Kamil in 1995, sought to persuade the IAEA that Iraq had met the UN's disarmament requirements so sanctions would be lifted.

ISG found a limited number of post-1995 activities that would have aided the reconstitution of the nuclear weapons program once sanctions were lifted.

- The activities of the Iraqi Atomic Energy Commission sustained some talent and limited research with potential relevance to a reconstituted nuclear program.

- Specific projects, with significant development, such as the efforts to build a rail gun and a copper vapor laser could have been useful in a future effort to restart a nuclear weapons program, but ISG found no indications of such purpose. As funding for the MIC and the IAEC increased after the introduction of the Oil-for-Food program, there was some growth in programs that involved former nuclear weapons scientists and engineers.
- The Regime prevented scientists from the former nuclear weapons program from leaving either their jobs or Iraq. Moreover, in the late 1990s, personnel from both MIC and the IAEC received significant pay raises in a bid to retain them, and the Regime undertook new investments in university research in a bid to ensure that Iraq retained technical knowledge.

Evolution of the Nuclear Weapons Program

The Regime and WMD Timeline

For an overview of Iraqi WMD programs and policy choices, readers should consult the Regime Strategy and WMD Timeline chart, enclosed as a separate foldout and in tabular form at the back of Volume I. Covering the period from 1980-2003, the timeline shows specific events bearing on the Regime's efforts in the BW, CW, delivery systems, and nuclear realms and their chronological relationship with political and military developments that had direct bearing on the Regime's policy choices.

Readers should also be aware that, at the conclusion of each volume of text, we have also included foldout summary charts that relate inflection points—critical turning points in the Regime's WMD policymaking—to particular events/initiatives/decisions the Regime took with respect to specific WMD programs. Inflection points are marked in the margins of the body of the text with a gray triangle.

The Early Years: Ambition

Saddam demonstrated his commitment to obtain a nuclear weapon over two decades. Saddam's close association with the Iraqi Atomic Energy Commission (IAEC) stems from his service as Vice President of the Republic from 1968 until 1979 when he became President of Iraq. From 1973 to 1979, he also served as President of the IAEC and sponsored its acquisition of foreign-supplied facilities with which to support a nuclear weapons program.

In 1968, Iraq commissioned a Russian supplied IRT-2000 research reactor and commissioned a number of other facilities that could be used for radioisotope production at the Tuwaitha Nuclear Research Center, home of the IAEC. In the 1970s, through contracts with French and Italian firms, the IAEC built facilities at Tuwaitha that, if operational, could have allowed Iraq to attempt to produce plutonium for a weapons

program. **The Israeli destruction of the Tammuz 1 (Osirak) research reactor on 7 June 1981 and Iraq's subsequent failure to replace or rebuild it compelled the Iraqis to pursue a more clandestine uranium enrichment program for a nuclear weapon by the mid-1980s.**

Between 1979 and 1982, Iraq bought large quantities of uranium in various forms including yellowcake and uranium dioxide from several countries. Some of the purchases were reported to the IAEA and some were not. Iraq's uranium purchases are detailed in its CAFCD in 2002 and in other, earlier disclosures.

Not long after the start of the Iraq-Iran war, Iraq began to formally pursue uranium enrichment. In January 1982, the Office of Studies and Development (OSD) was established in the IAEC to conduct research and development in uranium enrichment. The staff of OSD was drawn largely from the staff of IAEC and numbered no more than several hundred. In late 1982, the IAEC was restructured and OSD became known as Office 3000.

During the Iraq-Iran war, Iraq studied a variety of uranium enrichment techniques. It was not until near the last year of the war in the late 1980s that Iraq began to make decisions and take serious steps to develop a nuclear infrastructure.

In April 1987, the IAEC created a group structure that assigned responsibility for gaseous diffusion research projects to Group 1, EMIS research and development to Group 2, and support activities to Group 3 in the Office of Studies and Development, or Office 3000.

Also in April 1987 a program, codenamed the Al-Husayn project (HP), was formed under Husayn Kamil, supervisor of the State Organization for Technical Industries at the time, to study the steps required to start a nuclear weapons program in Iraq. The finished report outlined a range of projects and served as the basis of a formally constituted nuclear weapons program. In November 1987, the project team was transferred to the IAEC and in April 1988 became Group 4 in Office 3000. The program was implemented in June 1987 and construction began on a nuclear weapon research, development, and production complex at Al Athir in August 1988.

In August 1987, Group 1 formally left the IAEC and Tuwaitha to act independently as the Engineering Design Directorate (EDD) in the Ar Rashidiyah District of Baghdad. At that time the EDD began to develop centrifuge enrichment technology and throughout its existence was directly responsible to Husayn Kamil.

Nearly all avenues of uranium enrichment were considered, but by late 1987 Iraq began construction of a large electromagnetic isotope separation (EMIS) plant at Tarmiya. To support the large investment in EMIS technology, a network of facilities was created to concentrate uranium, convert uranium to feed materials, fabricate EMIS equipment, and chemically recover product.

 ***As the Iraq-Iran war drew to a close, further changes were made in the Iraqi Nuclear Program structure that would ultimately place the nuclear weapons program under Husayn Kamil.*** In May 1988, when the Ministry of Industry and Military Industrialization (MIMI) was officially established, EDD, renamed the Engineering Design Center (EDC), became one of the institutions of the Military Industrialization Commission (MIC), under MIMI. In November 1988, Office 3000 (Groups 2, 3, and 4) was transferred to the MIMI and in January 1989 officially given the name Petrochemical Project 3 (PC-3) under Dr. Ja'far Diya' Ja'far. Husayn Kamil, Director of MIC and MIMI, assumed control of the Iraqi Nuclear Program.

In August 1988, German engineers traveled to Baghdad and presented European centrifuge design data that EDC immediately copied to advance its otherwise slow progress in developing centrifuge enrichment. In the years before the 1991 Gulf war, several more German engineers became involved, and centrifuge design documents based on technology developed for the European enrichment consortium URENCO were transferred to EDC. Contracts were signed with a number of European firms to acquire key component manufacturing technology and critical equipment for the centrifuge program.

 ***After the invasion of Kuwait and the UN economic embargo, Iraq initiated an accelerated, or “crash program,” to produce a nuclear weapon that called***

for the diversion of IAEA-safeguarded research reactor fuel at Tuwaitha. Iraq planned to further enrich some research reactor fuels using an envisioned 50-machine centrifuge cascade to produce enough weapon-grade uranium for one nuclear weapon. There were numerous obstacles—such as deficiencies in cascade development, uranium recovery capability, and weapons design and development—that prevented the Iraqis from succeeding.

At the time the program ended in early 1991, the Iraqi Nuclear Program (INP) had several thousand personnel, and Iraq was commissioning EMIS equipment at Tarmiya and producing micrograms of enriched uranium. The centrifuge enrichment program was successfully operating a single machine in a test stand and building facilities for a small enrichment cascade. The Iraqis were working on a first-generation nuclear weapon design, which they intended to make into a device deliverable by missile.

Decline (1991-96)

Following the invasion of Kuwait, nearly all of the key nuclear facilities—those involved in the processing of nuclear material or weapons research—were bombed during Desert Storm. Many of the facilities located at Tuwaitha were devastated, and the EMIS enrichment plants at Tarmiya and Ash Sharqat were largely destroyed. Iraq's yellowcake recovery plant at Al-Qa'im and feed material production plant at Mosul (Al Jazira) also were bombed during the war. Al-Athir—a high-explosives testing site revealed after the war to be Iraq's planned nuclear weapons development and assembly site—was also damaged. Iraq's centrifuge research and development site at Rashdiya and the planned centrifuge production and operations site at Al Furat were neither found nor targeted in the 1991 war, but industrial sites, found after the war to be supporting nuclear weapons efforts, were attacked and damaged.

The Iraqis first chose not to disclose the extent of their clandestine nuclear program in their April 1991 declaration. As part of a denial and deception effort at the end of May 1991, Kamil issued orders to collect all documents and equipment indicating



Non-Proliferation Treaty violations. Equipment and documentation were moved to a variety of locations to hide program elements from the IAEA. Iraqi researchers were instructed by their managers to dispose of their laboratories, some of which were then set up in universities and institutes. In addition, Kamil ordered that at least one set of all nuclear-related documents and some equipment be retained by a senior scientist.

It was not until the Iraqis were confronted with evidence and IAEA successfully seized EMIS components in June/July 1991 that the Iraqis admitted to the large enrichment program. *Large quantities of EMIS equipment were unburied and delivered to IAEA for destruction* later that year.

Even though the existence of their centrifuge enrichment program was known before 1991, the Iraqis did not fully declare its extent and maintained that it was only a limited research and development activity located at Tuwaiitha, rather than Ar Rashidiyah. In 1991 the Iraqis also declared the planned centrifuge facility at Al Furat as under construction.

- After the seizure of documents pertaining to Iraq's nuclear weapons program in late September 1991, the Iraqis admitted to the existence of the Al Athir. The facility was destroyed by IAEA in April-June 1992.

Starting in 1992, MIC Director Husayn Kamil distributed PC-3 and EDC personnel and work centers around various military research and production facilities. The intention, according to one scientist from the pre-1991 nuclear program, was to keep researchers together in anticipation of a reconstituted nuclear weapon program.

Former PC-3 or EDC personnel working at the Pulse Power Research Center, which became Al Tahadi State Establishment in 1995, created an ion implantation lab with components from former IAEC and PC-3 projects (1994) and a rail gun experiment for air defense, which also used equipment from IAEC and PC-3 (1993-95).

Iraq resisted a more comprehensive disclosure of its nuclear program until after the defection of Husayn Kamil in August 1995, when a large collec-

tion of centrifuge and nuclear program documents and equipment was given to UNSCOM and IAEA.

From that point onwards, the Iraqis appear to have cooperated and provided more complete information. The centrifuge program appears to have largely been declared, though a full set of documents delivered by German engineers was not supplied to IAEA inspectors.

Efforts that could preserve the progress and talent that had been developed up to the 1991 war included keeping the nuclear cadre engaged in a variety of projects, such as rebuilding of Iraq's infrastructure. However, the nuclear program was ended and the intellectual capital decayed in the succeeding years. The economy had declined, and the talent had been focused on rebuilding the country as well as other military priorities. In some cases, extraordinary measures had to be taken to retain scientists, such as restricting foreign travel or seeking other jobs.

Recovery and Transition (1996-2002)

Iraq collaborated with the International Atomic Energy Agency (IAEA) to produce a series of Full, Final, and Complete Disclosure (FFCD) statements, including a "final" presented to the IAEA in September 1996, which reported its review findings to the UN Security Council in October 1997. The IAEA concluded that it had a technically coherent picture of the pre-1999 nuclear weapons program, although it was troubled by the absence of centrifuge program documentation and there were gaps in knowledge about nuclear weapon design and development activities and the role of foreign assistance—the latter point also a reference to a pre-1991 offer by a representative of Pakistan's A. Q. Khan to assist Iraq in developing nuclear weapons.

'Abd-al-Tawab 'Abdallah Al Mullah Huwaysh became director of the MIC in 1997 and appeared to bear no loyalty to the former nuclear program and IAEC personnel. He standardized salaries, eliminating the preferential pay differential given former PC-3 workers, and instituted measures to emphasize and monitor performance throughout MIC.



With the influx of funds from the Oil For Food (OFF) Program and later the suspension of cooperation with UNSCOM, Saddam's attention began to return to the former employees of the Iraqi Nuclear Program. In the late 1990s, raises in salaries were given to the employees of both the MIC and the IAEC. New programs were initiated, which would employ the talent of former Iraqi Nuclear Program employees, and both the MIC and IAEC expanded. Joint programs with universities were started not only to support a deteriorating university system but also to encourage involvement in MIC and IAEC efforts, offering the opportunity to pass knowledge on to new generations of scientists.

After 1998, interest by Saddam in air defense stimulated projects involving a former nuclear researcher—including one project that had the prospect of supporting a renewed nuclear weapons effort. The IAEC started a rail gun project in 1999, and the MIC was sponsoring a rail gun project at Al Tahadi in 2000. Both projects, and other air defense projects at IAEC, had poor prospects for success as weapons. The IAEC rail gun effort—led by the former head of the pre-1991 nuclear weapons design and development effort, Khalid Ibrahim Sa'id—could, with significant further development, be useful for future nuclear weapons design and development research.

New departments were established in the Physics Department of the IAEC. While primarily supporting the IAEC rail gun project, a Technical Research Branch—with laboratories for high-speed imaging, flash X-ray, impact studies, electronics, and computing—was established in 2001 in newly created laboratories outside the gates of Tuwaitha. A new laser division was created in 1999, and other departments were modernized through purchases of new equipment. Efforts were made to expand ties to universities and train more students at IAEC. Procurements were made through MIC to improve the equipment at IAEC's machine tool workshop.

Miscalculation (2002-2003)

In the year prior to Operation Iraqi Freedom (OIF), MIC undertook improvements to technology in several areas that could have been applied to a renewed centrifuge program for uranium enrichment. These dual-use technologies included projects to acquire a magnet production line at Al Tahadi, carbon fiber filament winding equipment for missile fabrication at al Karama, and the creation of a new Department of Rotating Machinery at Ibn Yunis. All of these projects were created to improve specific military or commercial products, but the technologies could have helped support a centrifuge development project. ***ISG, however, has uncovered no indication that Iraq had resumed fissile material or nuclear weapon research and development activities since 1991.***

Results of ISG's Investigation on Nuclear Issues

Iraq did not possess a nuclear device, nor had it tried to reconstitute a capability to produce nuclear weapons after 1991.

ISG has uncovered no information to support allegations of Iraqi pursuit of uranium from abroad in the post-Operation Desert Storm era.

- In the late 1970s and early 1980s, Iraq had an aggressive program to acquire uranium. Iraq's known inventory of safeguarded uranium has been accounted for by the IAEA and Coalition in June 2004. These issues are described in detail in the uranium pursuits section of this paper.

Iraq did not reconstitute its indigenous ability to produce yellowcake. As a result of Desert Storm and IAEA inspection efforts, Iraq's indigenous yellowcake production capability appears to have been eliminated. Bomb damage in 1991 destroyed the uranium extraction facility at the Al Qaim Superphosphate Fertilizer Plant. During the years of intrusive inspections, the IAEA also closed and sealed the Abu Skhair mine to curtail Iraq's secondary pilot plant production capability for acquiring uranium.

- ISG also investigated the former nuclear facility at Tarmiya but found no indicators that the processes being developed there had produced more than a few kilograms of uranium-bearing wastes as a byproduct of phosphoric acid purification.
- These issues also are further described in the uranium pursuits section of this paper.

Post-1991, Iraq had neither rebuilt any capability to convert uranium ore into a form suitable for enrichment nor reestablished other chemical processes related to handling fissile material for a weapons program. Prior to the 1991 war, Iraq had established uranium conversion and feed material capabilities at the Tuwaitha Nuclear Research Center—Baghdad's premier nuclear center—as well as a feed material plant near Mosul called Al-Jazira. Iraq also was establishing chemical processes at Tarmiya, and Al-Sharqat—its two primary sites for uranium enrichment

using the electromagnetic isotope separation (EMIS) technique. Baghdad also planned to produce feed materials for its centrifuge program at its main centrifuge research site Rashidiyah and planned a pilot plant at Al Furat. Uranium metal production planned for the pre-1991 program was planned for the Al-Athir nuclear weapons assembly facility. These issues are described in the EMIS and uranium conversion sections of this paper.

Available evidence leads ISG to judge that Iraq's development of gas centrifuges for uranium enrichment essentially ended in 1991. Prior to 1991, gas centrifuge technology was one of the primary methods being pursued for uranium enrichment, with emphasis being placed on carbon-fiber composite centrifuge rotors.

- According to Iraq's disclosures to IAEA, ISG interviews and documentary evidence, Iraq's centrifuge program by June 1990 had built—with foreign assistance—two magnetic-bearing centrifuges, one of which was tested with uranium hexafluoride (UF_6) feed. Two oil-bearing centrifuges had also been built by the Iraqis as of June 1989.
- ISG believes a reconstituted program for the purpose of producing material for nuclear weapons would have required redevelopment and testing of centrifuge manufacturing technology, the manufacture of thousands of machines required for a production plant, effort to gain experience in enrichment operations, and production of metric-ton quantities of uranium hexafluoride (UF_6) feed. However, the initial research and development stages might use only a single centrifuge.
- Former Presidential Scientific Advisor Amir Hamudi Hasan al-Sadi stated that he neither received nor issued orders to resume any centrifuge-related work and could not have done so because the war had destroyed the equipment and facilities.
- The head of design implementation in the former centrifuge program, Faris 'Abd Al 'Aziz Al Samarra'i, did not believe that there was a reconstituted nuclear weapons program in Iraq after 1991. He stated that he did not believe that the universities

had the resources or ability to undertake weapon-related research. Since 1992, Dr. Faris had worked for MIC, in Studies and Planning, and as Director General of the Al-Shaheen Company since 1996 and of the al Samud State Company since 2002.

- Jamal Ja'far, the designer of the pre-1991 magnetic centrifuge program, stated in an interview that he also did not believe that it was possible, given the conditions in Iraq in 2002, to reconstitute such a complicated and serious effort.
- Additional details on ISG's investigation into centrifuge-related issues can be found in sections dealing with aluminum tubes, carbon fiber, flow forming, magnet production, potential centrifuge-related facilities, and rotating machinery.

ISG also judges that Iraq continued work on none of the many other uranium enrichment programs explored or developed prior to 1991, such as EMIS or lasers. However, many of the former EMIS engineers and scientists continued to work for either the Iraqi Atomic Energy Commission (IAEC) or the Military Industrialization Commission (MIC) in roles that could preserve their technical skills.

- Since Operation Iraqi Freedom, significant looting and damage have occurred at most of the dual-use manufacturing facilities that supported the pre-1991 EMIS program. ISG has not been able to confirm that the Iraqi Regime attempted to preserve the EMIS technology, although one scientist with this pre-1991 program kept documents and components that would have been useful to restarting such an effort.
- Additional details can be found in the EMIS and Laser Research sections of this report.

It does not appear that Iraq took steps to advance its pre-1991 work in nuclear weapons design and development. ISG has not identified a materials research and fissile component manufacturing capability that would be required to reconstitute a nuclear weapons program. Working with molten highly enriched uranium requires special consideration for criticality during the melting and solidification process. ISG

found no evidence that Iraq had acquired or developed the technology dealing with casting and machining issues of highly enriched uranium.

- While ISG has not identified any explosive lens development effort in Iraq that was associated with a renewed nuclear weapons program, we do believe that the Al Quds Company—a MIC establishment created in 2002—had a technical department, which built a facility capable of conducting research. ***Such a facility appears well suited for types of explosives research that could be applicable to conventional military and nuclear weapons research.***
- ISG obtained evidence from recovered documents and from debriefings of Iraqi scientists that Iraq utilized high-speed switches—like those of potential interest for nuclear weapons development—in support of rail-gun projects that we believe were intended for air defense. ***ISG has found no links between Iraq's interest in special high-speed switches after 1991 and a nuclear weapons program.***
- ***ISG also was not able uncover indications that Iraq had resumed any work related to neutron initiators/generators for a renewed weapons program.*** The only neutron generation capability found by ISG pertained to known non-weapons-related research under way at the IAEC at Tuwaitha.
- These activities are described in further detail in Potential Weapons Development Issues, IAEC Modernization, and Rail Gun portions of this report.

ISG has uncovered two instances in which scientists linked to Iraq's pre-1991 uranium enrichment programs kept documentation and technology in anticipation of renewing these efforts—actions that they contend were officially sanctioned.

- A former engineer in the pre-1991 EMIS program claimed he was told by the head of MIC in 1997 to continue his work with ion implantation at his Al Tahaddi lab as a way to preserve EMIS technology.

- The former head of Iraq's pre-1991 centrifuge program also retained prohibited documents and components in apparent violation of the Regime's directives. Though this activity was isolated, it also had the potential to contribute to a possible restart of Iraq's uranium enrichment programs.
- Additional details on the disclosures of these two former enrichment officials can be found in the section of the report concerning Hidden Enrichment Technology.

Furthermore, although all of the officials interviewed by ISG indicated Iraq had ended its pursuit of nuclear weapons in 1991, some suggested Saddam remained interested in reconstitution of the nuclear program after sanctions were lifted. Specific details concerning Saddam's continued intent to develop weapons of mass destruction can be found in the section of this report concerning Regime Strategic Intent.

Consistent with Saddam's nuclear ambitions, starting around 1992, Iraq directed scientific expertise to several Iraqi establishments. This action would be consistent with either preserving knowledge for the eventual reestablishment of the nuclear weapon program or with simply utilizing Iraq's technical expertise in areas where it was most needed. In either case, some of the work performed by these former PC-3 scientists inherently preserved some capabilities that would be needed for a reconstituted nuclear weapon program. Details on these activities can be found in the sections of the report concerning IAEC Modernization, University Programs, and Migration of PC-3 Capabilities.

Investigation Into Uranium Pursuits and Indigenous Production Capabilities

Foreign Pursuits

ISG has not found evidence to show that Iraq sought uranium from abroad after 1991 or renewed indigenous production of such material—activities that we believe would have constituted an Iraqi effort to reconstitute a nuclear weapons program. As part of its investigation, ISG sought information from prominent figures such as Ja'far Diya' Ja'far—the head of the pre-1991 nuclear weapons program.

- According to Ja'far, the Iraqi government did not purchase uranium from abroad following its acquisition of yellowcake from Niger in 1981. However, Iraq also purchased uranium dioxide from Brazil in 1982. Iraq declared neither the Brazilian purchase nor one of the Niger purchases to the IAEA—demonstrating that the Iraqi Regime was willing to pursue uranium illicitly.

Regarding specific allegations of uranium pursuits from Niger, Ja'far claims that after 1998 Iraq had only two contacts with Niamey—neither of which involved uranium. Ja'far acknowledged that Iraq's Ambassador to the Holy See traveled to Niamey to invite the President of Niger to visit Iraq. He indicated that Baghdad hoped that the Nigerian President would agree to the visit as he had visited Libya despite sanctions being levied on Tripoli. Former Iraqi Ambassador to the Holy See Wissam Zahawie has publicly provided a similar account.

- Ja'far claims a second contact between Iraq and Niger occurred when a Nigerian minister visited Baghdad around 2001 to request assistance in obtaining petroleum products to alleviate Niger's economic problems. During the negotiations for this contract, the Nigerians did not offer any kind of payment or other *quid pro quo*, including offering to provide Iraq with uranium ore, other than cash in exchange for petroleum.

Embassy of the Republic of
IRAQ
Nairobi

Embassy of the Republic of
IRAQ
Nairobi

Confidential

No. 7
Dated May 20, 2001

Foreign Affairs Ministry – Ministry Office – Research and Analysis information office /2
Subject / Uranium Material

Enclosed is the report made by a friend from Uganda, Abdul Jamal Abdunnasser, (Bika) about getting uranium and other important metals from his friend in Congo. He told us that he is ready to supply Iraq with these metals if Iraq wants them and it can be done without implicating Iraq. After we checked them, we told him we don't deal with these materials and we explained to him the circumstances of Iraq and the imposed sanctions, and that Iraq is not concerned about these matters right now. He said that he will do his best to help Iraq and Iraq's regime for Jihad together against our enemy, and he considers supporting the power of Iraq to be his participation which is the power for all Muslims, and he feels that his duties are to support and strengthen that power.

Please consider. He kept two samples of uranium and coltat. "A list of elements he offered" Comrad Please give me your opinion - my regards

Attachments
Stated above

Rafiq Abdl Lateef (Comrade)
send a copy of the letter
and a copy of the attachment
to D-5 to get his opinion)
//illegible signature//

//illegible signature//
M.D.BTM/2
May 20

July 28
(1-1)

Recorded 3/3

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May 20. P.O.BOX 49213, Tel 581142 FAX 580267

Figure 1. Letter rejecting opportunity to purchase uranium.

- ISG recovered a copy of a crude oil contract dated 26 June 2001 that, although unsigned, appears to support this arrangement.

So far, ISG has found only one offer of uranium to Baghdad since 1991—an approach Iraq appears to have turned down. In mid-May 2003, an ISG team found an Iraqi Embassy document in the Iraqi Intelligence Service (IIS) headquarters related to an offer to sell yellowcake to Iraq. The document reveals that a Ugandan businessman approached the Iraqis with an offer to sell uranium, reportedly from the Congo. The Iraqi Embassy in Nairobi—in reporting this matter back to Baghdad on 20 May 2001—indicated it told the Ugandan that Iraq does not deal with these materials, explained the circumstances of sanctions, and said that Baghdad was not concerned about these matters right now. Figure 1 is the translation of this document.

Indigenous Production Capabilities

As a result of Desert Storm and IAEA inspection efforts, Iraq's indigenous yellowcake production capability appears to have been eliminated. ISG has uncovered no indicator Iraq had reconstituted production processes to refine uranium or produce yellowcake on a scale needed for a weapons program.

- Iraq's main plant for yellowcake production prior to 1991 was at Al-Qa'im. The plant was designed, erected, and commissioned by Mechim Company of Belgium during the period 1982 to 1984. Using phosphate ore from the Akashat mine and the Prayon process, the first batch of yellowcake was delivered to the IAEC in December 1985 with approximately 168 tons delivered through 1991.
- Bomb damage in 1991 destroyed the uranium extraction facility at the Al-Qa'im Superphosphate Fertilizer Plant. In 1991, inspectors found that Al-Qa'im had been heavily damaged in the war and the structure was unsafe. Visits to the site in interim years did not reveal any attempt to reestablish the plant to produce yellowcake.



Figure 2. Al Qaim uranium extraction facility destroyed.



Figure 3. Graphite furnace (top left); mixer-settlers (top right); atomic absorption-flame emission spectrometer (bottom left); gas chromatography (bottom right).

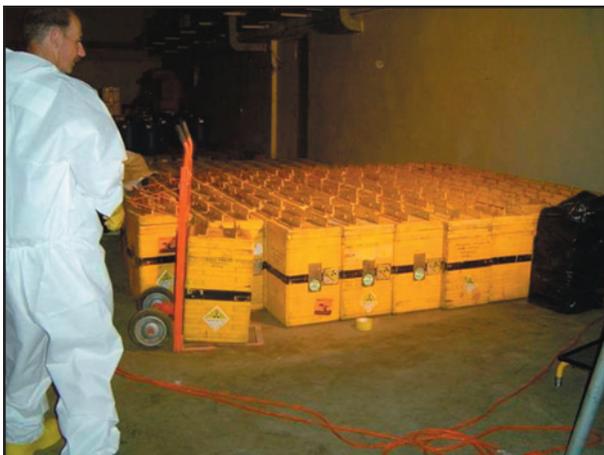


Figure 4. Monitoring containers of “yellowcake.”

- During the years of intrusive inspections, the IAEA also closed and sealed the Abu Skhair mine to curtail Iraq's secondary pilot plant production capability for acquiring uranium. A year before the closure of the Abu-Sha'ir mine under IAEA supervision in 1993, the processing plant was converted to produce "Alum" from kaolin ore. Subsequent visits by UNSCOM/IAEA continued to report inoperability of the mine. The operation established at Abu-Sha'ir in September 1988 produced 800 tons of ore, 10 tons of which were delivered to a pilot plant at the Geological Survey State Enterprise (GSSE) prior to 1991. Despite this effort, only 0.5 kg of yellowcake was obtained.
- Ja'far also claims that Iraq did not attempt to build another yellowcake production plant after 1991 (see Figure 2).

In May 2003, coalition forces visited the former yellowcake extraction plant at Al-Qaim and discovered 16 drums of yellowcake and radioactive waste—materials we believe were associated with the pre-1991 nuclear weapons program. These drums were transferred in late June 2003 to the yellowcake storage facility located at Tuwaitha. There is no evidence that this material had been produced after Desert Storm

ISG also investigated the Ibn-Sina' Facility—which in 1991 was part of Iraq's EMIS uranium enrichment program—but found no indicators that the chemical processes being developed there had produced more than a few kilograms of uranium-bearing wastes as a byproduct of phosphoric acid purification. ISG believes that the Ibn-Sina'—which concentrated much of the chemical engineering staff from the former PC-3 nuclear weapons program—would most likely have been involved in an effort to reestablish a uranium recovery capability, had such an effort been under way.

Iraq's Known Uranium Holdings

Known Iraqi uranium holdings have been accounted for by the Coalition and the IAEA. In June 2004, a joint IAEA and Coalition team verified the inventory of Iraqi uranium compounds—an inventory comprising both imported material and that indigenously produced prior to 1991 (see figure 4).

- During the 1970s and early 1980s, Iraq bought uranium in various forms from the international market. These materials included about 486 tons of yellowcake, 33,470 kg of "natural" uranium dioxide, 1,767 kg of "low-enriched" uranium dioxide (2.6 percent ²³⁵U), and 6,005 kg of "depleted" uranium dioxide from Portugal, Italy, Niger, and Brazil.

Prior to 1991, Iraq also acquired highly enriched uranium for its research reactors from France and Russia—material that was removed from Iraq following the 1991 Gulf war. Following the Husayn Kamil defection in 1995, Iraq admitted that in 1991 it had intended to use this highly enriched fuel as part of a "crash program" to develop a nuclear weapon (see Table 1).

Table 1 Declared Iraqi International Uranium Purchases					
Country	Organization/ Company	Time-frame	Uranium Form	Amount	Comment
Portugal	Emprese National de uranio EP	20 Jun 1980	"Yellowcake"	138.098 tons (uranium content approximately 103 tons)	IAEA notified through "ICR" report (29 Jun 80) (not subject to safeguards according to INFCIRC/153 corrected.)
		17 May 1982	"Yellowcake"	148.348 tons (uranium content approximately 110 tons)	No IAEA notification (not subject to safeguards according to INFCIRC/153 corrected.)
		31 May 1982			
		20 Jun 1982			
Italy	SNIA-TECHINT through CNEN	12 Dec 1979	"Depleted" uranium dioxide	6,005 kg	Under IAEA safeguards
		12 Dec 1979	"Natural" uranium dioxide	4,006 kg	
		12 Dec 1979	"Natural" uranium dioxide (pellets & fuel rods)	500 kg	
		18 May 1982	"Low-Enriched" uranium dioxide (2.6% ²³⁵ U)	1,767 kg	
Niger	ONAREM (Office National Des Ressources Minieres)	08 Feb 1981	"Yellowcake"	(uranium content 199.9 tons)	IAEA notified (not subject to safeguards according to INFCIRC/153 corrected.)
		18 Mar 1981			No IAEA notification (not subject to safeguards according to INFCIRC/153 corrected.)
Brazil	Through CNEN (Commissao Nacional de Energia Nuclear)	Sep 1981	"Natural" uranium dioxide	7,964 kg	No IAEA notification
		Jan 1982	"Natural" uranium dioxide	21,000 kg	

Iraqi Uranium Conversion Program

Iraq's pre-1991 uranium conversion program was established at different sites to produce the necessary uranium compounds for the enrichment, reprocessing, and metallurgy programs to support its pre-1991 nuclear weapons program. Iraq had established much of its uranium conversion basic research and development at Tuwaitha. As processes were developed, they were adapted for production at Tuwaitha and other sites as appropriate (see Figures 5 and 6).

- Iraq produced a variety of uranium compounds to support its pre-1991 nuclear weapons program at a number of facilities, including Tuwaitha, al Jazira, Tarmiya, Ash Sharqat, Rashdiya, and Al Athir. At the time of Desert Storm, Iraq's capabilities to produce uranium compounds/metal varied as noted in Table 2.

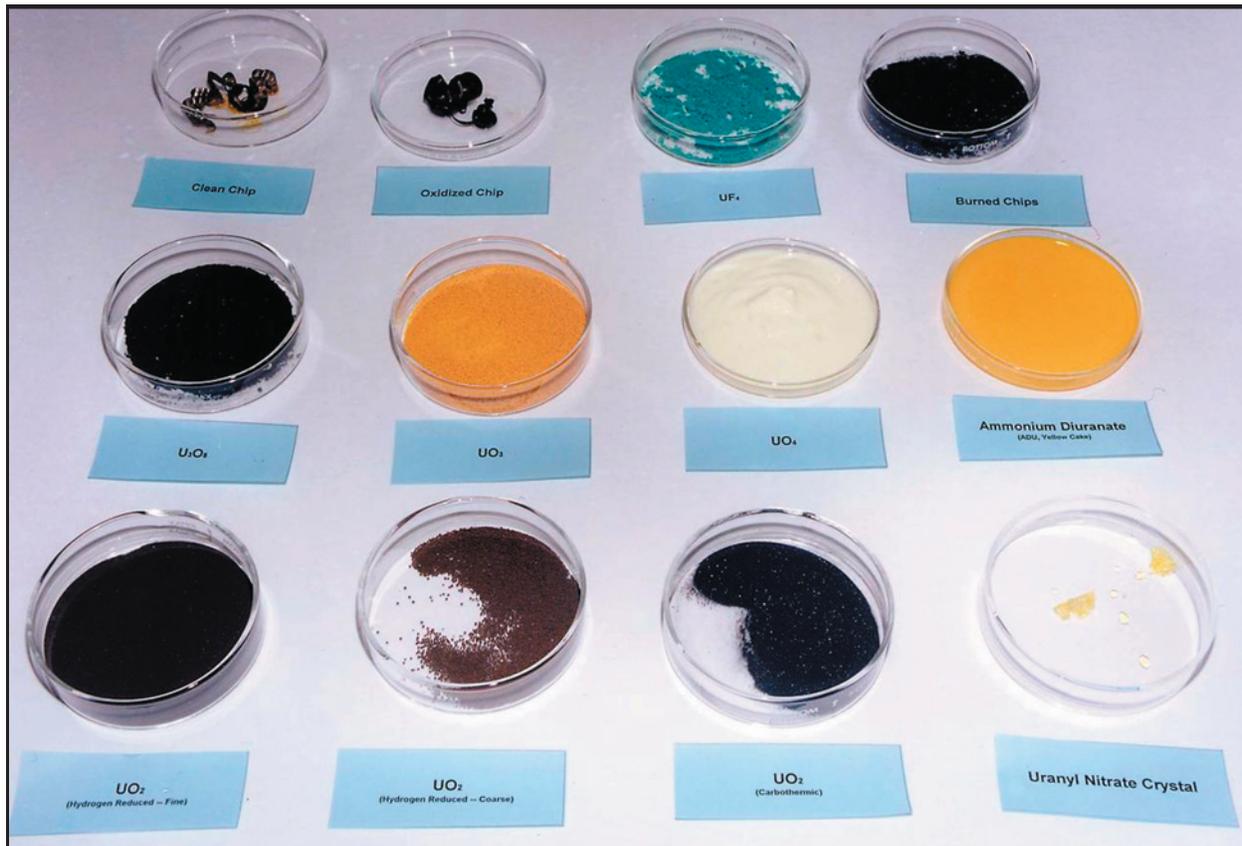


Figure 5. Forms of uranium.



Figure 6. Tuwaiitha (Baghdad Nuclear Research Center) (top); Tarmiya (Ibn Sina) uranium recovery facility (bottom).

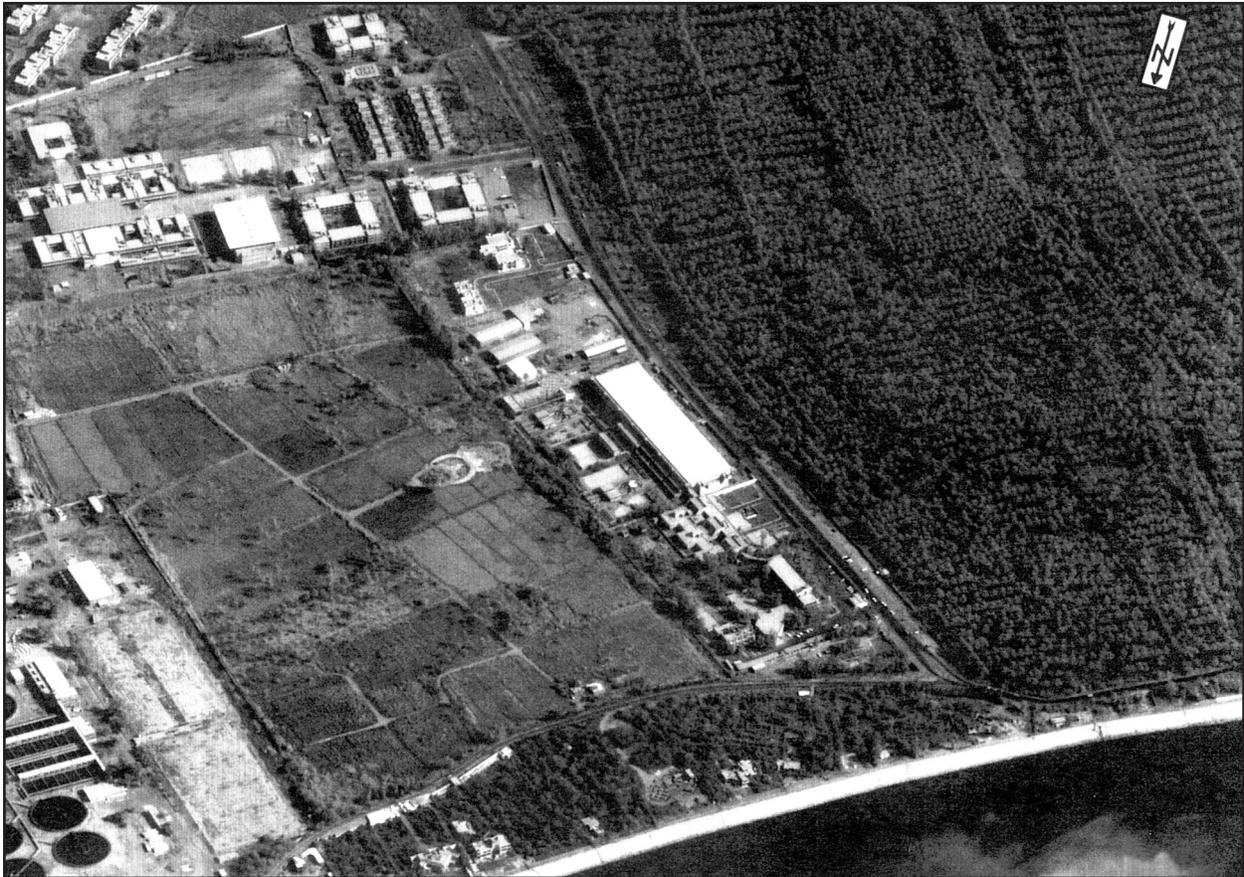


Table 2			
Iraq Uranium Conversion Program (Pre-Operation Desert Storm)			
Site	Bldg	Activity/Capability	Status at ODS
Tuwaittha	9	Reprocessing of irradiated fuel	Operational
	10	Uranium purification	Operational
	15B	UO ₂ to UCl ₄ lab production for EMIS; UF ₄ to U metal preparation experiments; UF ₄ and UF ₆ production & lab scale preparation	Operational
	22	Reprocessing	Operational
	38 (G1 wing)	UF ₄ production	Operational
	64	Uranyl nitrate to U metal; UO ₂ to UF ₄ to U metal	Operational
	73A&B	UF ₄ to U metal production; U metal purification; UF ₄ preparation	Operational
	73A	Dissolution of U pellets & fuel; nuclear-grade UO ₂ conversion.	Operational
	73B	“Yellowcake” purification & conversion to UO ₂ experiments.	Operational
	85	UO ₂ to UCl ₄ lab & pilot plant production for EMIS; Pilot plant recovery of U from R-100 & R-50 graphite collectors; Purification of UF ₆	Operational
RWTS	Pilot plant U recovery from R-100 & R-50 liners	Operational	
Al-Jazira	000	AYC to UO ₂ production for EMIS.	Operational
	510	Utilities & storage tanks for Project 212	Operational
	400	UO ₂ to UCl ₄ production for EMIS	Operational
	401	Utilities for Project 244	Operational
	3 Underground Facilities	Spare parts storage for U program construction phase	Operational
Tarmiya	210	U recovery from R-120 (nongraphite)	Precommissioning
	220	U recovery from R-120 (graphite)	Incomplete
	230	Recovered U to UCl ₄ (nongraphite)	Incomplete
	240	Lab support for Project 266	
	265	Pilot scale U recovery from R-120 (graphite & nongraphite)	Operational
Al-Sharqat	350	Chemical recovery for natural U from components of R120	80% constructed; 60% checked out
	360	U recovery (HEU & depleted U) from R120 & R60 collectors	85% constructed; 50% checked out
	370	U recovery from R60 collector components	80% constructed; 60% checked out
Rashidiya	Hall C	Lab scale UF ₆ preparation & purification; UF ₄ production	
	9	UF ₆ and UF ₄ R&D	
	10	UF ₆ and UF ₄ R&D; UF ₆ purification	
	22	UF ₆ production	Operational

Table 2			
Iraq Uranium Conversion Program (Pre-Operation Desert Storm) <i>continued</i>			
Site	Bldg	Activity/Capability	Status at ODS
Al-Atheer	6830	U metallurgy	Incomplete
	6520	U metallurgy	Operational
	6580	U chemistry	50% complete
Al-Rabee		U metallurgy	Transferred to Al-Atheer
References: <i>Currently Accurate, Full, and Complete Declaration of the Past Iraqi Nuclear Program</i> , 3 Dec 2002			

As a result of Desert Storm and the UN and IAEA efforts afterwards, many of the Iraqi uranium conversion facilities were destroyed or damaged and the program crippled. Many of the facilities of Tuwaitha, Al-Athir, al Sharqat, Rashidiyah, and Al-Athir were destroyed during Operation Desert Storm or subsequently through IAEA inspections. Table 3 indicates the destruction of facilities at the original sites and by whose action.

As a result of Operation Iraqi Freedom and its aftermath, much of Iraq's residual potential uranium conversion capability was destroyed. ISG site visits to many locations found not only destruction resulting from Operation Iraqi Freedom, but also looting that rendered many facilities inoperable. ISG investigations, including sampling and radiation surveys, during these visits uncovered no indications of nuclear weapons-related activity.

- *Tuwaitha (Baghdad Nuclear Research Center)*. ISG conducted a series of visits to Tuwaitha. During these visits, 151 structures were surveyed and cleared, 28 structures judged destroyed, and eight structures deemed hazardous (see figure 7).
- *Al-Athir*. US military forces found Al-Athir abandoned and heavily looted. ISG visited and found no evidence of uranium conversion activities.

- *Al Zahf Al Kabeer (Taji Metallurgy)*. ISG visits to Al Zahf Al Kabeer found that all research and production buildings showed extensive evidence of looting. They found no evidence of uranium metal production or weapon component production and received no positive readings from radiation surveys.
- *Al Raya*. ISG visits to Al Raya found extensive bomb damage and widespread looting. They found no evidence of uranium metal production or weapon component production and received no positive readings from radiation surveys.
- *Ibn Sina (Tarmiya)*. An ISG visit to Ibn Sina found the facility to be closed since major ground combat operations. The facility had been subject to some looting and was apparently in the process of restoring operations. No indicators or evidence of WMD activity was found (see Figure 8).
- Exceptions to the general destruction and looting were Al Amal and Al Salaam. Al Amal was active 24 hours a day, seven days a week to support an oil refinery at Basrah. Al Salaam was not damaged but showed evidence of minor looting (see Figures 7 and 8).

Table 3 Iraq's Uranium Conversion Program (Post-Operation Desert Storm Iraqi & UN/IAEA Activities - Facilities)					
Site	Bldg	ODS Impact	Iraqi Actions	IAEA Actions	
Tuwaittha	9	Destroyed			
	10	Destroyed	Leveled by Iraq		
	15B	Destroyed	Leveled by Iraq		
	22	Destroyed			
	38 (G1 wing)				
	64	Destroyed			
	73A&B	Destroyed	Leveled by Iraq		
	73A	Destroyed	Leveled by Iraq		
	73B	Destroyed	Leveled by Iraq		
	85	Destroyed	Leveled by Iraq	IAEA destruction	
		RWTS	Destroyed		
	Al-Jazira	000	Destroyed	Leveled by Iraq	
510		Destroyed			
400		50% destroyed; 40% equipment destroyed			
401		Destroyed			
		3 underground Facilities		Closed and sealed	
Tarmiya	210	Partially destroyed			
	220	Not destroyed			
	230	80% destroyed			
	240	Not destroyed			
	265	Not destroyed			
Al-Sharqat	350	Destroyed			
	360	Destroyed			
	370	Destroyed			
Rashidiya	Hall C		Evacuation and/or destruction of significant materials	Transfer and/or destruction of significant materials	
	9				
	10				
	22				
Al-Atheer	6830			Destroyed by IAEA	
	6520			Destroyed by IAEA	
	6580			Destroyed by IAEA	
Al-Rabee					

References: Currently Accurate, Full, and Complete Declaration of the Past Iraqi Nuclear Program, 3 Dec 2002.



Figure 7. Tuwaitha Building 15 area (top left); Tuwaitha Building 15 area (top right); Tuwaitha Building 73 area destroyed (bottom left); Tuwaitha LAMA Facility (Building 22 destroyed) (bottom right).



Figure 8. Tarmiya (Ibn Sina) uranium recovery facility.

Aluminum Tube Investigation

Baghdad's interest in high-strength, high-specification aluminum tubes—dual-use items controlled under Annex 3 of the Ongoing Monitoring and Verification Plan as possible centrifuge rotors—is best explained by its efforts to produce 81-mm rockets.

ISG conducted numerous interviews related to Iraq's interest in acquiring these tubes—information that regularly pointed toward similar tubes being used in the Nasser-81 ground-to-ground rocket system.

- Postwar interviews included prominent figures from Iraq's pre-1991 centrifuge effort, including its director, the project manager for rotor manufacture, other former staff, as well as the head of the overall nuclear weapons program. ISG also interviewed numerous officials directly involved in the 81-mm rocket effort and Iraq's Military Industrialization Commission (MIC). None of these officials admitted to any intended end use of the tubes beyond rockets.

Although ISG also uncovered inconsistencies that raise questions about whether high-specification aluminum tubes were really needed for such a rocket program, these discrepancies are not sufficient to show a nuclear end use was planned for the tubes. For example, ISG has found technical drawings that show the 81-mm rocket program had a history of using tubes that appear to have fallen short of the standard demanded in procurement attempts in the years before the war. Iraq also accepted lower-quality, indigenously produced aluminum tubes for 81-mm rockets in the months before the war despite continued foreign procurement attempts for high-specification tubes.

- ISG believes that bureaucratic momentum made it difficult to abandon the perceived need for high-specification tubes from abroad. These foreign pursuits probably also were affected by a lack of sufficient indigenous manufacturing capabilities—an effort Iraq reportedly began only in mid-2002—the high cost of that production, and pressure of the impending war.

- Efforts to press the Iraqis on other inconsistencies in individual recollections on history, production, questionable engineering practices, or accomplishments also did not produce statements to link the tubes to any effort other than 81-mm rockets.

Elements of ISG Investigation

ISG investigated key indicators that suggested a possible centrifuge end use for the tubes—questioning that revealed plausible explanations for use of the tubes in 81-mm rockets, notably:

- Purported high-level interest in aluminum tubes by Saddam and Iraq's Deputy Prime Minister—a potential indicator of a program of national importance, such as a centrifuge program.
- Possible association of Iraqi nuclear entities with the tubes it sought to procure—reporting suggestive of a nuclear end-user.
- Tube characteristics and shipping requirements—reporting that showed the tubes were subject to nuclear controls and seemed to be over specified for conventional rockets.
- Iraqi effort to indigenously manufacture tubes for an 81 mm-rocket program and its continued effort to acquire tubes with higher specifications.
- Alleged Iraqi interest in 84-mm tubes—a size that would have been inconsistent with the 81-mm rocket program.

In the course of this investigation, ISG did not uncover evidence of a program to design or develop an 81-mm aluminum rotor centrifuge. Other sections of ISG nuclear report describe findings concerning equipment and materials that could have supported a renewed centrifuge effort.

Purported High-Level Interest in Aluminum Tubes

ISG has found that high-level Iraqi interest in aluminum tubes appears to have come from efforts to produce 81-mm rockets, rather than a nuclear end use. Multiple reports indicate Dr. Huwaysh was keenly interested in high-strength, high-specification aluminum tubes for rocket production. Dr. Huwaysh attributes his pursuit of 81-mm rockets to the delivery of some launchers to the military shortly after he became the head of MIC in 1997. As a result, Dr. Huwaysh claims he was bound by requests from the Minister of Defense to produce rockets for those launchers—a task he regularly pressed on MIC leadership at quarterly meetings.

- Dr. Huwaysh's advocacy of 81-mm rockets appears to explain why he sought the delivery of items that were probably sample aluminum tubes. In early 2002, Dr. Huwaysh sought two shipments of high-strength aluminum from an Iraqi procurement firm in Syria.

Several Iraqi officials also commented on Saddam's potential interest in rockets. One official indicates Dr. Huwaysh told MIC engineers that Saddam asked him to make 81-mm rockets. But this link between the tubes and Saddam remains uncorroborated, even by Dr. Huwaysh.

- Ja'far Diya' Ja'far, the head of Iraq's pre-1991 nuclear weapons program and most recently a Presidential Science Advisor, has offered somewhat conflicting accounts regarding Saddam's awareness of the aluminum tubes. While discussing 81-mm rockets, Ja'far claimed Saddam was very interested in aerial weapons. Ja'far has also stated, however, this rocket program was unimportant and that work, including procurement, was known only to lower-level officials. Ja'far—whose debriefing accounts have been known to vary—also doubted Saddam understood the technical specifications of the tubes.

Other interest by senior officials in the 81-mm rocket can be traced to around 1984, when Husayn Kamil reportedly approved a proposal to reverse-engineer and build the weapon system. The proposal, made by an Iraqi Army Aviation officer was based on the premise that it was too expensive to continue importing 81-mm rockets from Italy.

Possible Association of Iraqi Nuclear Entities With the Tubes

The limited information found by ISG that ties Iraqi nuclear entities to the tubes also appears related to the 81-mm rocket program. A 6 March 2003 letter from the Iraqi National Monitoring Directorate (NMD) to the IAEA's Iraq Nuclear Verification Office (INVO) notes that the Iraqi Atomic Energy Commission (IAEC) conducted material composition testing on a sample aluminum tube in early 2001. According to that letter given to ISG, the Rashid State Company—one of the entities involved in 81-mm rocket production—obtained the sample tube through the Ahmed Al-Barrak Bureau, an import/export firm in Baghdad.

- The tube tested by the IAEC reportedly measured 900 mm in length and 81 mm in diameter—a size consistent with prewar procurement attempts. The Rashid State Company requested other physical property tests, but the IAEC did not have capabilities to do the work.

A leading Iraqi nuclear expert measured the tubes to answer questions posed by the IAEA, but ISG has found no indication that this represented interest by Iraq in the tubes for centrifuge applications. In the months before the war, Ja'far Diya' Ja'far admits calling on a leading technical figure in the former centrifuge effort, Dr. Faris 'Abd Al-Aziz Al-Samarrai, to measure dimensional variances on several 81-mm rockets. Multiple officials interviewed by ISG confirm Aziz's work for Ja'far to address questions from IAEA inspectors about the tubes.

- Nonetheless, the letter to the IAEA incorrectly claims that measurements of rockets made with the original pre-1991 tubes met the higher specifications for tubes set by the 2000 committee.

Ja'far's study for the IAEA inspectors apparently acknowledged it was possible to make a centrifuge from the tubes, although he thought doing so was impractical. Ja'far thought the IAEA officials agreed with his assessment but notes they did not make a definitive statement on the utility of the tubes for centrifuges. Ja'far thought the size of the rocket tubes would cause the enrichment output to be far lower

than the centrifuge design Iraq had pursued as of 1991. ‘Abd Al-Baqi Rashid Shiya, a former Director General of the Rashid State Company and a key figure in the 81-mm rocket program, told ISG that he informally heard that Ja’far and Al-‘Aziz determined that the tubes could not be used for centrifuges.

- In his postwar debriefings, Ja’far also opined that using 81-mm rockets as a cover story for a centrifuge program would not have been very useful because Iraq had difficulties importing any goods. Ja’far also told debriefers that developing an indigenous carbon-fiber filament winding capability would have been much more useful if Iraq intended to resume a centrifuge effort.

Dr. Mahdi Shukur Al ‘Ubaydi, the head of the pre-1991 centrifuge program, similarly did not consider it reasonable that Iraq could have pursued a centrifuge program based on 81-mm aluminum tubes. Al ‘Ubaydi believes that, besides himself, the only Iraqis capable of assessing the suitability of aluminum tubes for centrifuge use were Jamal Ja’far, Dr. Farid Bashir Yusef, and Dr. Makki Kadhim Rashid—the latter two having fled Iraq years before the war. Al ‘Ubaydi assessed that no one in Iraq could have redesigned the centrifuge to use an 81-mm aluminum rotor.

- Al ‘Ubaydi stated that Iraq was able to quickly develop its pre-1991 centrifuge program because of the raw intelligence of Jamal, Farid, Makki, and himself—an underestimation, we believe, of the contribution of technology, designs, and expertise provided by a few experts from the European uranium enrichment consortium, URENCO. Nonetheless, Al ‘Ubaydi stated it still took Iraq 2.5 years to understand the working design it obtained from abroad.
- Al ‘Ubaydi assessed that redesigning a centrifuge by scaling it up or down in size would have been a completely different task, and he would have hesitated “a million times” before attempting to do so. Al ‘Ubaydi opined that a renewed effort would more likely build on this earlier work with URENCO-type machines and utilize carbon fiber.
- Another official from the former centrifuge program similarly told ISG that Iraq lacked the

necessary expertise to design a centrifuge using 81-mm diameter high-strength aluminum tubes. The official noted Iraq’s prewar expert in centrifuge modeling left the country around 1996 and now most likely is a university instructor. The same source describes other losses of personnel with one colleague having left to work in private industry while a third moved to a MIC center.

ISG also has not found a nuclear connection that influenced the evolution of the design or tolerances for the 81-mm tubes. According to reporting, ‘Arif Kaddur Al-Kubaysi, former al Fatah Director of Engineering Affairs and lead 81-mm rocket designer, freely set the design of the metal parts of the rocket as he saw fit. This reporting claimed no one changed any specifications for the aluminum tube rocket body after 2000—notably not Ja’far Diya’ Ja’far, ‘Abd-al-Tawab Huwaysh, ‘Abd Al-Baqi Rashid Shiya, or Faris ‘Abd Al-Aziz Al-Samarrai.

ISG found only one former nuclear official connected—the connection may be coincidental—to the design of the 81-mm rocket. As the former head of al Qa’Qaa’, Sinan Rasim Sa’id reportedly was involved in developing propellant for the rocket—one of the alleged underlying causes of the inaccuracy of the weapon. Prior to 1991, reporting indicates Sa’id helped maintain electrical equipment for the electromagnetic isotope separation (EMIS) and centrifuge uranium enrichment efforts.

Tube Characteristics and Shipping Requirements

ISG’s investigation into why Iraq sought aluminum tubes with such high specifications before the war—a key factor that raised concerns that the Regime had restarted a centrifuge effort—has uncovered plausible but not always consistent accounts that link the tubes to 81-mm rockets. Multiple officials involved with the Iraqi rocket program claim that the tight specifications on the aluminum tubes were driven by efforts to improve the accuracy of this barrage-type weapon. These sources report that in 2000, Dr. Huwaysh formed a committee to set final rocket specifications and address problems with its accuracy.

Varied Reactions to the Tube Seizure in 2001

ISG has uncovered mixed and sometimes conflicting reactions by Iraqi officials to the June 2001 seizure of high-strength aluminum tubes—items reportedly stopped based on concerns the tubes violated sanctions and nuclear export controls. Ja'far told debriefers that the seizure did not capture his attention because he thought the tubes simply were stopped as a result of sanctions. He claims he was not aware of any MIC inquiries in the wake of that seizure to suggest the tubes were intended for centrifuge use and deemed foreign government claims in 2002 that the tubes were suitable for centrifuges as insignificant. He also claims he did not become concerned about centrifuge allegations until early 2003 when the issue arose in the United Nations Security Council.

- *Ja'far's reported efforts to gather information in early 2003 to deal with IAEA inspectors from Faris Aziz and others seem to be the extent of his concerns with the tubes prior to the war. ISG believes that Ja'far is a likely candidate to have known of renewed nuclear work—had any been under way—given his preeminent role as the head of the pre-1991 nuclear weapons program.*

Similarly, the head of Iraq's pre-1991 centrifuge program reportedly had no knowledge of a nuclear connection to the aluminum tubes until the issue surfaced months before Operation Iraqi Freedom. According to interrogation interviews, he was not part of Ja'far's review for inspectors, and he was not tasked to consider the suitability of the aluminum tubes for centrifuges. Reportedly Al 'Ubaydi said he learned the tubes were destined for a rocket program in late 2002 when Dr. Amir Al-Sa'di, a Presidential Advisor, queried him if the pre-1991 centrifuge program had used aluminum.

- *Al 'Ubaydi reportedly learned from Jamal Ja'far, a technical expert from the pre-1991 centrifuge program, that aluminum could be used in magnetic-bearing centrifuges—and passed this point to Sa'di.*

Dr. Huwaysh, however, claims he took several actions in the wake of the 2001 seizure—one of many claims he makes that are inconsistent with other debriefing accounts. Dr. Huwaysh indicates that it was the procurement front company that first informed MIC that the tubes were stopped because of centrifuge concerns. Dr. Huwaysh then claims he asked Al 'Ubaydi to investigate and received word in early 2002 from Hussam Muhammad Amin, the head of Iraq's National Monitoring Directorate that Al 'Ubaydi concluded the tubes could be used for centrifuges. Dr. Huwaysh then claims he ordered 'Abd Al-Baqi Rashid Shiya, then Director General of the Al-Rashid State Company, to find an alternate metal—not subject to nuclear export controls—that would still be strong enough to make the motor cases for the 81-mm rockets.

- *Dr. Huwaysh adds that he trusted Baqi to change the alloy and did not confirm the order was followed. When shown a copy of a 2003 fax from a procurement company that specified the prohibited alloy, Dr. Huwaysh adamantly claimed it was a mistake, as Baqi would never have disobeyed his order.*

Baqi claims that Dr. Huwaysh did not ask him to make any changes after the capture of the tubes during the summer of 2001, adding that other key rocket program officials would have known of such a modification if it had been ordered. Baqi reportedly heard indirectly that Dr. Huwaysh did not think the tubes were suitable for centrifuges and that news reporting in this regard was mistaken.

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- *Engineer Abd Al-Baqi Rashid Shiya, then Director General of the al Rashid State Company, led the 17-member committee, supported by his deputy and head of the National Monitoring Directorate (NMD) at al Rashid, Sa'ad Ahmad Mahmud. NMD head Lt. Gen. Husam Amin also participated, ostensibly due to his rocket engineering expertise, as did Arif Kaddori Atawi Al-Kubaysi, the lead engineer for the 81-mm rocket program. (See inset on insights.)*

- *The committee reportedly completed its work in September 2000, concluding that inconsistencies between rockets resulted in variations in range and accuracy—a problem they chose to address, in part, by reducing mass differences between rockets and components by tightening specifications. The committee also reportedly considered propellant-related problems and quality-control issues.*

Comments From the Head of the “2000 Committee”

ISG interviews with ‘Abd Al-Baqi Rashid Shiya revealed insights into the thinking of the 2000 Committee, which he led in an attempt to improve the accuracy of the 81-mm rocket. Baqi claims that the 2000 committee noticed that the engineering drawings for the 81-mm rocket had undergone many ad hoc revisions over the years, changes ostensibly made to ease its manufacture. Baqi told postwar debriefers that one goal of the 2000 committee was to return the 81-mm rocket to its original Italian-based design by setting new specifications for imported tubes—an unrealistic goal given that Iraq had made changes in the late 1980s that affected propellant performance and lifetime.

According to Baqi, the committee checked all the parts of the rocket and found that unwanted dispersion was caused by problems with the nozzle and the nonalignment of the propellant, nozzle, and motor case—a slightly different cause than the mass differences noted by other officials. Baqi also described that the committee examined problems with the propellant, manufactured by the Al-Qa’ Qaa’ State Company, because this would occasionally cause rockets to explode during flight. The committee reportedly concluded these misfirings were caused by pitting of the tubes—probably a reference to corrosion marks caused by improper storage—and problems with the insulator between the propellant and the tube. Baqi also claimed that the launcher was not a significant part of the rocket’s scatter problems—a conclusion also reached by the 2000 Committee.

- A separate source associated with the rocket program claimed the 81-mm rocket accuracy was adversely impacted by a number of factors—some resulting from its conversion from an air-to-ground into a ground-to-ground system. This source claimed that down-range accuracy problems were caused by a lack of initial velocity, instabilities from the ground launch platform, and insufficient design features that would have produced more spin.
- This source also claimed the quality of Iraqi propellant adversely affected the range of the 81-mm rocket. Iraq reportedly modified its 81-mm rocket propellant in 1988 or 1989 when Amir Al-Sa’di,

then Director of the MIC, commissioned a group at al Qa’ Qaa’ to examine why some Italian-made rockets prematurely exploded. The group discovered droplets of nitroglycerine formed on the propellant inside the rocket body, causing the malfunction. By modifying the propellant, Iraq increased rocket shelf life from 1 to roughly 5 years but at the cost of consistent propellant performance that affected accuracy.

Baqi claims he was not alone on the 2000 committee in questioning why the military wanted the 81-mm rocket, adding that the 107-mm rocket was easier to produce, had fewer parts, and a bigger warhead. Baqi notes the lead production engineer and Kubaysi as two of the 2000 committee members who shared his views that it was a bad idea for Iraq to make the 81-mm surface-to-surface rocket by attempting to copy the Italian air-to-surface rocket. Baqi claimed many engineers wanted to end the 81-mm rocket program in favor of the 107-mm rockets.

- Baqi echoed claims by Dr. Huwaysh that the military apparently wanted the 81-mm rocket because they already had launchers for them. Additionally, Baqi noted quality control was a general problem with the 81-mm rocket program.
- Reporting indicated that the 81-mm rocket program should have been canceled because other rockets in Iraq’s arsenal were capable of fulfilling its role and posed fewer problems. According to this reporting, the nominal 9.5-kilometer range of the 81-mm rocket could be covered by the 107-mm and 122-mm systems with ranges of 1-8 kilometers and 5-20 kilometers, respectively. According to reporting, many military officers were opposed to the 81-mm rocket system, but they allegedly were overruled by more senior leadership. According to reporting, the 81-mm rocket suffered about twice as much scatter as the 122-mm rockets Iraq produced.

Nearly all critical linear dimensions and related tolerance specifications that raised prewar concerns over possible centrifuge end use can be linked to decisions reportedly made by the 2000 Committee for rockets. While participating in the work of the 2000 Committee, multiple officials indicate the lead design engineer tightened the inner and outer diameter specifications for imported tubes. In his interviews with ISG, the lead design engineer noted that the 2000 Committee decided that the rocket body mass could vary by only 30 grams—a tight requirement that led to the setting of diameter specifications used in Iraqi procurement attempts since April 2002—the same values Iraq’s NMD declared to the IAEA in the 6 March 2003 letter. (see Table 4.)

- The lead design engineer also reportedly sought to reduce the total allowed mass variation between rockets to 300 grams out of 8.5 kilogram total weight, with only 150 grams allocated to differences stemming from metal parts. Reportedly, pressure testing confirmed that trimming wall mass from the rocket tubes did not adversely affect the strength of the tube.

Reporting indicates the shipping requirements originated from recommendations by Dr. Sami Ibrahim of the Baghdad University of Technology, who investigated why the aluminum tubes, purchased from Germany in the 1980s for the 81-mm rocket program, corroded when stored outdoors at Tho Al-Fiqar.

- Ibrahim concluded that the unanodized German tubes corroded from a galvanic reaction made possible by stacking the tubes horizontally in direct contact with each other and outdoors. Ibrahim reportedly noticed other unanodized 7075 alloy aluminum tubes also stored outdoors since 1989 at Tho Al-Fiqar, a flow-forming facility. These tubes were stored upright and separated from each other with nylon mesh—factors that influenced his recommendations on how to prevent tube corrosion.

Baqi’s requirements seem to have grown out of a desire to avoid angering Dr. Huwaysh, who reportedly was upset when he saw the corroded tubes at Tho Al-Fiqar during a visit in 1998. Iraq also took a further precaution of reanodizing aluminum parts after machining to ensure that no further corrosion would occur.

Tho Al-Fiqar also seems to have set other specifications for the rocket program that were not directly addressed by the 2000 Committee in its procurement specification document. According to a former official in the 81-mm rocket program, the Tho Al-Fiqar specifications document was prepared to assist procurement officials in acquiring high-strength aluminum tubes. In that document, the lead production engineer reportedly set an artificially tight specification of 0.05 mm for eccentricity—one of the properties related to uniform tube wall thickness. Tho Al-Fiqar officials insisted on the specification—twice as tight as the 0.1 mm reportedly actually needed—to ensure that imported tubes would pass military quality-control requirements after the tubes were machined.

- The lead design engineer has also claimed that he determined the maximum value for eccentricity of the raw aluminum tubes as needing to be between 0.05 mm and 0.1 mm.

With the reported exception of latitude given to the Director General of Tho Al-Fiqar to further tighten tolerances, few changes reportedly were made to the imported tube requirements specified by the 2000 Committee. According to an official from the Iraqi rocket program, no one was permitted to loosen the specification set by the 2000 Committee. However, the lead production engineer reportedly had the authority to further tighten specifications in order to ensure that usable parts were received from vendors. Otherwise the parts received might not meet the requirements stated in the pertinent procurement documents.

- The latitude reportedly available to the lead production engineer could explain why Iraq tightened the eccentricity specification on the tubes in early 2002—an action viewed at the time to be unnecessary for a rocket program. Tight eccentricity specifications reportedly were needed to pass military quality-control inspection—a check that could not be overruled by production personnel, according to reporting.
- Reporting indicates the hardness requirement for the nozzle was one of the few changes made after the committee completed its work, adding there were no other changes to the metal part specifications, including the rocket motor tube.

Table 4 Rocket Tube Dimensions				
	Iraqi	Technical for year	Drawing	
Rocket Chamber/ Tube Characteristic	1989	1993	1997	Specification After 2000 Committee
Outer Diameter	81.0 mm	81.0 +/- 0.2 mm	81.0 +/- 0.2 mm	81.0 + 0 / - 0.1 mm
Inner Diameter	74.4 mm	74.4 + 0.1 – 0.3mm	74.4 + 0.1 – 0.3mm	74.4 + 0.1 / - 0 mm
Final Length	868 mm	868 + 0.2/-0 mm	868 +/- 0.2/-0 mm	868 +/- 0.3 mm
Mass	1812g	1820 +/- 100g	1820 +/- 150g	1828 +/- 30g

A summary of Iraqi tube linear dimension specifications as found on 81-mm rocket drawings before and after they were reportedly tightened by the 2000 Committee.

Indigenous Tube Manufacture—A Possible Sign Baghdad Did Not Need High-Specification Tubes

Frustrated by its inability to import tubes, Iraq began indigenous production efforts in mid-2002 that ultimately raise questions about whether high-specification tubes really were needed for rockets.

Dr. Huwaysh reportedly formed a committee in May or June of 2002 to study how to indigenously produce tubes for 81-mm rockets. One report indicates the committee—led by the heads of the al Nida and Tho Al-Fiqar State Companies—considered using the extruder at the Ur Establishment in Nasiriyah and two flow-forming machines at Tho Al-Fiqar to produce tubes. This committee conducted its work while foreign procurement attempts continued as well as indigenous manufacture of rockets using corroded tubes.

- Efforts to extrude tubes reportedly failed after four to six weeks despite assistance from the Badr and al Shahid State Companies and the University of Technology in Baghdad—including Dr. Sami Ibrahim. Multiple reports indicate the Ur extrusion press was too weak to handle high-strength 7075 T6 alloy. An effort by Badr to develop a special tool for the press reportedly ended with the war.
- Accounts differ on those responsible for developing the flow-forming techniques that successfully produced about 50 tubes per day through continuous

operations at Tho Al-Fiqar. One piece of information credits the University of Technology and the 2002 Committee for developing the necessary heat treatment procedures while another indicates that the Director General of the al Nida State Company devised the production process. MIC reportedly envisioned the Sabah Nisan (Seventh of April) Company would make forgings for future operations, but this plan also was interrupted by the war.

The indigenous effort to produce tubes in the last months before the war resulted in production and handling standards that fell short of those required for the imported tubes. Reporting indicates that the lead production engineer gave Dr. Huwaysh some sample flow-formed tubes in late September or October 2002, noting that the production process was costly and time consuming. The lead production engineer also indicated that the best possible tolerance achievable on the outer diameter of flow-formed tubes was $81 + 0.2 / -0.1$ mm—a figure that falls short of the requirements set for imported tubes. Another source indicates these aluminum tubes reportedly were flow-formed to a diameter of about 82.5 mm then machined to their final dimensions. To accommodate for the limitations in flow-forming technology, a separate, looser set of technical specifications reportedly were produced for indigenously produced rocket bodies (see Table 5).

- Reporting also indicates indigenously produced tubes were also handled differently than those that would have been imported. Between flow-forming steps indigenously manufactured tubes reportedly were shipped in ordinary wooden boxes or simply stacked for storage—a sharp contrast to the packaging and anodization requirements demanded by the 2000 Committee for imported tubes. The same reporting also indicates the tubes also reportedly were not individually wrapped or separated from each other and were sometimes positioned horizontally—again contrary to the 2000 Committee recommendations.

In late 2002, the lead production engineer informed Dr. Huwaysh that the indigenously produced flow-formed tubes could be used without affecting rocket performance—a significant shift from the 2000 Committee findings and one that the MIC director reportedly accepted. The lead production engineer reportedly passed this view to Dr. Huwaysh in a meeting attended by lead engineer Kubaysi, another member of the 2000 Committee.

- Reporting also indicates indigenously manufactured flow-formed tubes were successfully used in flight tests completed at the end of 2002 with the Iraqi Army approving the looser specification design in January 2003.

Iraq's Interest in Steel Rocket Body Tubes

About a year before Iraq reportedly began its effort to indigenously produce aluminum tubes, the head of Tho Al-Fiqar reportedly explored the option of making 81-mm steel bodies for rockets instead. Baqi claims that he approved a proposal from the lead production engineer to study steel for the 81-mm rocket body as Iraq was struggling to import aluminum tubes. The lead production engineer reportedly delivered his proposal after a few months, but Baqi rejected it as it would have required almost a complete redesign of the rocket. Baqi claims he did not raise the issue with the lead production engineer again and that no 81-mm steel rockets were produced.

- Separate information confirms that Baqi rejected the notion of steel tubes for an 81-mm rocket on the basis that the modification was too significant for Dr. Huwaysh to accept. This reporting claims, however, that Baqi asked the lead production engineer to restart his work around 2002 because of the difficulties in acquiring aluminum tubes. The lead production engineer reportedly was insulted by Baqi's previous rejection, and refused to do the work.
 - This reporting indicates that, around 2002, the lead production engineer produced some flow-formed steel tubes for use in 81-mm rocket bodies. The lead production engineer reportedly found the steel bodies weighed too much and the effort halted.
-

Table 5 Tube Specification Comparison				
Rocket Chamber/ Tube Characteristic	Specification Required After 2000	Indigenously Pro- duced Tube 2003	Tubes Imported From Germany in Late 1980s	Original Italian Rocket
Outer Diameter	81.0 + 0 / - 0.1 mm	81.0 + 0.2 / - 0.1 mm	81.0 +/- 0.2 mm	81.0 + 0.4 / - 0 mm
Outer Diameter at 30.5 mm from ends		81.8 + 0.3 / -0.1 mm		
Inner Diameter	74.4 + 0.1 / - 0 mm	74.4 + 0.2 / - 0 mm	74.4 + 0.1 / - 0.3 mm	74.4 + 0.5 / - 0 mm
Final Length	868 +/- 0.3 mm	869 +/- 0.3 mm	868 +2 mm	868 + 0 / - 1 mm

A summary of Iraqi tube linear dimension specifications showing tighter specifications required after 2000 compared to those accepted for use from indigenous production in 2003. A second outer diameter specification for the indigenously produced flow-formed tube covers a 30.5-mm length on either end of the tube where the Iraqis allowed the tube diameter to significantly increase. Information on the imported German tubes—taken from an Iraqi quality-control document captured by ISG—provides figures inconsistent with Iraqi claims that it measured these tubes in 2003 and found them to be tighter than the 2000 Committee specifications. For comparison, the specifications of the Italian rocket that the Iraqis reverse-engineered is included.

Despite relaxed standards for indigenously produced tubes and increased international attention on the prospect of a renewed nuclear program, Baghdad continued to pursue high-specification aluminum tubes from abroad. According to reporting, in late 2002 or early 2003, the lead production engineer provided a representative of the Syrian-based Awad Amora Company with the same high-specification requirements for tubes as had been used with other prospective suppliers. Separate reporting confirms the Awad Amora procurement attempt, noting that Sa'ad Ahmed Mahmoud, the NMD representative at the Al-Rashid State Company, was told by MIC in 2003 to contact the company.

- Sa'ad also reportedly told the director of the NMD, General Husam Muhammad Amin about the ongoing procurement attempt. Amin reportedly became nervous about this continued effort to acquire goods subject to the nuclear controls under Annex 3 of UN Resolution 1051 and raised his concerns with Dr. Huwaysh. Nonetheless, the Awada Amora deal was still being negotiated at the time the war started, according to the reporting—a point ISG can independently confirm through captured documents.
- Dr. Huwaysh is the lone dissenter again in describing the events surrounding the dealings with Awad Amora, claiming the open bid was probably issued in 2002, not 2003.

Systemic problems such as bureaucratic inefficiencies and fear of senior officials seem to have played a significant role in the history of the 81-mm rocket and probably influenced why Iraq persisted in its effort to seek tubes with high specifications. Reporting suggests Dr. Huwaysh exhibited a rigid managerial style. For example, on hearing that the lead production engineer had succeeded in producing 50 tubes a day by continuously operating the two flow formers at Tho Al-Fiqar, Huwaysh reportedly insisted the production be doubled. The stress of working on the flow-forming project ordered by Dr. Huwaysh reportedly caused the Tho Al-Fiqar Director General to have a heart attack. Dr. Huwaysh also insisted on final approval of any changes to the rocket design after the 2000 Committee issued its results. Reportedly, the staff of Al-Fiqar feared Dr. Huwaysh's anger if modifications caused rocket failures.

- Fear of senior officials also traces back to the origins of the 81-mm rocket program in 1984 when Army officials reportedly were loath to challenge the decision by Husayn Kamil, then Saddam's son-in-law and head of MIC, to reverse-engineer and produce the weapon. Reporting indicates the Iraqi Army actually wanted 81-mm rockets for helicopters because they preferred the existing 122-mm and 107-mm rockets for ground-to-ground use.
- Reporting also reveals how the results of the 2000 Committee may have been influenced by a need to avoid problems with Dr. Huwaysh. One report claims the committee focused on specification and material problems to gain time to solve production problems at manufacturing facilities. Another report indicated Dr. Huwaysh wanted results quickly from the 2000 Committee; therefore, they did not attempt in-depth, detailed engineering analyses of rocket scatter. Instead, this report noted that the committee tightened some design specifications based only on the notion that doing so would improve rocket performance—a questionable engineering practice.
- Another report from the rocket program notes that many of the changes made by the 2000 Committee did not make technical sense, as members were simply tightening specifications in order to appear effective in addressing problems. The lead design engineer also told debriefers that rocket assembly was plagued by a lack of personal integrity, as people were more concerned with avoiding punishment or achieving quotas. The lead design engineer also claimed engineers and scientists would often make false claims or inflate their results in order to garner favor with Dr. Huwaysh.
- Fear of being held responsible for the cost of rejected tubes, components, or rockets also reportedly affected the lead production engineer and his decision to tighten tube specifications for the rocket program. A reportedly such punitive accountability practices were common for engineers or managers in Iraq when projects failed. With the high number of procured tubes involved, the cost to reimburse MIC would be excessive, probably leading to individuals being imprisoned until the debt could be repaid.

- Timing also could have affected why Iraq continued to use the tight specification requirements when dealing with Awad Amora. The acceptance testing by the Iraqi Army occurred around the same time that the Awad Amora deal was being broached—probably too soon for the new technical drawings from the flow-forming work to be forwarded to prospective foreign suppliers.

Iraqi Interest in 84-mm Tubes

ISG has been unable to corroborate reporting that suggested Baghdad sought 84-mm-diameter tubes—a diameter that would be too large for the 81-mm rocket launcher and a possible sign that Iraq intended some other nonrocket use for high-strength aluminum tubes. Information from a foreign government service received in mid-2004 indicates that the potential supplier was asked about supplying 84-mm diameter tubes—a change that would have resulted in a 3-mm increase in outer diameter as compared to the 81-mm size consistent with earlier purchase attempts. We have investigated this report further, and the connection with Iraq is unclear, as is the intended use of the 84-mm tubes.

A captured document reveals that Iraq already had 500 tons of 120-mm-diameter 7075 aluminum shafts at the Huteen State Establishment—stock that ISG believes Iraq could have used to produce tubes even larger than 84 mm if it intended to renew its centrifuge program. Reporting indicates Iraq imported 120 mm and 150-mm-diameter 7075 aluminum shafts before sanctions were imposed in 1990. Iraq had been using the material in the months before the 2003 war to support the Tho Al Fiqar flow-forming operations related to the 81-mm rocket program.

Carbon Fiber

ISG investigations have revealed that MIC's carbon fiber project was ultimately aimed toward the production of components for missiles; specifically, the combustion chambers of the al Fat'h missile.

ISG has found no evidence to suggest that the MIC's carbon fiber project in 2001/2002 was connected to a program to restart uranium enrichment gas centrifuge production; however, the project would have allowed Iraq to acquire valuable carbon-fiber-related knowledge that could be used in the future reconstitution of a centrifuge program.

Carbon Fiber and Iraq's Pre-1991 Gas Centrifuge Program

Iraq's magnetic-bearing centrifuge uranium enrichment program began in mid-1988 when German engineers brought European centrifuge design information to Baghdad. Further deliveries by additional German engineers gave the Engineering Design Center (EDC) a significant body of centrifuge design details. These German contacts also arranged procurement and technology transfer applicable to the design, production and operation of centrifuge cascades.

- In 1989, maraging steel cylinder fabrication proved difficult, and the EDC acquired a consignment of about 20 carbon fiber cylinders from a German supplier in 1990. Iraq used some of these cylinders to develop test machines for its centrifuge program.
- Iraq was arranging for a shipment of winding equipment and materials when sanctions were imposed in 1990. A winder and large quantity of carbon fiber for EDC never reached Iraq.

After adopting UNSCR Resolution 687 in April 1991, Iraq ceased work on centrifuge development, although the Iraqi Concealment Committee took the decision to hide documents and equipment related to this program. Although IAEA inspections were able to expose significant activities related to the centrifuge program, Iraq continued to conceal significant centrifuge documents and materials until the defection of Husayn Kamil in 1995. This defection triggered additional disclosures to IAEA inspectors.

- Mahdi Shakur Al ‘Ubaydi—the former head of the pre-1991 centrifuge program—continued to hide centrifuge components and documentation for future effort after the Husayn Kamil defection. We cannot link Al ‘Ubaydi’s efforts to hide these materials after 1994 to any instruction from Regime officials.

The EDC successfully produced two centrifuges using imported carbon fiber rotors and foreign assistance by mid-1990, one of which was tested with UF₆ feed. In 1989, the EDC began seeking machinery and raw materials to establish an indigenous carbon fiber production capability in support of a centrifuge production effort.

- This included the attempted procurement of a filament winding machine from the ALWO company in Switzerland and carbon fiber, which was sought through an order placed with the German company ROSCH (see Figures 9, 10, and 11).

However, ISG analysis suggest that, at the time of Desert Storm, Iraq did not have the capability to indigenously produce carbon fiber suitable for use in gas centrifuges.

- A former senior MIC executive revealed to ISG that, although Iraq had the capability to produce epoxy resin for carbon fiber applications, it had no capability to produce carbon fiber. The That Al-Suwari Company E-Glass plant could produce only low-strength fiber glass.
- An ISG site survey of South Taji, conducted in January 2004, found no evidence of carbon fiber production or a latent capability to produce carbon fiber.

Iraqi Concealment of Carbon Fiber-Related Activity, Materials, and Documents After Desert Storm

In the short period between the end of Desert Storm and Iraq’s acceptance of Resolution 687, the EDC continued its development of gas centrifuges and resumed work on a 50-machine cascade—an effort that was part of a crash program to produce enriched uranium for a weapon by further enriching uranium from its safeguarded research reactor fuel. A senior nuclear scientist told ISG that, as soon as the 1991 Gulf war ended, a Presidential Scientific Advisor ordered the resumption of work on a 50-machine test cascade.

On adoption of Resolution 687, work ceased on the test cascade, and the Iraqi Concealment Committee took the decision to hide documents and equipment regarding gas centrifuge research from the UN. ISG analysis suggests that this was motivated by a desire to restart gas centrifuge research and production at a time when sanctions were lifted. However, by late-1991 the IAEA was actively removing and destroying the majority of Iraq’s centrifuge research program.

- A senior Iraqi nuclear scientist recalled that one of the committee’s first decisions was to hide both the EDC’s Rashdiyah and Al Furat facilities and strip all nuclear-related material from them. The SSO was responsible for the removal and packaging of EDC documents and equipment.
- The scientist also revealed that Iraq intended to build a 100-machine cascade when sanctions were lifted and that the EDC documents and components collected by the SSO in 1991 were to be used in this effort (see Figure 11).

In a separate action, Husayn Kamil ordered the retention of at least one copy of all nuclear-related documents and some centrifuge components by a senior nuclear scientist. In 1995, following Husayn Kamil’s defection, the IAEA seized a number of WMD-related documents and items of equipment from the Haidar Chicken Farm. The equipment seized included spools of high tensile, carbon fiber, and other centrifuge-associated components.

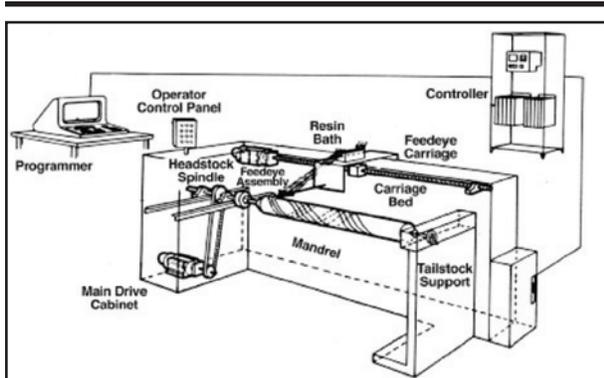


Figure 9. Horizontal filament winding machine.

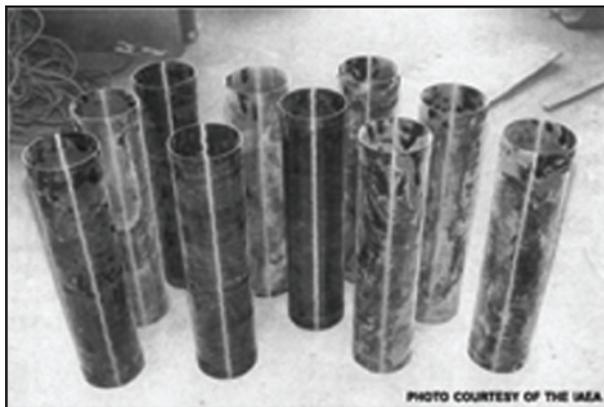


Figure 10. Carbon fiber tubes.

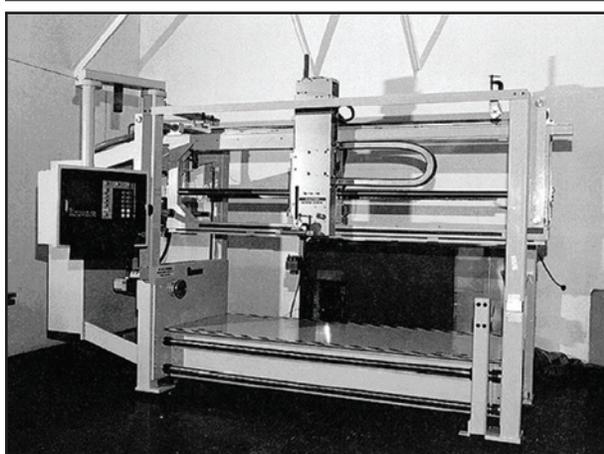


Figure 11. Example of horizontal filament winding machine.

In 2003, Al 'Ubaydi publicly revealed that he had retained centrifuge-related equipment and documents at his home throughout the 1990s and during many UN inspections. Al 'Ubaydi stated that this had been done in response to Husayn Kamil's order to keep a copy of all centrifuge-related documents.

The MIC Carbon Fiber Project in 2001/2002

The MIC carbon fiber project in 2001/2002 began exploring carbon fiber technology for use in the Iraqi Missile Program and was managed by the MIC-owned Al Rashid State Company. The material researched was specifically for use in the al Fat'h missile, and possibly the Al Naqwa anti-tank guided missile (ATGM). The project aimed to create an indigenous carbon-fiber-based production capability, based on previous experience with the Brazilian ASTROS Rocket in the 1980s, and included the refurbishment of one filament winding machine already within Iraq and the production of a second. At the time of Operation Iraqi Freedom, the refurbishment of the first machine was 50 percent complete, and the production of the second had not started.

Al 'Ubaydi, the former head of the Iraqi centrifuge project, played a role in the MIC carbon fiber project. ISG has not found any evidence to suggest that Al 'Ubaydi was involved in the project at the technical level. His main role was to head the committee that selected the company to build the filament winding machine.

In mid-2002, the Al Rashid State Company took delivery of a filament winding machine from the IAEC. This machine was to be refurbished because it was in a nonoperational state, and the design then copied for the second filament winding machine. According to a former MIC scientist the IAEC, the carbon fiber filament winding machine had not been used since 1990. The scientist was not aware of why the IAEC had such a machine.

ISG investigations and debriefs with multiple officials reveal that the minimum production diameter of the filament winding machines under development by MIC was 500 mm. This is consistent with the al Fat'h missile. This is significantly wider than

the carbon fiber rotor used in the pre-1991 Iraqi gas centrifuge, which had a diameter of approximately 145 mm.

Limited information indicates that the filament winding machines may have been used in the manufacture of components for the Al Naqwa ATGM. This missile has a diameter of between 150-200 mm and is much more closely matched to that of the pre-1991 carbon fiber rotor. However, ISG has been unable to find information to corroborate this claim, and a second report stated that the Al Naqwa ATGM motor case was made on a turning machine and not a winding machine.

With the exception of the filament winding machine that the Al Rashid State Company received from the IAEC, ISG has not found any further evidence of cooperation between MIC and the IAEC on the carbon fiber project, or any instances of the IAEC taking an interest in the progress or results of the research undertaken by MIC. Multiple source debriefs support this in that numerous former IAEC and MIC employees attest to the fact that the IAEC and MIC rarely worked together on joint projects.

Flow-Forming Machinery

ISG did not find evidence that flow-forming equipment was used to produce rotors for a reconstituted nuclear centrifuge program. As a result of IAEA inspections and Iraqi mishandling of equipment—in an effort to avoid potential military strikes—Iraq effectively lost its capability to conduct flow-forming operations of the type needed to support a centrifuge program.

- On 23 June 2003, an ISG team inspected the Umm Al Marik site. It was severely looted and vandalized. The team saw several of the machine mounts where the flow formers had been mounted prior to the war. The remains of one large flow former remained, stripped of all usable parts.

Beginning in 1989, Iraq was pursuing advanced flow-forming technologies and equipment from foreign sources. One company that provided considerable technical support and machinery to the Iraqi industrial base was the H&H Metalform Company of Germany. Iraq's Engineering Design Center failed to develop a maraging steel centrifuge rotor due to manufacturing limitations, which helped precipitate the shift to trying to acquire a carbon fiber production capability.

- As of 1991, H&H Metalform had sold nine flow-forming machines to Iraq.
- In February 1993, a UN Inspection Team visited the Nassr Plant; they inventoried and recorded the serial numbers of eight Flowtronics, H&H flow-forming machines. Iraqi officials contend that these machines were used to produce 122-mm rockets and components (see Figures 12 and 13).



Figure 12. H&H flow formers.



Figure 13. Dispersed and destroyed flow-forming machines (Tho Al Fiqar).

Planned Magnet Production Lines at Al Tahadi

ISG has not uncovered information indicating that the magnet production capability being pursued by Iraq beginning in 2000 was intended to support a gas centrifuge uranium enrichment program, but the magnet production lines would have allowed the Iraqis to preserve their skills for a centrifuge magnet program.

- Iraq investigated use of centrifuges as one approach to manufacturing enriched uranium in their pre-1991 nuclear program. One of the centrifuge designs investigated included use of magnetic bearings to support the rotor. The pre-1991 Iraqi nuclear program was able to successfully test a magnetically supported rotor.
- Iraq purchased Aluminum-Nickel-Cobalt (AlNiCo) and Cobalt-Samarium (CoSm) ring magnets for their pre-1991, magnetic-bearing centrifuge program. Centrifuges can be designed to use a variety of ring magnets of different dimensions and materials.

ISG also cannot refute Iraq's claim that the magnet production lines it sought beginning in 2000 were intended for other than routine industrial and military uses. The declared use of the magnet production lines were for production of ring magnets in the Saham Saddam Missile and for field telephones. According to Iraqi officials, the Iraqis chose to purchase the production lines *in lieu* of buying the magnets, which would have been cheaper. In addition, the Iraqis wanted the experience and knowledge that would eventually come with operating the lines. The Al Tahadi site was heavily looted after Operation Iraqi Freedom, and no documents or equipment remained at the site.

Procurement Details

The Al Tahadi Company contracted to purchase magnet production lines on two occasions beginning in 2000—neither of which were completed or delivered. Iraqi specifications for the magnet production lines were typically vague. The Al-Sirat Company, a trading company responding to MIC requests, initiated the first of two procurement efforts in 2000. The procured line would include cast or powered magnets of all types, including Aluminum-Nickel-Cobalt (AlNiCo) and Samarium Cobalt (SmCo)—the latter was used in Iraq's pre-1991 nuclear program. According to a MIC engineer experienced in magnet production, this contract for magnet production lines was signed in 2000 with a Romanian company.

- The contract included equipment to manufacture AlNiCo ring, cubicle and cylindrical magnets ranging in mass from 0.5 to 500 grams—a range that could have supported production of magnets needed for centrifuges. Such magnets, however, also would have had to conform to specific density and morphology requirements for use in centrifuges.

The second contract for magnet production lines was signed in 2001 with a Belarusian company. Only some of the equipment specified in the contract was received, including a press machine and a mixer. The contract had included equipment to produce permanent ferrite magnets.

Rotating Machinery Department

ISG has not been able to find evidence to show that the machine tools ordered in 2002 by a new department in MIC's Saad Company called the Rotating Machinery Department were intended for a renewed centrifuge program, and available information suggests that the equipment was not capable of supporting such work. The equipment sought included machines for rotary balancing and spin testing, as well as a milling machine and a lathe.

- Such machines can be used to balance equipment such as turbines, pumps, and compressors. They are also applicable to developing skills useful for centrifuge design and testing. Iraq's pre-1991 nuclear program used rotary balancing machines, a technology used widely in industrial applications, in development of centrifuges for enrichment of uranium.
- The Ibn Yunis Center, part of the MIC's Saad Company, formed the new Rotating Machine Department in mid-2002. The department was small—only four engineers—when it was set up. The intention was to establish a profit center to perform repair and maintenance work on the many compressors, turbines, and other rotating machines in Iraqi industry.

In mid-2002, Dr. Khalid Ibrahim Sa'id, a former PC-3 scientist, asked about the capability of the balancing machine ordered for the newly formed Rotating Machinery Department. ISG has received conflicting information as to whether the inquiry shows interest in its potential use for a centrifuge program or was an attempt to ensure that the equipment did not violate provisions of UN Security Council Resolution 1051, Annex 3 of the Ongoing Monitoring and Verification Plan.

- Dr. Sa'id, a high-ranking Baathist and Secretary of the Industrial Committee at the time, asked the Director General of Ibn Yunis Center whether the equipment being sought would violate the provisions of Annex 3. The Director General asked engineers in the Rotating Machinery Department whether the equipment could be used for centrifuges. The response from the engineers was "no" because the equipment did not meet the specifications required for centrifuge use.
- The Ibn Yunis director, however, reported that Sa'id's involvement stemmed from his role as the secretary of the Industrial Committee, which gave him responsibility for allocations of foreign currency for procurements. MIC Deputy Director Dagher sought non-MIC currency allocations for the Department of Rotating Machinery purchases, and Sa'id reportedly selected un-used IAEC funds for these purchases. Huwaysh told ISG that it would make no sense for the IAEC to have used its budget to buy equipment for the MIC.
- Al 'Ubaydi stated in an interview that he was sufficiently curious about Sa'id's interest to press a friend, a former engineer in the pre-1991 centrifuge enrichment program and member of the Rotating Machinery Department, for information on potential inquiries he may have received concerning the reconstitution of a centrifuge program.

The purchase by the Rotating Machinery Department machinery used purchasing channels that were not the norm—adding to the suspicion surrounding the order. The MIC, of which the Rotating Machinery Department was part, had its own purchasing procedures. The order for the machines was placed using IAEC resources for the purchase—a procedure that would be outside the normal MIC purchasing procedures. ISG has not discovered the reason for the alternate purchasing arrangement.

- Huwaysh told ISG that it would make no sense for the IAEC to have used its budget to buy equipment for the MIC.

The Rotating Machinery Department also sought a balancing machine, which, at the minimum, would have helped Iraq maintain important skills that could have been applied to a renewed centrifuge program. It is not clear whether this machine could balance centrifuge rotors, given that the machine specifications called for balancing much heavier components, up to 500 kgs. The balancing machine that was ordered by the Ibn Younis Center for the Rotating Machinery Department was never received.

Balancing machines were purchased by at least two other organizations in the MIC—which Iraq declared to the IAEA as not being covered by Annex 3 (see Table 6).

- The Specialized Institute for Engineering Industries (SIEI) purchased a vertical-type balancing machine with a maximum balancing speed of 1,200 rpm. This is an engineering support company that provides resources for the engineering and industrial sector.
- The Factory for the Repair of Jet Engines (FRJE) purchased a vertical-type balancing machine with a maximum balancing speed of 4,000 rpm. The mission of FRJE is to repair various types of jet engines used in the Iraqi Air Force (see Figure 14).

Specification	Balancing Machine Ordered	Annex 3 Restrictions
Rotor Length ^a	1500 mm	> 400 mm
Swing/Journal Diameter ^{a, b}	10-120 mm	>75 mm
Mass Capability ^a	750 kg	0.9 to 23 kg
Balancing Speed ^a	3000 rpm	>5,000 rpm
Residual Imbalance ^b	0.0015 kg/mm/kg	Better than 0.010 kg/mm/kg
Drive Type ^b	Drive and belt options supplied	Belt

^a Centrifugal balancing machines designed for balancing flexible rotors (Annex 3, item 57.1)—all conditions must be met to be prohibited.

^b Centrifugal balancing machines designed for balancing hollow cylindrical rotor components (Annex 3, item 57.2)—all conditions must be met to be prohibited.

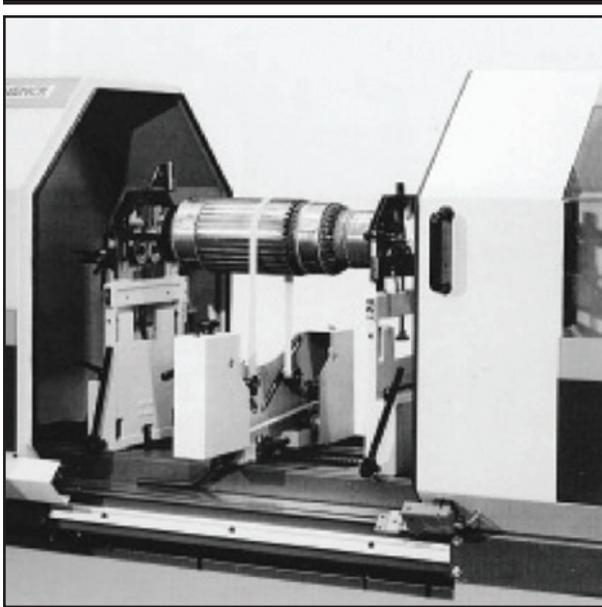


Figure 14. Typical horizontal balance machine.

Investigation of Potential Centrifuge-Related Facilities

ISG investigations of sites related to the pre-1991 centrifuge program did not uncover any attempt to utilize these facilities to support a renewed centrifuge effort. ISG site visits revealed significant looting and destruction, which have rendered the sites inoperable.

- Site exploration of the Al-Furat site conducted in September 2003 revealed looting and occupation by squatters. In the pre-1991 program, a centrifuge assembly hall and cascade had been planned for Al-Furat. The IAEA removed the centrifuge-related equipment from this site in the 1990s.

Support Facilities

ISG investigation into known or potential support facilities also found no evidence these sites had been involved in any renewed enrichment work.

Along with research and development and production facilities, a centrifuge program would require a large infrastructure for fabrication, assembly, testing, and material support. The following sites were investigated because of their potential as locations where key elements of the reconstitution could take place:

- Ash Shaykhili Storage Facility
- Al Karama State Company
(Al-Waziriya Site (al Samud Factory, Khadimiyah Site (Ibn Al-Haytham), Al-Fatah Factory (Al Quds Factory))
- Basdr and Umm Al-Marik State Companies
(Khan Azad Military Production Plant)
- Al-Tahadi State Company
- Salah al-Din State Company
(Samarra Electronics Plant)
- Al-Nida State Company
- Nassr State Company
(Taji Steel Fabrication Plant)
- Ur State Company
(An-Nasiriyah Aluminum Fabrication Plant)

Ash Shaykhili Storage Facility

Ash Shaykhili Storage Facility—prior to Operation Iraqi Freedom—had stocks of fluorine, Anhydrous Hydrogen Fluoride (AHF), and UF₆ cylinders in Building 27A. Building 27B also contained a specialized ventilation system with scrubbers, which would be ideal for pilot-scale development of UF₆ production process. In the early 1990s, the IAEA either destroyed or collected centrifuge components from various sites across Iraq and placed them in storage at Ash Shaykhili. The IAEA inspectors, upon returning to Iraq in late 2002, performed a detailed inspection of the Ash Shaykhili storage site and made several more inspections of the site in early 2003.

In late April 2003, the site was surveyed by Coalition forces, which found it damaged and burned from bombing and looting. Also in early July 2003, an ISG team returned to Ash Shaykhili to assess the condition of Buildings 27A and 27B. They found that the contents of Building 27A had been burned and everything inside Building 27B had been removed, except for portions of the air-handling duct work (see Figure 15).

The results of environmental samples taken at Building 27B, during the April 2003 ISG site visit, indicated the presence of fluorides at the site, which we suspect are the result of pre-1991 activities. ISG did not find that any nuclear-related activity had been established here and based on the current condition of the Ash Shaykhili, ISG concludes that it would not be able to support any centrifuge activities without major rework.

Al Karama State Company

The al Karama State Company consists of several facilities that have precision machining capabilities. Al Karama's subordinate facilities are:

- Waziriyah Site (al Karama Missile and Electronics Plant).
- Khadimiyah Site (Ibn Al-Haytham Missile Production and RDT&E Center).
- Al Samud Factory (Abu Ghurayb Missile and GSE Support Facility).
- Al Fatah Factory.
- Al Quds Factory.

Although the facilities associated with the Al Karama State Company continued to function during the 1990s, ISG did not find that any of these sites were used to support a uranium enrichment program.

Al-Wazeriya Site

An ISG exploitation team visited the Karama Al-Wazeriya Site in early August 2003 and concluded that the site appeared to have been abandoned for at least several months. According to one source at this site, no missiles were produced at the facility after the site was bombed during Operation Desert Fox in 1998. Iraq did not rebuild the missile production capability at Al-Wzaeriya after Desert Fox, and instead used the site as the headquarters for Al Karama.

Khadimiyah Site (Ibn Al-Haytham Missile R&D Center)

The Khadimiyah Site was part of the al Karama State Company and Iraq's primary production and integration facility for the al Samud and al Samud II Short-Range Ballistic Missile (SRBM). The facility suffered damage from Coalition air strikes in late March 2003.

Al Samud Factory (Abu Ghurayb Missile Facility)

Al Samud Factory was Iraq's primary al Samud component production facility. The al Samud Factory was significantly damaged during Operation Iraqi Freedom by Coalition air strikes in late March 2003. ISG visited the site on 28 September 2003 and verified both the bomb damage and the effects of the massive looting.

Badr and Umm Al-Marik State Companies (Khan Azad Military Production Plant)

Badr fabricated mechanical components for the pre-1991 gas centrifuge program and initially retained flow-forming capability after Operation Desert Storm. Such flow-forming machines—had they been maintained through the years—could have been used for making metal rotors. ISG has not found that these machines were used for fabrication of rotors for gas centrifuges in a renewed centrifuge program. Site visits conducted in May 2003 revealed that the site was in severe disarray (see Figure 16) and could not function again without extensive renovations.

Al-Tahadi State Company

Al-Tahadi was established in 1995 by the MIC. Former PC-3 engineers from Tarmiyah were transferred to this facility where they continued their work on electromagnetic devices and transformers and their research on permanent magnets. Al-Tahadi had a good lab for measurement of magnetic properties that included a computerized system that could measure the magnetic properties of hard and soft materials. Al-Tahadi was looted, and no documents or equipment remain at the site.

Salah Al Din State Company (Samarra Electronics Plant)

The Salah al-Din Company is an electronics company located near Samarra that produced radar equipment, antennae for various purposes, communication equipment, printed circuit boards for electronic equipment, and plastic covers for agricultural purposes. Exploitation of this site in July 2003 confirmed that the plant appeared to produce different types of electronics and electronic components for various uses. The presence of certain industrial chemicals seems to be consistent with the types of industry found at the facility. The facility itself appeared to be in reasonably good shape. This site did not suffer from some of the large-scale looting and scavenging prevalent in other facilities.

Al-Nida State Company

This facility, along with the Rashid State Company's Tho Al-Fiqar Factory, had general-purpose machine shops utilizing CNC lathes, CNC milling centers, hydraulic presses, welding equipment, coordinate measuring machines, quality-control laboratories, nondestructive testing equipment, and CAD/CAM computers prior to the recent war. Such facilities would be necessary for a reconstituted centrifuge program. An ISG team visited the Al-Nida site in late August 2003 and found that the entire plant had been systematically looted of all equipment, computers, and documents.

Rashid State Company's Tho Al-Fiqar Factory (formerly the Nassr State Establishment Mechanical Plant)

Prior to Operation Desert Storm, the machining plant at Nassr produced centrifuge and EMIS components for Iraq's nuclear weapons program. After Operation Desert Storm, an IAEA inspection team found vertical flow-forming machines. In August 2003, an ISG exploitation team visited this site. The team found four flow formers, none of which were functional because they lacked parts.

- Also found were seven, five-axis machine tools. The Iraqis assisting the team mentioned that the five-axis machine tools could not function as designed. The team also found two-axis milling machines, four Hartford milling machines (two vertical and two horizontal), and large stamping and press machines for serial production of tail fins for rockets.

The team also found thousands of 81-mm aluminum tubes. The Iraqis stated that on the site approximately 90,000 tubes were classified as rejected tubes or tubes that did not pass prescribed testing. The Iraqis stated that they had a 10-percent acceptance rate of domestically made 81-mm tubes. Figure 17 shows a nonfunctioning flow former at Tho Al-Fiqar, aluminum tubes for 81-mm rockets, and a fully assembled 81-mm rocket.

Ur State Company (An-Nasiriyah Aluminum Fabrication Plant)

Iraq attempted to indigenously produce aluminum tubes for its 81-mm rocket program by using the extrusion facilities at Ur State Company. The extrusion equipment reportedly was designed to extrude only 6063 type aluminum alloy; thus, attempts made to extrude 7075 aluminum alloy (the type required for centrifuges) were unsuccessful.



Figure 15. Damage at Ash Shaykhili Building 27B and remaining air ducting in July 2003.



Figure 16. Destruction at Badr and Umm Al Marik State Companies (Khan Azad Military Production Plant), May 2003.



Figure 17. Flow-former (left); aluminum tubes (center); 81-mm rocket (right) found at Rashid State Company's Tho Al Fiqar factory.

Uranium Enrichment—EMIS

ISG judges that the Iraqi Regime did not attempt to reconstitute the EMIS program after 1991, although many of the former EMIS engineers and scientists still worked for either the IAEC or MIC in roles that could preserve their technical skills. These technical skills, if maintained, would have helped build the foundation for a future nuclear weapons program and would have allowed scientists to reenter a nuclear program further up the learning curve. Since Operation Iraqi Freedom, significant looting and damage have occurred at most of the dual-use manufacturing facilities that supported the pre-1991 EMIS program. There are no indications that the Iraqi Regime attempted to preserve the EMIS technology either through former EMIS scientists and researchers or by retaining technical documents and historical files on the former EMIS program, although one scientist associated with this pre-1991 program appears to have unilaterally kept relevant records and some parts that would have been useful to restarting such an effort.

Electromagnetic Isotope Separation (EMIS)

The electromagnetic isotope separation process (EMIS) was the primary technology used by the Iraqis for uranium enrichment in their pre-1991 nuclear program. This process was chosen because of the availability of this technology in open literature and the technical capabilities of the Iraqis. In EMIS, a source containing solid uranium tetrachloride (UCl_4) is electrically heated to produce U^+ ions. The ions are accelerated by an electrical potential to high speed. These charged particles follow a circular trajectory in a magnetic field as shown in Figure 18. The diameter of the circle depends upon the strength of the magnetic field, the velocity of the ion, and the mass of the ion. The ions accumulate after passing through slit apertures at the collector.

An EMIS system includes the following processes:

- Isotope separation—electromagnetic equipment used to separate the uranium isotopes (see Figure 19).

- Chemical recovery—chemical processes used to remove uranium from separator collectors (see Figure 20 for type of collector used in Iraqi program).
- Uranium conversion—used to convert the uranium removed from the separator collectors to a form that is usable either in further enrichment equipment or other downstream processes.

A flow diagram of the pre-1991 Iraqi EMIS process, shown in Figure 21, demonstrates the various steps. Iraq conducted its research and development into the EMIS process at the Tuwaitha Nuclear Research Center and was outfitting a production-scale uranium enrichment facility at Tarmiya, a duplicate site under development at Ash Sharqat, and a feed material production plant near Mosul called Al-Jazira.

A schematic of the Iraqi EMIS separators setup is shown in Figure 22.

Facilities

The pre-1991 EMIS project consisted of three primary production sites. These sites included the Al Safa'a EMIS Plant uranium enrichment facility at Tarmiya (isotope separation and uranium recovery), the Al Fajr EMIS Plant uranium enrichment facility at Ash Sharqat (isotope separation and uranium recovery), and the Al-Jazira feed material production plant near Mosul. Ash-Sharqat was being built as a backup facility to Tarmiya. Also, several sites were utilized for fabrication of equipment needed for EMIS, including the Zaafaraniya Mechanical Workshop, the Zaafaraniya Power Supply Production Facility, and Al-Radwan (Batra Military Production Feed Plant).

Al Safa'a EMIS Plant at Tarmiya

The Al Safa'a EMIS Plant uranium enrichment facility at Tarmiya was designed to produce enriched uranium for the Iraqi nuclear weapons program, using the EMIS process. It was externally complete by January 1991 but was not fully operational. The plant had two types of EMIS buildings: alpha units (R120s) for primary uranium enrichment and beta units (R60s) for enriching material produced by the alpha units to weapons-grade.

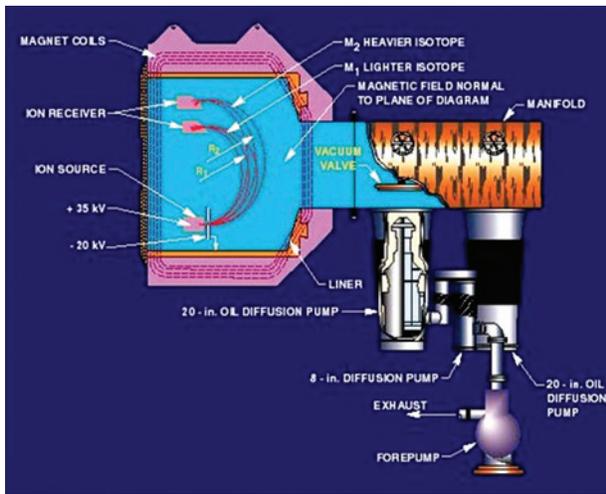


Figure 18. Example of EMIS separator and vacuum system.



Figure 19. Photograph of Iraqi EMIS electromagnet.

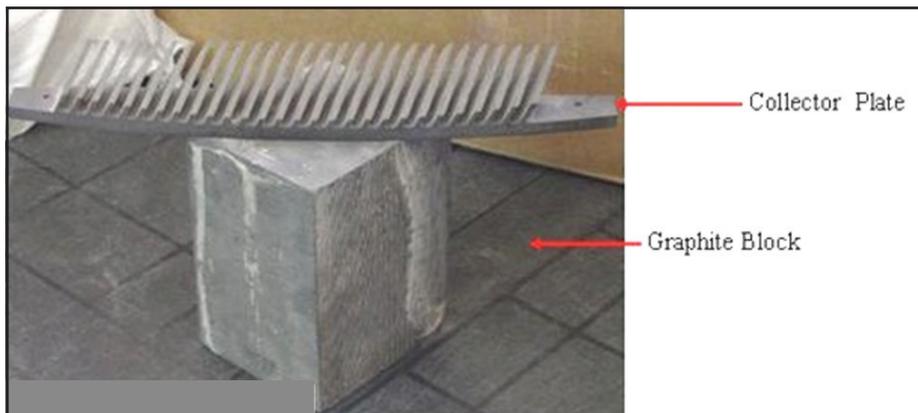


Figure 20. Collector plate removed from Iraqi scientist's home, July 2003.

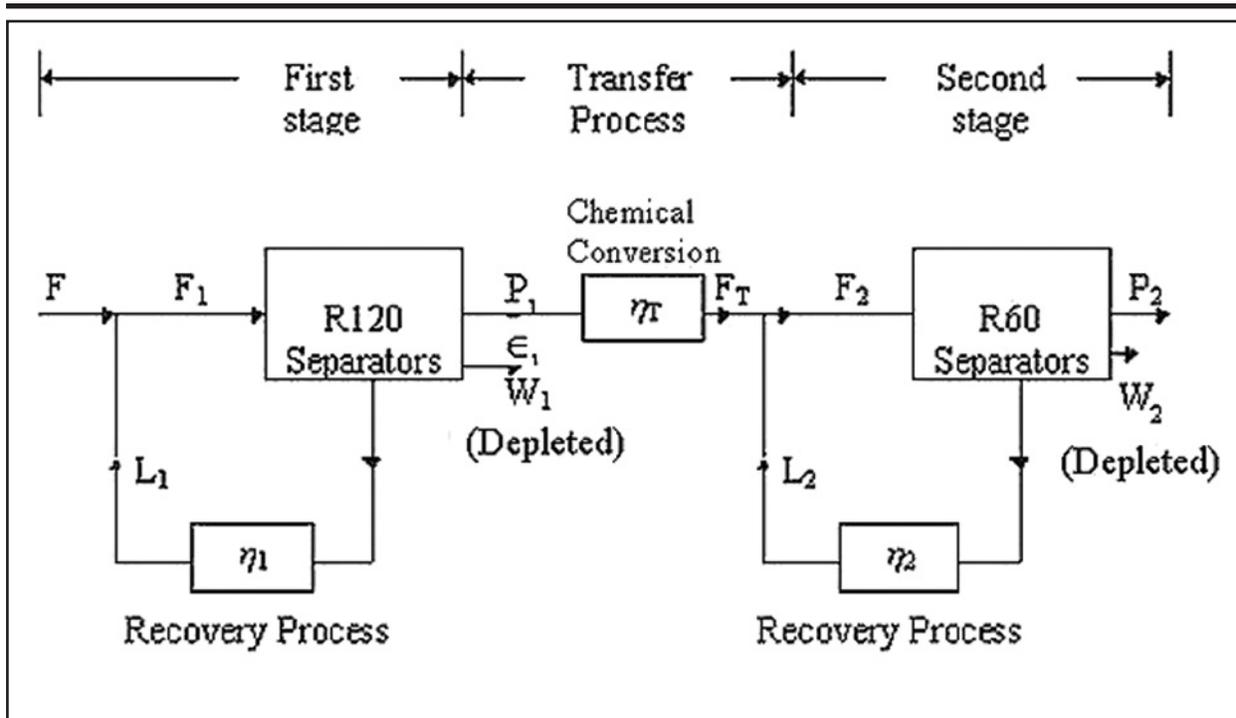


Figure 21. Flow diagram of the Iraqi EMIS process.

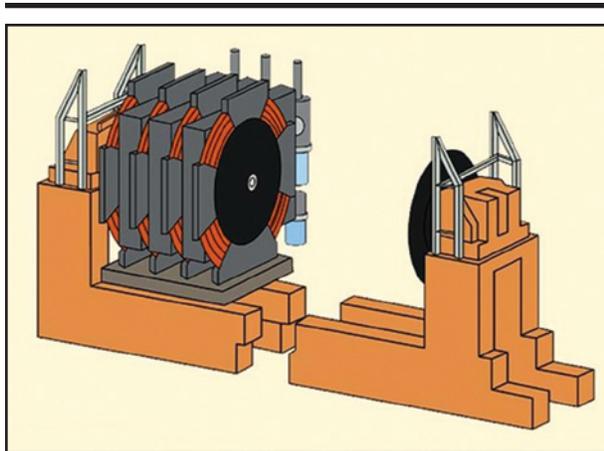


Figure 22. Schematic of the Iraqi EMIS machines.

In 1991, the Al Safa'a EMIS Plant uranium enrichment facility at Tarmiya was in the process of bringing online R-120 separation units, with eight units completed and functioning. An Iraqi mechanical engineer, working at the site, estimated that 70 to 80 percent of the equipment in the building was destroyed by the 1991 Gulf war. IAEA inspectors also supervised the destruction of EMIS equipment beginning in mid-1991.

The EMIS facilities occupied most of the central portion of the Tarmiya site. The shell of the large alpha-enrichment building is located near the northern entrance of the facility (see Figure 23). The damaged shell of the smaller beta enrichment building is in the south-central portion of the facility.

Most of the major buildings at Tarmiya were extensively damaged by coalition air strikes during Desert Storm. In late 1992, it was rendered inoperable under the UN-mandated destruction. Since 1991, the plant engaged ostensibly in chemical pilot plant construction, design, and low-volume production of a number of specialty chemicals for Iraq's weapons programs (see Figure 24).

In late October 2003, a senior Iraqi researcher at Ibn Sina stated to an ISG team that, from 1993 to 1994, he had created a small processing line consisting of 15 mixer-settlers in which he produced “very pure” phosphoric acid. After 1995, he claimed to have designed a second phosphoric acid purification line using packed columns instead of mixer/settlers (see Figure 25). According to the researcher, the purification line was dismantled in 1997, and the equipment (the mixer-settlers) was placed in storage (see Figure 26). The researcher claimed that any extracted uranium was treated as an impurity and disposed of as part of the waste generated by the processes.

There were no indications of any renewed uranium enrichment operations at Tarmiya. ISG did learn, however, of a phosphoric acid purification study conducted in the mid-1990s at the site that recovered what Iraqi staff described as an “insignificant” amount of uranium that was diluted and discharged downstream as waste.

Al Fajr EMIS Plant at Ash Sharqat

The Al Fajr EMIS Plant uranium enrichment facility at Ash Sharqat was constructed to be a replica of the Tarmiya site. The Iraqi’s decided late in 1987 to execute this project to serve two purposes: 1) to replace Tarmiya if the latter is rendered completely nonoperative for whatever reason, or 2) to serve as a backup to enhance production when required. The Al Fajr EMIS Plant main production buildings were destroyed during Desert Storm and in accordance with UN Security Council Resolution 687 in 1991. According to Iraq’s declarations, initial installation of EMIS separators at Ash Sharqat was to begin only after Tarmiya separators had been installed. The site has not been rebuilt as of March 2003.

Al-Jazira (Mosul Feed Materials Production Facility)

Al-Jazira (a.k.a. Mosul Feed Materials Production Facility) was established to produce nuclear feed materials for the EMIS program, namely UO_2 and UCl_4 . The facility was built in the 1980s and put into operation in 1989.

In 1992, the MIC took control of this facility, and it was subordinated to the General Establishment for Extraction Operations. The primary purpose for this

facility was to extract raw iron from the iron-rich ores around the area of Mosul. We know from IAEA inspections that the facility had also been converted since 1991 to make pigments for paint. In October 1996, control of the plant was transferred from the State Establishment for Extraction and Mining Operations (SEEMO) to Al-Kindi State Establishment in Mosul. In 1997, the name of this facility was changed to the Center for Extraction. The purpose of the facility continued to be the extraction of iron oxide from scrap metal. Additionally, the facility engaged in the research for the production of hydrochloric acid. In 2003, this facility was renamed the Al-Ramia Factory.

As of late April 2003, the facility included buildings associated with administration, electricity generation, ammonia production, hydrochloric acid production, waste storage, and chemical laboratories. Extensive looting had occurred throughout the buildings and some structural components (such as piping) had been ripped out. Although portions of this site remained active, ISG has not uncovered any evidence that this site has been used for any fissile material processing since 1991.

Al-Zawra State Company

The Zaafaraniyah Power Supply Production Facility (also known in 1991 as Al-Dijla and renamed Zawra Electronics Plant in 1992) was designed to produce electronic components for the Iraqi uranium enrichment program using the EMIS method. The factory became operational by June 1988. The facility was capable of manufacturing electronic switch gear and high-voltage power supplies for EMIS.

The Zawra facility was inspected by ISG in August 2003. It had been severely damaged by vandals and looters. Several industrial machines were found on site and there was a warehouse for parts. Most of the warehouses and machine shops were empty at the plant. The Zawra site does employ civilian workers and is trying to become productive again.

Al-Nida State Company (Zaafaraniya Mechanical Workshop Al-Rabiyah)

The Al-Nida State Company (Zaafaraniyah Mechanical Workshop Al-Rabiyah), also known in 1991 as Zaafaraniyah Nuclear Fabrication Facility Al-Rabiyah, produced vacuum chambers and components



Figure 23. Destroyed Alpha-Enrichment building at Tarmiya (photo taken by ISG Team, December 2003).



Figure 24. Building at Tarmiya where phosphoric acid purification occurred at Ibn Sina in the 1990s (photo taken by ISG Team, December 2003).

for Iraq's EMIS program. The facility was capable of manufacturing major metal components for the EMIS process. The status of the facility as of March 2003 is shown in Figure 27.

An ISG team visited the Al-Nida State Company site in late August, 2003 and found that the entire plant had been systematically looted of all equipment, computers, and documents.

Al-Radwan (Batra Military Production Facility)

The Al-Radwan (Batra Military Production Facility) produced components for Iraq's EMIS program. This facility was not damaged during Operation Iraqi Freedom; however, since early summer of 2003, the installation was subjected to massive looting, which destroyed or damaged the critical elements needed to restart production operations. At least 60 percent of the fabrication and production buildings had their roof material stripped and their internal components removed. The remaining buildings were lightly to moderately damaged during the looting.

Al-Nassr Al-Adhim State Company

Al-Nassr Al-Adhim State Company, known prior to 1997 as the State Enterprise for Heavy Engineering Equipment (SEHEE) and also known as Daura, is a large heavy equipment fabrication and metallurgical facility that was used to produce vacuum chambers for the pre-1991 600-mm and 1,200-mm separators. This facility was not damaged during Operation Iraqi Freedom. ISG exploitation teams visited the site in January 2004 and observed process equipment (tanks, piping, industrial materials, and chemicals) stored at the site but did not uncover any evidence of activities associated with a uranium enrichment program.

Disposition of EMIS-Related Equipment

Equipment and components from Iraq's pre-1991 EMIS enrichment program remained in Iraq after 1991. ISG has not discovered any effort by the Iraqi Regime to use these items to reconstitute an EMIS enrichment program. The pre-1991 EMIS project required several types of components and equipment, such as power supplies, ion sources, control systems, magnet field coils, magnets, magnet poles, return iron, ovens (for vaporizing the UCl_4), vacuum systems (pumps, liners, vacuum chambers, piping), and material collector assemblies. In the early 1990s, IAEA inspectors collected and either destroyed or had the equipment transferred from the various EMIS facilities (i.e., Tuwaitha, Tarmiya, Ash Sharqat, Al-Jazira) to Ash Shaykhili and Al-Nafad (open area adjacent to Ash Shaykhili) for storage. In early 2000, the Iraqis transferred some of the EMIS components (ring-shaped coils; no disks) stored at Ash Shaykhili to the Al Shaheed State Company, a brass and copper products company. Most likely, this transfer was accomplished to salvage copper from the EMIS coils for other industrial needs. ISG found an Iraqi video that showed scrap material identified as copper and coils at Al-Shaheed State Company in April 2002 being collected and disposed of in a smelter.



Figure 25. Packed columns used in phosphoric acid purification studies conducted at Ibn Sina in the mid-1990s (photo taken by ISG Team, December, 2003).



Figure 26. Mixer-settlers in storage at Ibn Sina (photo taken by ISG Team, December 2003).



Figure 27. Facility, Al-Nida State Company (Zaafaraniyah mechanical workshop) in March 2003 prior to start of OIF.



Figure 28. Items stored at former EMIS scientist's home—high-purity tantalum sheets (left), technical papers (center), and mass spectrometer (right).

Laser Research in Iraq

The Iraqi government at the time of Operation Iraqi Freedom was supporting laser research and development work in military and industrial applications. ISG found no evidence of a renewed laser isotope separation (LIS) program to enrich uranium.

- ISG believes that only a few Iraqi scientists have the knowledge and experience to recommence an LIS project. Furthermore, the technology and infrastructure to support an LIS program does not appear to exist in Iraq.

Laser Related Work After Desert Storm

After Operation Desert Storm, laser work that had been under way in the IAEC as part of an effort to enrich uranium in the 1980s was transferred to universities and to the MIC. The various laser projects conducted at these organizations allowed the Iraqis to retain much of their technical know-how in laser technology.

- In 1992, Dr. Falah Hamza—the former head of pre-1991 research efforts to enrich uranium with lasers—asked Husayn Kamil to provide additional funding for the IAEC Laser group. Hamza claimed high-power lasers could be used for air defense as well as for enrichment, seeming to imply that there were other, valuable uses of lasers and laser technology in the Iraqi military and industrial complex. Husayn Kamil agreed to the additional funding, perhaps to learn if Hamza could further develop laser technology into a usable uranium enrichment method.
- In 1993, an IAEC Optical Center was established at the University of Baghdad. Hamza’s laser project was transferred to the Optical Center, and Hamza became one of the Center’s Group Leaders.
- In 1994, laser projects in Iraq were organizationally moved from the IAEC to the MIC and in 1997 were physically consolidated at the Laser Research Center. It was later named the Al-Razi State Company and became known as the Ibn Khaldun Laser Center. Al-Razi was co-located at the Alwiyah Drug Industrial Center Ibn Al Baytar.

- According to the MIC Director Dr. Huwaysh, Al-Razi engaged the Technology University to assist in laser projects. The Dean of the Physics Department received a 6-million-dinar contract, which was the largest contract MIC had with a university professor. This occurred sometime after laser research was started at Al-Razi in 1997.
- The former Minister of Education, Dr. Humam ‘Abd Al-Khaliq Abd Al-Ghafur, stated that the Dean of the Plasma and Laser Institute at Baghdad University, up until Operation Iraqi Freedom, was Dr. Nafi ‘Abd Al-Latif Tilfah and that the Baghdad University of Technology also conducted laser research. In October 2003, he stated that he was not aware of any nuclear-related research being conducted at these institutes.
- According to an interview with Dr. Nafi ‘Abd Al-Latif Tilfah, Dean of Baghdad University’s Institute for Laser and Plasma Studies in November, 2003, post-1991 laser research was conducted at several locations including the Baghdad University Institute for Laser and Plasma Studies, the Baghdad University of Technology, Mustansiriyah University, and at the Al-Razi Company. Tilfah stated, however, that he was not aware of any LIS-related laser work being conducted at these institutions.

A knowledgeable source indicated that some of the important team members of the 1980s LIS team were working on the development of a copper vapor laser (CVL) in 1997 at Al-Razi—a technology with potential applications to LIS. This work continued until mid-2002 with the successful development of a CVL designed to pump a dye laser. The CVL development effort was led by an Iraqi scientist, who successfully operated a CVL in March or April 2001. The scientist hosted a demonstration of the 10-watt CVL to MIC Director Huwaysh on 5 July 2002. The CVL system reportedly was placed into storage in 2002 in an adjacent underground facility. In April or May of 2003, the underground facility adjacent to the main Al-Razi facility was visited and found to have been looted, and equipment was missing. The Iraqi scientist stated that after the CVL demonstration he worked on a barium vapor laser up until Operation Iraqi Freedom.

- The Iraqi scientist said LIS work was never done at Al-Razi. He also stated that Huwaysh expressly forbade such work and, therefore, no one would have attempted LIS. The Iraqi scientist also indicated he would have been aware of any such work at other facilities because he was the only laser researcher in Iraq with a functioning CVL.
- The Iraqi scientist indicated no written reports were produced on the Al-Razi CVL work. Exploitation of documents from Al-Razi contains very few mentions of LIS or uranium isotope information, and no mention of the CVL development work has been found in these documents.

In the 1990s Iraq pursued various laser application. However, LIS and its nuclear application does not appear to have been part of this work.

- According to one scientist, who started working at Al-Razi in 2002, laser work for military applications such as jamming, range finding, communications and guidance was being conducted at Al-Razi. Also, according to the same scientist, one group at Al-Razi was working on a carbon dioxide (CO₂) laser for an antimissile defense project. This project reportedly was abandoned because of technical problems.
- Laser work also was being done with Nd-YAG and Nd-Glass lasers at Al-Razi. Additionally, an investigation using hydrogen fluoride and deuterium fluoride lasers for an antimissile defense program was being studied.

Current Status and Future Potential

A few former LIS scientists remain in Iraq, but the equipment and facilities needed to reconstitute an LIS program are extremely limited. For example:

- Following Operation Iraqi Freedom, the CVL that had been demonstrated to the MIC Director in mid-2001 was reportedly stolen from the underground facility in which it was placed. ISG was unable to determine the location or the current status of the CVL.

- Although Al-Razi was not damaged during Operation Iraqi Freedom, it was heavily looted afterward.

Iraq's Pre-1991 LIS Efforts

Beginning in 1981, Iraq committed significant resources to exploring the use of LIS techniques for enriching uranium. This work was prompted by then Vice President of the Iraqi Atomic Energy Commission, Dr. Humam 'Abd Al-Khaliq 'Abd Al-Ghafur. LIS techniques that were under development included atomic vapor laser isotope separation (AVLIS) and molecular laser isotope separation (MLIS).

These pre-1991 LIS efforts were under the auspices of the IAEC, rather than the PC-3. The LIS program was terminated in 1988.

- The results of the 26th IAEA On-Site Inspection in Iraq led to the conclusion that the level of skills, equipment, and infrastructures available in Iraq was totally inadequate in the pursuit of any meaningful activity in LIS.
- A report written by Dr. Faleh Hassan Hamza has revealed the results of the former Iraqi AVLIS effort were inconclusive—his team could not confirm that uranium was actually separated. The MLIS experiments successfully enriched sulfur but could not achieve repeatable results with uranium. Based on these experiments, Dr. Hamza wrote a review of the state-of-knowledge of LIS, concluding that Iraq had neither the technology infrastructure nor the capability to purchase the necessary equipment to achieve success with LIS. The laser work stopped in 1988.

Rail Gun Summary

Iraq's efforts to develop rail guns appear to have been for air defense, but ISG found that laboratories established to partly support an IAEC project led by Dr. Khalid Ibrahim Sa'id—the head of Iraq's pre-1991 nuclear weapons design and development program—also could build skills needed for a renewed nuclear weapons effort.

- ISG has not uncovered information that shows that Iraq's work on rail guns in the late 1990s was part of a renewed nuclear weapons effort—although some of the reporting acknowledges this potential.
- Rail gun equipment and materials uncovered by ISG similarly do not appear to have been part of a nuclear weapons design and development effort, even though a few items—with further development—had the potential of supporting such work.
- Theoretically, the rail gun could provide the range and altitude capability to shoot down aircraft in the no-fly zone, a reported goal of Saddam's (see inset).

Rail Gun Efforts

Multiple sources and captured documents indicate that, in early 1999, Sa'id initiated a project under the IAEC to develop a rail gun, an experimental device that, if further developed, could, in theory, have applications including nuclear weapons research and anti-aircraft weapons. The IAEC rail gun project—named Al Muharek al Khati or “The Linear Engine”—occupied two primary locations, a laboratory at the Roland Missile Facility near the Rashid Air Base and a small facility within former residential compound outside the Tuwaitha Nuclear Research Center. The Roland site was destroyed by Coalition bombing in March 2003, while the facility outside of Tuwaitha—called the “Technical Research Branch”—was the subject of an ISG site visit in August, 2003.

- We know from postwar debriefings that Sa'id used the Technical Research Branch as headquarters of the IAEC rail gun project. Documents found at the site and former scientists involved in the work indicate that Dr. Karim Kalif Mohamid was the head of the photography unit of the Technical Research Branch.

Numerous Iraqi scientists interviewed by ISG stated that the IAEC rail gun was an effort to develop an anti-aircraft weapon—a point that we believe is supported by documents captured at the Technical Research Branch and at IAEC's headquarters at Tuwaitha. A set of papers found at the site—which we have determined were written by Sa'id—connect the rail gun to anti-aircraft work for the Ministry of Defense. Former scientists involved in the effort indicate at least two progress reports were submitted to the Air Defense Commander, Lieutenant General Shaheen. These same sources, as well as documentary information found by ISG, indicate Shaheen visited the IAEC rail gun project (see inset on Saddam's Interest in Anti-aircraft Weapons).

- Other indications the rail gun project was intended for anti-aircraft applications include the need for a technical cadre specialized in air defense, a plan to locate the work at the air defense site at the al Rashid Military Camp, and the intent to use a visual device to target the projectile—according to notations in Sa'id's papers. The document also notes plans in early September 1999 to test the rail gun on what appears to be salvaged military aircraft from an airplane repair company.
- An Iraqi scientist told ISG that the IAEC rail gun project was one of many projects at the Tuwaitha Nuclear Research Center that were supported by the Ministry of Defense. The same source indicates any scientist could suggest an air defense project—purportedly a means to obtain extra funding and recognition.

Despite indications that the IAEC rail gun was intended for anti-aircraft use, the project preserved skills that could support a renewed nuclear weapons design effort. Given his past leadership in the nuclear weapons program, ISG believes that Sa'id clearly

Saddam's Interest in Antiaircraft Weapons

The antiaircraft application is consistent with Saddam's reported intense interest in air defense technologies. One scientist told ISG that Saddam became obsessed with achieving a capability to shoot down an enemy aircraft in the no-fly zone and had challenged the scientific community to rally around that goal. Saddam reportedly believed that achieving such a capability would render the no-fly zone ineffective and foster a change in political climate that would hasten the lifting of sanctions.

- *Fadil al-Janabi, head of the IAEC since 1996, indicates that Saddam would often attend monthly meetings with his son Qusay to discuss air defense projects—meetings Janabi also claims to have last attended in February 2003.*

Fadil al-Janabi indicates that Saddam tasked him to develop knowledge in atomic energy areas and support air defense projects. Air defense was the IAEC's number-one priority.

understood that his rail gun project also dealt with technical subject areas applicable to nuclear weapons research. In one section of text that we suspect was part of his proposal to build the IAEC rail gun, Sa'id refers to work on gas guns—technically simpler devices that also can accelerate projectiles to high speeds.

- Sa'id's notes describe that gas gun work had been planned for al Atheer—a site where he and his staff had planned to design, develop, and assemble nuclear weapons as part of the pre-1991 weapons program. Iraq planned to use gas guns as a research tool for its pre-1991 nuclear weapons program.

According to a scientist involved with the rail gun program, Sa'id also indicated one of the objectives of the project was to train a new generation of IAEC scientists in applied physics. One source indicated that working on the rail gun project was like attending a seminar where staff could learn new subjects such as plasma physics, electrical engineering, motion physics, high-speed photography, and flash radiography.

- Documentation found at the Technical Research Branch also describes work in each of these areas but noted in the context of an air defense project (see inset on Technical Research Branch).
- A proposal for a 10-year effort to recruit and train university students was also found at the Technical Research Branch site.

The IAEC Technical Research Branch

According to a document captured by ISG, the IAEC Technical Research Branch consisted of various laboratory units, which include:

- ***Photography Unit:*** *The aim of this unit was to strengthen the scientific tests on various physics phenomena for the purpose of treating the photographic montage and also to study the specifications of standard and digital cameras.*
- ***Pressure Measuring Unit:*** *Aimed at counting the pressure of various materials and their mechanical specifications.*
- ***X-ray Unit:*** *Aimed at studying matter specifications, counting the speed of moving bodies, and the natural behavior of movement of these bodies through x-ray photography.*
- ***Electronic Unit:*** *Aimed at testing and measuring electrical specifications (resistance, induction, voltage, and current) and also repair of electronic instruments and computers.*
- ***Programming:*** *This unit dealt with the physical problems and factors that affect scientific programming.*

One Iraqi scientist told ISG that Sa'id's rail gun pursuits were more personally motivated because he was nearing the end of his professional career and he wanted to increase his stature with Saddam. This source indicates Sa'id may have wanted to leave his mark with a high-profile project—like shooting down

a Coalition aircraft. Another Iraqi scientist noted that, even though Sa'id had been removed from the IAEC after reaching the compulsory retirement age in mid-2002, he continued to run the rail gun project and eventually Saddam reinstated him at the IAEC.

- Postwar document exploitation efforts reveal Sa'id applied—probably in late 2002—for a position as the Director General of the Industrial Committee. His application details work experience from 1989 to 2001, noting his work on the IAEC rail gun project as well as work on Iraq's "complete, final, and inclusive document for the canceled project/Group 4." ISG doubts that Sa'id would have needed to pursue the new job or need reinstatement if he had been part of a concerted Iraq effort to restart Baghdad's nuclear weapons program.

Sa'id managed, nonetheless, to initiate his IAEC project despite a more experienced rail gun effort having been reinitiated under the MIC at Al Tahadi in 2000. Reporting from former scientists in the rail gun program suggests that the IAEC project seems to have been the favored effort as the leaders of the MIC project reportedly were asked to join the IAEC rail gun program. At least one scientist from the Al Tahadi rail gun project reportedly also was tasked to assist the IAEC, participating in three meetings between late 2001 and June, 2002. The same source indicates the Al Tahadi effort also provided equipment to the IAEC rail gun (see inset on MIC's Rail Gun Projects and Figure 29).

Documentation found at the Technical Research Branch also indicates an agreement was being discussed to have Al Tahadi repair and examine the IAEC rail gun.

ISG has found only tenuous indicators that would suggest the rail gun was part of an effort to renew a nuclear weapons program. One Iraqi scientist recalled Sa'id's role in gas gun work for the pre-1991 nuclear weapons program and thought it possible that the rail gun would be applied to a similar research effort. Documents found by ISG also indicate the IAEC rail gun effort was associated with a number of scientists from the former nuclear weapons design and development program including other former members of Iraq's pre-1991 nuclear weapons program (see inset on Tapping PC-3 Expertise).

MIC Rail Gun Projects

Iraq's interest in rail guns for air defense, according to a senior official involved in the program, traces to around 1993, when an Iraqi scientist recently returned from his Ph.D. studies in Russia, wrote to the MIC to advocate the development of rail guns. This letter reportedly generated research and development efforts at the High Voltage Establishment—an outgrowth of the electromagnetic isotope separation (EMIS) portion of the pre-1991 nuclear weapons program at Tarmiya. The High Voltage Establishment was renamed Al Tahadi in 1995. Rail gun efforts fell under the direction of Dr. Khaluq Rauf Hamdi, who arrived at the establishment in 1994.

- The MIC program at the High Voltage Establishment succeeded in producing a rail gun with a barrel 1 meter long, capable of shooting a 1-gram, quadrilateral-shaped polycarbonate projectile to a speed of 400 to 450 meters per second, according to an official involved in that program.
- ISG found other evidence that the rail gun at Al Tahadi had reached a speed of 1 km/sec in March 2000. The so-called Iraqi Electromagnetic Rail Gun used a capacity of 55 kJ to accelerate a 1.5-gm projectile to the 1-km/sec speed.

Although well under the limits of Annex 3 (2,000 meters per second), the MIC rail gun project was routinely hidden from inspectors. According to a former senior official involved with the work, before UN/IAEA inspectors would visit the site, Iraqi personnel took efforts to conceal equipment associated with the project. The project was killed in 1995 when MIC Official Amir Rashid Al 'Ubaydi became concerned that the research and development effort would be discovered.

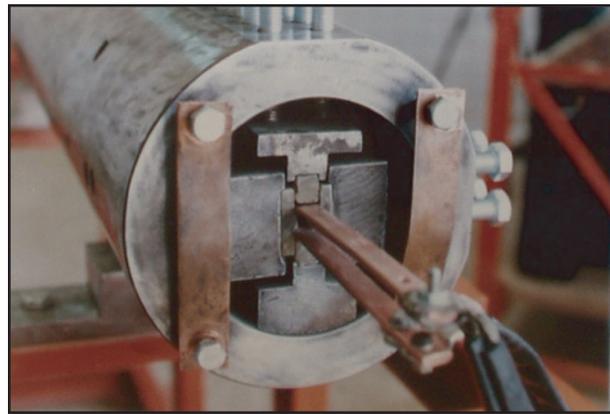
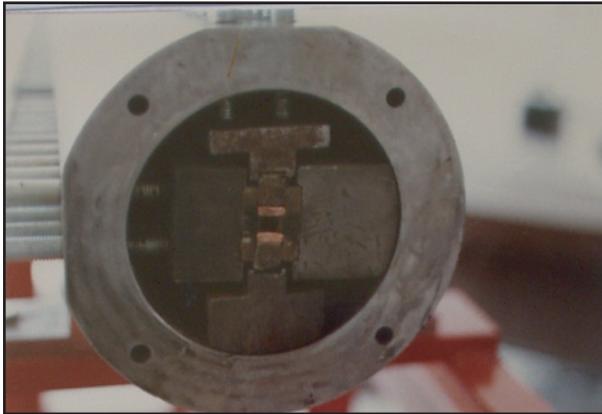


Figure 29. Cross-sectional view of Al-Tahadi rail gun showing how the rails are held with insulators and metal supports in a photo obtained from Hahdi Hadi Jasim.

- Based on information gathered through debriefings and documents, ISG has determined that the IAEC rail gun effort was a classified program, and at least part of it was code-named Project 505—actions reminiscent of how Iraq classified its pre-1991 nuclear weapons programs. A scientist associated with the rail gun project claims the rail gun project was classified not because of the sensitivity of its application or technology—which appears to have been drawn from open literature—but to create an aura of importance.
- Another source associated with the rail gun effort recalled an emergency meeting called by Sa'id in 1995—under the authority of Husayn Kamil, the former head of Iraq's WMD programs—to ask about the feasibility of manufacturing man-made diamonds. When told the project was impractical, Sa'id reportedly indicated this was why the rail gun project was needed. Some types of artificial diamond production technology utilize skills similar to those needed in developing nuclear weapons.

An ISG inspection of the Technical Research Branch facility in August 2003 found evidence of new dual-use laboratories and equipment. When further developed, these dual-use technologies could possibly have been used in a nuclear weapons development program, especially in the area of hydrodynamic testing. Other activities discovered at the laboratory were clearly devoted to the IAEC rail gun project.

Rather than using official IAEC channels, Sa'id privately contacted outside contractors to acquire

several key pieces of equipment for the Technical Research Branch laboratory—a suspicious approach but one that we cannot link to a renewed nuclear weapons effort. To acquire a 300-kV flash X-ray machine, for example, Sa'id contracted with a trusted colleague, a former PC-3 Group 4 scientist who was working at the University of Technology in Baghdad. This colleague contracted with former coworkers at the Ibn Firnas Company for work done under contract to the university. The project reportedly was kept secret from the director of the Ibn Firnas Company as a means to provide Sa'id with financial cover.

- A colleague of Said also contracted with the Al Qaswar Company to provide a timing device using laser diodes to measure the speed of the rail gun projectile. The Al Qaswar Company is registered in the name of the wife of one of the Ibn Firnas employees that had worked on the flash X-ray system.
- One colleague of Sa'id—an expert in materials analysis—received a contract from Sa'id to outfit a laboratory for impact behavior studies. Part of this contract included a gun device to measure the impact of projectiles on various materials. This became the pressure measuring unit of the Technical Research Branch. Information from a senior official in the rail gun program indicates this unit was limited in its ability to gather material property data—the kind of data of interest in a renewed nuclear weapons effort—because of the lack of diagnostic equipment (see Figures 30 and 31).

Tapping PC-3 Expertise for the IAEC Rail Gun

Sa'id may have turned to former members of the pre-1991 nuclear weapons program, codenamed PC-3, for a variety of reasons—ranging from established competence, personal and professional relations, or even some hidden intent to tap this expertise to train a new cadre of nuclear scientists. Debriefings of Iraqis associated with the rail gun project and captured documents reveal the following former PC-3 personnel were connected to the effort:

- ***Dr. Khalluq Ra'uf Hamdi***—Former head of PC-3 Group 2B, responsible for Electromagnetic Isotope Separation (EMIS). Hamdi served as Sa'id's deputy on the rail gun project and the head of the IAEC Technical Research Branch.
 - ***Dr. Sabah al-Noor***—A trusted colleague of Sa'id and another former PC-3 Group 4 powder metallurgy specialist. Sabah reportedly contracted with Sa'id for the production of projectiles for the IAEC rail gun, a flash X-ray machine, and shock physics laboratory.
 - ***Dr. Abdullah Kandush***—Former head of PC-3 Group 4B (Applied Physics) and weaponization theoretician. Kandush had responsibilities for heat transfer issues.
 - ***Basil al-Qaisi***—Former Director at the Saad Center, al-Qaisi was associated with the funding of the rail gun project.
 - ***Dr. Faris Aziz al Samarra***—A former official in the pre-1991 centrifuge program—an effort administratively outside of PC-3 and the nuclear weapons design effort. Dr. Faris was the director general of Al-Shahid Company that produced copper and brass products. According to a captured document, he was to provide oxygen-free copper for the rail gun project.
 - ***Jamal Ja'far***—A former pre-1991 centrifuge design engineer who, according to a captured document, reviewed designs for the rail gun project in August, 1999. A senior scientist associated with the rail gun project indicates that Jamal Ja'far was one of two highly regarded engineers in Iraq who could be brought into a variety of projects for consultation.
-

According to a former senior official involved with the effort, the IAEC anti-aircraft project was focused on improving the efficiency of the rail gun and making it more transportable in the years before the war, rather than conducting materials experiments like those used in nuclear weapons research. Overall efficiency for converting electrical energy into projectile speed was poor, estimated at only one to three percent, according to a former senior official involved with the program.

- In an effort to reduce the size of the rail gun so it could be weaponized for use on the back of a vehicle-mounted 100-mm anti-aircraft gun frame, the Iraqis considered the use of homopolar generators to replace the bulky capacitors—390 of them—that made up the research device. Iraq planned a steady progression of building homopolar generators in sizes from 0.15 mega joules, to 1.5 mega joules, to 15 mega joules, but none of these items reportedly were completed because of the lack of precision machinery.
- The same official indicates that materials work was limited at the Technical Research Branch and that, because of limitations in the availability of diagnostic equipment, these tests primarily consisted of studying the impacts caused by projectiles on steel plates. Crude approaches to the study of materials using piezoelectric materials were reported.

Sa'id's documents refer to the need to conduct experiments above the 2,000-meter-per-second limit posed by the Annex 3 nuclear controls, specifically calling for speeds as high as 10,000 meters per second. ISG believes that this velocity range was used for calculations to estimate the electrical equipment needed to power a laboratory research tool for exploring the relationships between projectile mass and barrel length as found in references made later in the document.

- The IAEC project reportedly used three different barrels—two square annulus barrels measuring 15 mm and 30 mm, as well as a circular barrel measuring 32.5 mm in diameter. According to a senior official involved in the project, Iraq attained its best results with the circular barrel, which was able to accelerate a 28 gram polycarbonate projectile to a speed of 885 meters per second (see Figure 32 summarizing the Iraqi Rail Gun progress).



Figure 30. Technical Research Branch facility inspection—velocity measuring device for rail gun projectiles.



Figure 31. Technical Research Branch facility inspection—shock impact materials test rig.

Dr. Khalid Ibrahim Sa'id

Dr. Khalid Ibrahim Sa'id was a senior Ba'ath Party leader with ties to the Presidency. Prior to the first Gulf war, he had served as head of PC-3 Group 4, the nuclear weapon design and development group, and, after spending most of the 1990s as Director of Research in MIC, became Secretary to the Industrial Committee, which coordinated projects between the production ministries. Sa'id was reportedly killed running a Coalition roadblock on 8 April 2003.

Alternate View Of Science Projects and The Rail Gun

It should be noted that some senior scientists believed the Rail Gun project had neither scientific merit nor utility as an air defense weapon. In September 2003, Dr. 'Amir Hammudi Hasan al-Sa'di, former Presidential Scientific Advisor, commented on science projects and the Rail Gun in particular. 'Amir said that the state of scientific research in Iraq had declined after the UN imposed sanctions on Iraq following the 1991 Gulf war—the new generation of scientists could not distinguish between validating an idea and being able to mass-produce and deliver systems. He further said that Saddam had decreed that any scientist with an idea could make that idea a present to the presidency. Special-interest groups—those who stood to benefit from the project—would then press for its adoption.

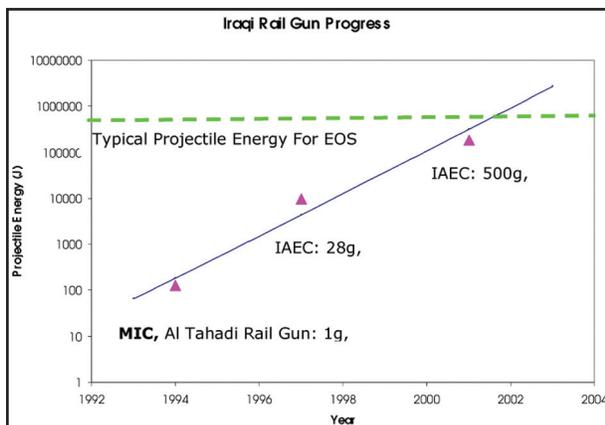


Figure 32. Iraqi rail gun progress.

If a knowledgeable person did not step in to put a halt to a scientifically invalid project, the project would proceed. Specifically, 'Amir mentioned the rail gun and certain decoys as examples of poorly developed concepts crafted to win Saddam's support and garner funds. 'Amir lamented that such programs wasted resources and efforts. In an earlier interview 'Amir assessment was more direct; he stated that the rail gun was "obviously not" for use against aircraft and viewed the idea as ridiculous. 'Amir said he did not know what the purpose of the rail gun was but suggested that it was probably a worthless project that someone thought up just to get more funding.

Issues Related to Nuclear Weapons Design and Development

ISG judges that Iraq has not worked on nuclear weapons design since 1991. ISG investigated Iraq's nuclear weapon design and component manufacture capabilities through interviews with scientists and other government employees, site visits of historically-associated Iraq nuclear weapon facilities, and exploitation of captured documents.

Casting Technology

ISG has not identified a materials research and fissile component manufacturing capability that would be required to reconstitute a nuclear weapons program. Working with molten highly enriched uranium requires special consideration for criticality during the melting and solidification process. ISG found no evidence that Iraq had acquired or developed the technology of dealing with casting and machining issues of highly enriched uranium.

- Iraq's pre-1991 nuclear programs experimented with crucibles and with vacuum induction furnaces, both imported and indigenously constructed, to varying degrees of success, to produce components in molds. Several types of crucibles and crucible materials were used in casting experiments with metallic uranium.
- An Iraqi scientist provided information to ISG that is consistent with other sources that Iraqi nuclear program work at Al Atheer was just getting started in January 1991 and that uranium metal casting work was accomplished within the limitations of the equipment at hand. Iraqi scientists encountered difficulties in use of vacuum casting furnaces to melt uranium metals prior to pouring into molds and with the molds. According to inspections, several small spherical and cylindrical pieces were produced, but of relatively poor quality as pertaining to void and impurity inclusions.

- According to Iraq's CAFCD addendum in 2002, a new Ceramics and Alloys Section had been formed under the IAEC Physics and Materials Directorate in 2000 to investigate ceramic coating of metals. ISG was unable to determine if the investigations were directed toward solving pre-1991 problems that Iraqis encountered in pouring of uranium metal into molds during the casting process.
- An ISG inspection team visited the South Taji industrial complex and searched for evidence of uranium metal production capabilities and nuclear-weapon-related component production. As a result of building damage, looting, and prior removal of equipment, ISG was not able to accurately assess the prewar functions of the facility.
- An ISG inspection team visited the south Taji industrial complex and searched for evidence of uranium metal production capabilities and nuclear-weapon-related component production. As a result of building damage, looting, and prior removal of equipment, ISG was not able to accurately assess the prewar functions of the facility.

Explosive and Lens Fabrication Capabilities

ISG has not identified any explosive lens development effort in Iraq that was associated with a renewed nuclear weapons program. ISG has found, however, that the Al Quds Company—a new MIC establishment created in 2002—had a technical department, which built an explosive test facility capable of conducting research. Such a facility appears well suited for types of explosive research that could be applicable to conventional military and nuclear weapons research.

- According to a captured letter, the General Manager of the IAEC Technical Research Branch sent a three-person group to the new Al Quds Company to “conduct tests and checks” in December 2002.

Iraq has maintained explosive development activities supporting conventional military weapons systems. This could be considered a dual-use activity, and

although not as exacting in tolerance requirements, the technology could be reapplied to explosive lenses for nuclear applications.

- ISG has not resolved the issue of missing explosive lens mold drawings of concern to IAEA inspections in March, 2003. A letter from Maj. Gen. Eng. Hussam M. Amin, Director General, National Monitoring Directorate, from February 2003, and acquired by ISG, indicated continued concern with missing explosive lens mold drawings that supposedly contained critical information.

High-Speed Switches

ISG obtained evidence from recovered documents and from debriefings of Iraqi scientists that Iraq utilized high-speed switches—like those of potential interest for nuclear weapons development—in support of its rail gun projects. ISG has found no direct evidence that the interest in special high-speed switches after 1991 was in support of a nuclear weapons program.

- In July 2003, ISG obtained information that in 2002 a graduate student at the Mustanseriyah University was working on an electrothermal accelerator using the rail gun under development at al Tahadi. This igniter could be considered a type of specialized, high-speed switch.
- Iraqi documentation recovered by coalition forces describes prototype testing of a gas switch with breakdown times that are likely less than one microsecond. The gas switch experiments proceeded within the rail-gun project. An ISG subject matter expert determined that the described switch was probably in violation of the Annex 3 guidelines of prohibited items.

ISG has found other indirect and fragmentary evidence of interest in specialized switches. However, ISG has not found this information to be connected to research into nuclear weapons.

- The Military Industrial Commission in 2000-2001 was interested in electromagnetic pulse generation that was described as a box containing a laser-controlled thyristor, a type of specialized switch.
- A CD-ROM recovered in 2003 from the Religious University in Baghdad contained files regarding spark-gap switches and electrothermal accelerators.

Fireset Development and Testing

ISG obtained limited corroboration of previously reported, pre-1991 fireset development status. No new information regarding fireset development was found. ISG found no evidence that Iraq continued fireset development or testing after 1991.

- An Iraqi scientist reported to ISG that development of one complete 32-point fireset directly applicable to nuclear weapon detonation initiation was completed prior to February 1990. A second fireset was being assembled and environmentally hardened in 1990 but was never completed. Work on both firesets was ceased in April 1991, and the firesets were evacuated to a safehouse and later returned to Al Atheer. One fireset was reported to be exhumed from rubble at Al Atheer in 1996 or 1997 and was turned over to inspectors. ISG confirmed that this information is consistent with that previously reported by Iraq. ISG has not been able to independently confirm the disposition of the second fireset reported to have been assembled in the pre-1991 nuclear program.

Neutron Generators

ISG was not able to find that Iraq had resumed any work related to neutron initiators/generators for a renewed weapons program. The only neutron generation capability found by ISG pertained to a previously known capability used for non-weapons-related research under way at the IAEC at Tuwaitha. This project is described in more detail in the IAEC Issues portion of this report.

Migration of the Capabilities From the PC-3 Nuclear Weapons Project

Starting around 1992, Iraq transferred many scientists from the defunct nuclear weapon program into several Iraqi scientific establishments. We have not found clear indications of the intent behind these personnel moves, but some of the work they pursued would have inherently preserved skills that could be applied to possible future nuclear weapon work.

PC-3 was officially dissolved in March 1992. Several senior Iraqi officials stated that there was an initial program to move PC-3 personnel into matching skill centers within the MIC to sustain skills. Some person-

PC-3 Comprised Four Main Groups

Group	Focus
1	Gaseous Diffusion Enrichment and Centrifuge Enrichment (Group One is later detached to become the Engineering Design Center)
2	EMIS, Chemical Enrichment, Chemical Engineering (Feed Products)
3	Administrative Support, Models, Studies, and Databases
4	Weaponization (High-Explosive Lenses and Neutron Generator Development)

Examples of Former PC-3 Scientists Migrating to New Positions by the Late 1990s

Person	Position	Late 1990s	Pre-1991 PC-3
Dr. Khalid Ibrahim Said		Secretary Industrial Committee	Former Head of Group 4
Dr. Ja'far Diya' Ja'far	Presidential Advisor	Industrial Committee	Former Head of PC-3
Dr. Mahdi Shaqr Al 'Ubaydi	Director General	Saad Center	Former Head of Group 1/EDC
Dr. Muhammad Habib		Razi State Company	Formerly of Group 4
Dr. Hikmat N'aim Al-Jalu	Director General	Ibn Sina	Formerly of Group 4
Dr. Faris Al-Samarra'i	Director General	Al Samud State Company	Former Engineer Group 1/EDC
Dr. Dhafir Al-Azzawi	Director General Al Raya	Zahfal-Kabir	Formerly of Group 4
Dr. 'Abdallah Kandush	IAEC	International Div Head	Formerly of Group 4
Dr. Fadil Al-Janabi	Director		IAEC
Dr. Abd Al-Rizaq Hammudi Al-Karaguli		Ibn Sina Center	Formerly of Group 2
Dr. Ahmad Abd Al-Jabbar Shanshal	Director	Al-Jazira	Formerly of Group 2
Dr. Abdul Halim Ibrahim Al Hajjaj	VP	IAEC	Formerly of Group 2
Dr. Thamer Mawlood	Director General	Al-Tahadi	Formerly of Group 2
Dr. Munqith Hikmat Shawkat Al Qaisi	Deputy Director General	Ibn Yunis/Saad Center	Formerly of Group 2
Dr. Saad Shakir Tawfiq	Director General	Al Khazin Center	Formerly of Group 2
Dr. Faia Ali-Husayn Berqudar		IAEC	Formerly of Group 4
Dr. Ala Abas	Director General	Diwaniya	Formerly of Group 2
Y.M. Al Jabouri	Director General	Nida	Formerly of Group 3
Dr. Wadah Jamil Rauf	Director	Raya Center	Formerly of Group 2
Ali Hussain Alwan	Director General	Al-Zafh Al Kabeer	Formerly of Group 1/EDC

nel were also moved to the Ministry of Industry and Minerals (MIM), the Electricity Commission, and the IAEC.

- ‘Abd-al-Tawab ‘Abdullah Al Mullah Huwaysh, former Director of the MIC, confirmed PC-3 scientists moved into the numerous companies in the MIC including Al Razi, Al Zawrah, Al Nida, Um al-Ma’rik, Al Majd, Al-Zahf Al-Kabeer, Al Radhwan, Abu Al Rushd, Al Rayah, al Tahadi, and Ibn Sina. It was Huwaysh’s contention that skill sets dictated the placement of scientists.

A senior MIC scientist stated that scientists associated with Iraq’s pre-1991 nuclear weapons program were often transferred en masse to one of several MIC companies, including the Al-Raya Company and the Ibn Sina Company. These scientists would participate in research projects that would help them maintain their knowledge of their former nuclear weapons research. An ISG site visit to Ibn Sina corroborated such activities, including phosphoric acid purification and lanthanide separation by ion exchange and solvent extraction—processes similar to those required for uranium extraction and reprocessing techniques (see Figure 33).

The reassignment of scientists to nonnuclear projects over the years is also reflected in comments provided by IAEC Chairman Al-Janabi to ISG. Janabi claims that he asked Saddam around March 2001 to gather former IAEC scientists and researchers at the IAEC in Tuwaitha. However, Saddam told Al-Janabi not to ask for them at this time because the MIC needed these scientists for other programs.

In the immediate aftermath of Operation Desert Storm, Iraq also tried to save some of its equipment and capability from the PC-3 program as part of a denial and deception effort. In some cases, preservation of the equipment and capability may have been intended for eventual reconstitution of a nuclear program but also were used to support other nonnuclear programs. The “Denial and Deception” program included the movement and/or destruction of equipment, movement of personnel, and destruction of facilities. Many actions were directly related to the degree of incrimination provided by equipment and facilities with respect to NPT violations. Table 7 indicates the deliberate destruction of some facilities by Iraq. Table 8 indicates some of the movements and actions undertaken by Iraq with respect to the uranium conversion program equipment.

- According to Iraq’s FFCD, “An order was issued to PC-3 and EDC [Engineering Design Center] at the end of May 1991 to hand over the main equipment and non-nuclear materials (that indicate NPT violation) of the nuclear program to SAP [Security Apparatus for the Protection of Military Industrialization Establishments] for protection.... The order covered only the equipment and nonnuclear materials which indicated violations of NPT.” “The main equipment and nonnuclear materials of the nuclear program were transferred through SAP to the army from the different sites during the period May 28, 1991 until June 9, 1991.” “The purpose of the above equipment and nonnuclear materials transfer was to avoid detection by IAEA Action Team-2.”
- Iraq’s declarations provide many examples where it salvaged equipment from sites formerly associated with its pre-1991 nuclear weapons program—a move ISG suspects was as much to conceal possible NPT violations as to preserve a reconstitution capability. Iraq’s declarations and IAEA inspections indicate that the early 1991 concealment activities resulted in some equipment being damaged or unilaterally destroyed. Ultimately, some items associated with the pre-1991 program were moved to a storage site at Ash Shaykili or utilized at several universities or state establishments.
- In the early years of inspections, Iraq also tried to claim its Al-Athir nuclear weapons assembly site was a materials development center.

The decision to destroy or salvage equipment appeared to have a simple criterion: the degree of incrimination with respect to NPT violation by Iraq.

In general, much equipment specific to a nuclear weapons program was to be destroyed, while dual-use equipment was to be salvaged. For example, Tuwaitha Building 64 was severely damaged during Operation Desert Storm. The undamaged plant equipment was salvaged and stored. The unit components that were contaminated with natural uranium were unilaterally destroyed while other general purpose components were retained for subsequent use in nonnuclear activities.

- Another example is the equipment at Rashidiyah. Equipment directly related to the nuclear program was to be destroyed while indirectly related or general purpose equipment was moved to General Establishment for Engineering Technologies

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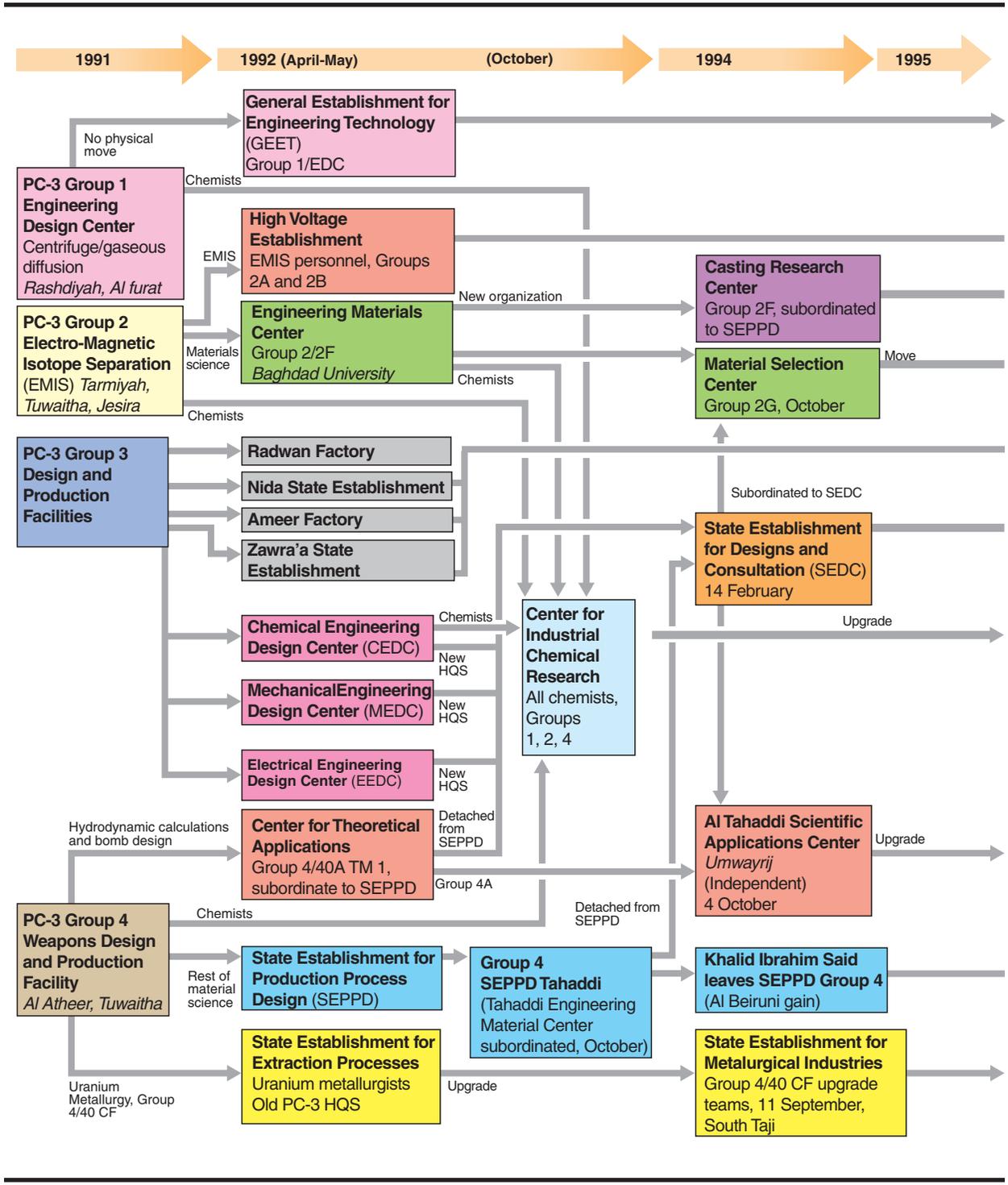
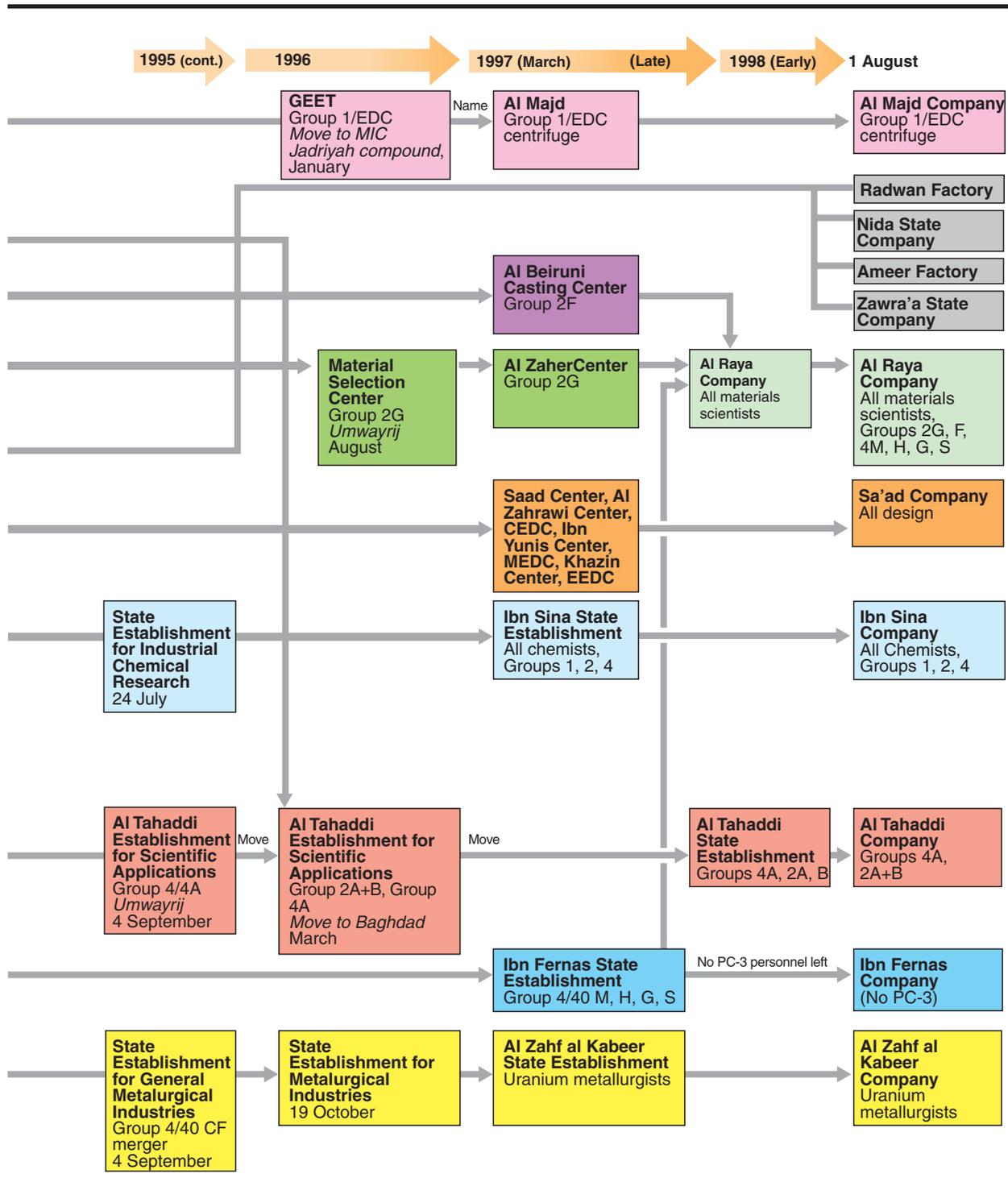


Figure 33. Evolution of Iraq nuclear weapons organizations since 1991 (Colors indicate organizational continuity).



Nuclear

Figure 33. Evolution of Iraq nuclear weapons organizations since 1991 (Colors indicate organizational continuity) (continued).

(GEET) storage. Iraq did not consider it relevant to declare these stores because Iraq considered this equipment neither nuclear nor nuclear related. Some of the equipment and materials were used in the reconstruction program while others were given to some establishments in need of the equipment.

In the early 1990s, Iraq retained residual capabilities that could support a nuclear program by adapting personnel and dual-use equipment to non-nuclear activities but display the generic capabilities applicable to their previous nuclear-related efforts. In the full accounting of program equipment, some equipment could only be accounted for as “lost.”

- According to one high-level scientist, workers at PC-3 sites were instructed to remove materials, equipment, and documents from their workplace prior to the UN inspections in May 1991. The laboratory from the Tarmiya EMIS uranium enrichment site was used to outfit a laboratory at the University of Baghdad College of Education (Adhamiya district) where research on Freeman ion sources was continued. Other researchers at Tarmiya also built a vacuum system laboratory at Baghdad University (Jadriya district).
- An example of “lost” equipment includes equipment at Al-Athir that was shipped for destruction. Although some boxes were destroyed by the army, the remaining boxes were returned. The items that were not found in these boxes and parts of which could not be located at the destruction sites were considered to be lost during evacuation.

IAEC Modernization

Interest in the IAEC and Intervention by Saddam Husayn

From at least 1999 onward Saddam became increasingly interested in the activities of the IAEC and began holding regular meetings with representatives of the IAEC. Saddam also began to personally intervene in matters related to the IAEC, ranging from internal personnel issues, to prompting other organizations to work with the IAEC and utilize the IAEC’s scientific capabilities. In late 1996, Saddam agreed to the Oil-for-Food program, resulting in significant fund, which he was able to use to bolster his scientific base.

- A former scientist at the IAEC spoke of many scientists leaving the IAEC in 1999 because conditions were so poor. The scientist claims that Saddam personally intervened, beginning in 1999, to improve conditions and raise salaries. He also made what the scientist called “a blanket rule” at this time forbidding scientists from leaving their posts.
- Dr. Huwaysh recalled that in 2001 and 2002 the frequency of meetings between Saddam and Iraqi nuclear scientists increased. During the same time frame, Saddam also issued a Presidential Order to the President of the IAEC, Dr. Fadil Al-Janabi, that he should keep nuclear scientists together at the IAEC in order to pool their skills and have them available when needed for starting numerous new projects. Dr. Huwaysh did not know the specific details of any of these projects.
- Dr. Huwaysh also recalled that, circa 2000, when Saddam found out that former nuclear workers in the IAEC were not being paid as well as those in the MIC, he met with Al-Janabi, initiated raises in their salaries, and instituted a bonus scheme.
- A former MIC official stated that, in January 2002, Saddam issued an order requiring the MIC to cooperate with the IAEC and to implement projects in the areas of physics, machining, and electronics.

Saddam also began to take an increased interest in the welfare of former nuclear scientists in the MIC. Dr. Huwaysh stated that in 2000 Saddam began asking about the welfare of former PC-3 scientists within the MIC and referred to them as “my people.” Saddam, a former IAEC Chairman in the mid-1970s, reportedly made it clear that he cared greatly about the former nuclear program and began showing a renewed level of interest in it at this time.

Increased Funding and Publicity of IAEC Activities

In the last years before the war, the IAEC received increased publicity for its achievements and a larger budget, prompting many former PC-3 scientists to want to return to the IAEC from the MIC. This was partly due to the perceived improvements in conditions and salary increases. More money also became available to the IAEC through direct funding by Saddam.

- The former MIC Minister recalled the budget of the IAEC increasing in 2001/2002 and that Saddam overruled the Finance Minister’s opposition to the budget increase. The MIC Minister did not know by how much the budget increased.
- A former IAEC scientist stated that the IAEC budget increased through the 1990s in line with standard inflation but then increased sharply beginning in 2000.

Infrastructure Improvements at the IAEC: The Modernization Project

New computer numerically controlled (CNC) machine tools sought for IAEC’s Tuwaitha workshop in what has come to be known as the Modernization Project were not subject to nuclear export controls and were reported as required by the UN’s Ongoing Monitoring and Verification (OMV) Regime. In 2001/2002, following meetings with Saddam, Al-Janabi and Dr. Khalid Ibrahim Sa’id embarked on a plan to improve the machine

tools workshop at Tuwaitha and supply it with new machines—an activity that was not completed before the war.

- Former MIC Minister Huwaysh recalled that in 2001, Al-Janabi and Dr. Sa’id approached him and requested support for a special project. He was not told the nature of the project but learned that it involved the procurement of very precise machines. Huwaysh, after consulting with Saddam, agreed with the understanding that the purchase would be conducted through MIC’s Al-Basha’ir Company.
- Due to reluctance on the part of international dealers to sell to the IAEC, Al-Janabi used the MIC to purchase the machines to conceal the fact that the IAEC was buying the machines. Al-Janabi also recalled that the contract for the high-precision machines was between the Al-Badr Company and a Taiwanese supplier. The Deputy Director General for Engineering was responsible for machine selection. Sa’id assisted in the project because of his extensive experience within the IAEC and his good managerial abilities. Sa’id’s main role was to coordinate with the Finance Ministry to receive approval for the purchases and draw the hard currency from state funds when necessary.
- Al-Janabi also stated that he approved the purchase of the machines as part of an initiative to modernize the IAEC. He believed the machines were more accurate than Iraq’s existing capability.
- While there is no question that the IAEC pursued these machines, there are conflicts in the information regarding the actual purchasing agent, the Al-Badr Company or the Al-Basha’ir Company. ISG believes that it is most likely the specifications and order were made by the Al-Badr company, on behalf of the IAEC, and the order was placed through the Al-Basha’ir Company, which was the actual purchasing agent.

Dr. Huwaysh told ISG that, although he was not explicitly aware of what was being purchased, in his opinion the machines that the IAEC were buying were more accurate than those at any MIC owned companies and that the IAEC was supply-

Modernization Project—Machine Tools

<i>Machine Type</i>	<i>Model</i>	<i>Country of Origin</i>	<i>Cost (US \$)</i>
CNC Milling Machines	2 x MCV- 600E	Taiwan	160,020
Surface smoothing	1 x KGC-84MSI	Taiwan	83,717
Wire-Cutting Machine	1 x A300	Taiwan	155,228
Spark Machine	1 x M50F	Taiwan	86,427
CNC Milling Machines	2 x MCV-1200	Taiwan	225,000
CNC Copy Milling Machine	1 x VTC-1400 CTC	Taiwan	395,000
Lathe Machine	1 x MT52S	Taiwan	90,000
Lathe Machine	1 x MT52L	Taiwan	95,000
Vertical Lathe Machine	1 x VL-12	Taiwan	268,926
Plasma-Cutting Machine	1 x 315A ROSSA	Bulgaria	165,400
3D Measuring Tool	1 x 3D DEA10	Italy	115,000
Sorting Machine	1 x MI-400	Unknown	Unknown
Lathe Machine	TNC-30NL	Unknown	Unknown
Punching Machine	Unknown	Taiwan	67,000
Laser Pointed Drill	Unknown	Spain	67,000

ing its workshop with high-precision machine tools. Furthermore, he stated the Modernization Project was classified to the extent that even he was not made aware of its details. This compartmentalization was evident at the top levels of the Regime, including Saddam, who personally verified that the MIC Minister was to assist the IAEC. However, none of the sources debriefed have been able to explain why the MIC Minister was excluded from the technical details of the project.

- Dr. Huwaysh’s assertion that the purchase of the machines was a secret program is puzzling, given that the machines were reported to the UN/IAEA and were thereby subject to inspection. Other sources have commented that it would have been impossible for Dr. Huwaysh not to know what was being procured because it was his organization doing the procurement and that the project may not have been classified. A high-level Iraqi scientist stated that these high-precision machines were

installed at Tuwaitha, and information regarding the machines was provided to the UN and IAEA in the declaration given in December 2002.

In contrast, former IAEC employees directly responsible for the selection and installation of the machines told ISG that the machines the IAEC purchased were the same as those already operating at Badr and were not particularly high precision. The same former IAEC employees went on to suggest that the machines were, in fact, of poor quality, cheaply made, and were prone to break.

- Former IAEC employees, Diya’ Jalil Husayn and Zuhair Al Yassiri, selected the machines based on generic workshop requirements. The majority of the machines were Asian in origin, and they were described as “cheap Taiwanese machines.”

ISG also received conflicting information regarding the specific use of the machine tools workshop

beyond general machining capabilities. The former President of the IAEC described the procurement of the machines as the development of Iraq's "non-nuclear scientific infrastructure." The machines would enable the IAEC to create molds and manufacture specialty parts for machinery in-house rather than outsourcing the work.

- A former IAEC employee with close ties to the project told ISG that the machines were to be used to manufacture equipment for use by the IAEC in R&D (primarily for the Physics Directorate) and were not to be used for the manufacture of items for outside organizations.
- A senior executive in the MIC described how the Center for Mechanical Design was to receive the equipment, reverse-engineer it, and send it to the Badr, which would then produce high-precision tools from it.

Perceptions the Regime Was Preparing for Reconstitution of the Nuclear Program

Saddam's increased interest in the IAEC and publicity of IAEC achievements, increased funding, and infrastructure improvements prompted Dr. Huwaysh to speculate that Saddam was interested in restarting a nuclear weapons program.

- Dr. Huwaysh was suspicious this procurement was part of an attempt to restart the nuclear weapons program because both Janabi and Sa'id were part of the pre-1991 nuclear weapon program. He also was suspicious of Sa'id's involvement because Sa'id was close to retirement. Furthermore, Dr. Huwaysh knew that high precision machines are needed to make centrifuges, although he admitted he only had the general notion of the capabilities of the machines.
- Dr. Huwaysh believed these factors may have been an indication that by 2000 Saddam had run out of patience waiting for sanctions to end and wanted to renew the nuclear program, though he could offer no concrete evidence to support this view. Alternatively, Dr. Huwaysh speculated that Saddam may

have had a small group of people advising him on nuclear power issues, although Dr. Huwaysh had never heard about it.

Alternatively, Al-Janabi says he approached the Presidential Secretary, 'Abd Hamid Mahmud Al-Khatib, in late 2001 with a proposal to modernize the IAEC in order to develop Iraq's nonnuclear scientific infrastructure. Khatab approved the idea and authorized the use of state funds through the Ministry of Finance. It was commonly understood that Khatab spoke for, and with the authority of, Saddam. As a result, Janabi began a broad effort to raise salaries and modernize departments, including procurement of the CNC machines.

- Other interviewees also were consistent in suggesting the new equipment was needed to fix a degraded, or lost manufacturing capability at Tuwaitha. A former vice president of the IAEC stated that the purchase of these machines was not intended to modernize the IAEC's manufacturing capability, but to re-create practical research capabilities.
- A MIC scientist working at the IAEC glass workshop described the machine purchase as a means of improving the machines of the tool room workshop because the existing machines in 2001 were no longer functioning or not functioning properly.
- Dr. Huwaysh also has quoted Saddam as saying "We do not intend or aspire to return to our previous programs to produce WMD, if the Security Council abides by its obligations"

IAEC Work on Neutron Generators

ISG has found no evidence of neutron generator or initiator research as part of a post-1991 nuclear weapons development program. Programs involving a French-supplied neutron generator are probably related to ongoing IAEC improvement efforts, which started by 2000.

- In 1984, the IAEC acquired a large neutron generator from a French company. In 2002, targets were bought for the neutron generator from the German

company Siemens because the United States would not sell to them. The generator has been used for research projects related to geology, food, and environmental studies. As of May 2003, some parts of the neutron generator had been looted. Iraq also had small Americium-Beryllium and Plutonium-Beryllium neutron sources.

- Dr. Shaker Al-Jabouri, Director of the IAEC Nuclear Physics Department from 1992 to 2003, was in charge of the neutron generator at Tuwaitha as well as being a professor in the Department of Physics, University of Baghdad, from 1987 to 2003. He supervised numerous graduate students at the University of Baghdad whose theses included “Measurement of Neutron Activation Cross Section Using Neutron Angular Distribution Produced by 14 MeV Neutron Generator” and “Calculation and Measurement of Neutron Cross-Section for Energy Range 0.5 to 3 MeV.” These studies indicate Jabouri and the University of Baghdad remained involved in material cross-section work—a subject area with applications to civil radiological programs and nuclear weapons research.
- According to translated Iraqi documents—specifically a 2002 memo from Jabouri—a neutron generator was used in his laboratory in several post-graduate nuclear activation projects. The projects included radiation effects on materials, development of control systems, design of a rotating target, design of a magnetic analyzer, and design of an ion source.
- The IAEC/Physical Research and Materials Directorate/Nuclear Applications Section carried out various research activities using a neutron generator and related technologies. ISG has not been able to identify any neutron generator activities by this organization related to a nuclear weapons program.

University Programs

Universities played a supporting role to preserve Iraq’s nuclear knowledge base. While ISG has found no information that universities supported any pursuit of nuclear weapons, ISG did find that universities offered a haven for some former PC-3 personnel and dual-use equipment after Operation Desert Storm and were being reestablished as a source of knowledgeable support for the IAEC and MIC after 1999.

ISG found that Iraqi educational institutions accepted equipment salvaged from the pre-1991 program, but we are unable to show that universities played a role in any renewed Iraqi nuclear weapons effort. The following are examples of instances where Iraqi institutions received equipment from the former nuclear weapons program:

- **Tuwaitha.** Iraq admitted that educational institutions that received equipment from Tuwaitha for storage and/or incorporation include Teachers Training Institute, Institute of Technology in Zaafaraniya (student dormitories in Al-Waziriya), University of Baghdad (dormitories in Jadiriya), and the College of Physical Education.
- **Tarmiya.** Iraq also declared that educational institutions that received equipment from Tarmiya—such as general laboratory devices and spare vacuum system parts—for storage and/or incorporation include University of Mustansiriyah, University of Baghdad (College of Science), Saddam University (College of Science), and the Institute of Technology (Department of Chemical Industries).
- **Al Atheer.** The Al Karama secondary school and Al-Anwar primary school received equipment evacuated from Al Atheer around February 1991, according to Iraq’s declarations. Similarly, some equipment not associated with any NPT violation was transferred to Saddam University and the University of Technology. According to Iraq’s declarations, the Babil University also received an unidentified number of boxes of unidentified equipment—allegedly most of which contained damaged and mixed components from the former nuclear weapons program at al Atheer.

- **Rashdiya.** The University of Baghdad also received equipment and materials from the former centrifuge program.

In the early 1990s Iraqi nuclear program personnel found temporary homes in educational institutions—moves that occasionally involved shifting of groups of scientists from the former weapons program. University programs offered a means to preserve the existing knowledge base by providing an opportunity for former PC-3 personnel to pass on their basic, fundamental knowledge to new generations of scientists.

- According to one high-level scientist, workers at PC-3 sites were instructed to remove materials, equipment, and documents from their workplace prior to the UN inspections in May 1991. The laboratory from the Tarmiya EMIS uranium enrichment site was used to outfit a laboratory at the University of Baghdad College of Education (Adhamiya district) where research on Freeman ion sources was continued. Other researchers at Tarmiya also built a vacuum system laboratory at Baghdad University (Jadriya district).
- Another high-level scientist confirmed that staff from PC-3 projects at Tuwaitha received the same instructions. As a result, Dr. Qais Abdul Hamin established Electronics Laboratories and Departments for Power Electronics, Instrumentation, and Distribution Control at the Technical University in Baghdad with equipment and staff from PC-3. A laboratory was established at the University of Baghdad led by Dr. Hamid Al Mundiri and staffed by PC-3 materials scientists. A Surface Inspection and Measurement Laboratory was established at the University of Baghdad led by Dr. Nabil Ramu.
- Documentary information collected by ISG indicates that Dr. Saadi Ja'far Hasan left Al Atheer in June 1991 and transferred equipment to Saddam University. Ja'far taught atomic physics, nuclear physics, nuclear spectroscopy, and advanced physics. The equipment was used to establish an atomic physics lab for second year students, a preliminary lab for undergraduates/third-year students, and a more advanced lab for fourth-year students.

Through the 1990s, educational institutions shared some personnel with MIC and the IAEC—activities that seem to be motivated most by the need for former weapons program officials to find new employment, but steps that inherently preserved access to scientific knowledge and capabilities from the pre-1991 program. Officials have indicated that former PC-3 scientists were unhappy with MIC employment, dissatisfied with IAEC pay, and used the universities as a way to supplement pay and create more interest in their work.

- According to Huwaysh, most PC-3 personnel were kept in the MIC after 1991. However, some nuclear physicists went to the universities because there was no nuclear work for them in the MIC.
- Al-Janabi stated that “most IAEC researchers also taught at universities or advised doctoral students, both for scientific and financial reasons.” However, there was no placement program to place IAEC scientists into university positions. Each scientist had to find a university position on his own and was permitted to work only one day a week at the university. Al-Janabi also stated that the IAEC provided approximately one million dinars per year to universities for research and that, during the universities’ summer break, many faculty members worked at the IAEC or the MIC to make additional money.
- According to Dr. Nafi ‘Abd Al-Latif Tilfah, Dean of Baghdad University’s Institute for Laser and Plasma Studies, post-1991 laser research was conducted at the Baghdad University Institute for Laser and Plasma Studies, the Baghdad University of Technology, Mustansiriyah University, and the al-Razi Company. While most of the research was paid for by the universities and the Ministry of Higher Education, the Al-Razi Company—which was subordinate to the MIC—also financed some postgraduate research projects. A number of key scientists from the pre-1991 laser uranium enrichment effort—including the head of that effort, Dr. Faleh Hamza—worked at Al-Razi after the 1991 war.

Reporting indicates the relationship between the universities and the MIC and IAEC was relatively ad hoc until the late 1990s, until efforts were made to send MIC and IAEC projects to the universities. With Saddam's support, MIC and IAEC dramatically increased joint university activities. The influx of funds would not only bolster a deteriorating university system but would also tend to focus university programs on MIC and IAEC issues. The result would be a new generation of scientists with a focus and understanding of MIC and IAEC pursuits.

- According to Huwaysh, cooperation between the MIC and Iraqi universities was largely a formality prior to 1999. Huwaysh claims that in 1999, he called a meeting of all Iraqi university heads to discuss the loss of professors to higher-paying industry jobs, which was crippling the university system. As a result of the meeting, he approved all professors to perform research for up to four MIC contracts each. Saddam liked his initiative so much that in late 1999 he ordered each of the ministries, including the IAEC, to implement a similar program of sending research projects to the universities. As a result, MIC-sponsored research projects in Iraqi universities jumped from approximately 40 in 1997 to approximately 3,200 in 2002.
- According to Iraqi declarations, the Institute for Training and Employee Development in the IAEC's Scientific Policies and Programs Department is described as providing a variety of coordination activities with universities. This includes both the opportunities for scientists to take advantage of university activities as well as the opportunity for university personnel to support IAEC facilities.

The historical relationship between former PC-3 scientists and Iraqi universities suggests that some nuclear-weapons-related research could have taken place within the universities, although ISG has uncovered no direct information that such work was under way. A number of highly placed individuals in the former Regime have stated that no nuclear-weapons-related research took place at universities. However, some research activities display obvious dual-use application to nuclear weapons development.

- **Laser Research.** Baghdad University's Institute for Laser and Plasma Studies researched and developed many types of lasers, including Copper-Vapor Lasers (CVL) as recently as 2002. This research was done in conjunction with al-Razi, with the stated purpose of research and development in laser targeting systems and directed energy weapons. CVL technology is relevant to Atomic Vapor Laser Isotope Separation (AVLIS) as well as many civil applications, and at least one of the researchers involved in this project was Dr. Faleh Hamza. ISG believes that this work does not indicate a reconstitution of a laser isotope separation program but offers an opportunity to preserve CVL knowledge and capabilities that could support future reconstitution. ISG has also uncovered reporting that indicates there was a prohibition of continuing nuclear weapons work including laser isotope separation.
- **Tarmiya Equipment.** ISG interviews of a high-level Iraqi official indicate that equipment from the PC-3 EMIS facility at Tarmiya was moved to Baghdad University after the 1991 war and prior to the start of intrusive inspections. At the university, studies reportedly were done in Freeman ion sources, and the Tarmiya employees built a vacuum system at the university. This work—while relevant to EMIS technologies—does not indicate a reconstitution of such a program, but offers an opportunity to preserve knowledge and capabilities that could have supported future reconstitution.
- **Other Examples.** A group of PC-3 materials scientists set up and staffed a laboratory at the University of Baghdad with equipment from Group 2FE. The laboratory was led by Dr. Hamid Al Mundiri. A surface inspection and measurement laboratory was also set up at the University of Baghdad and was led by Dr. Nabil Ramu. This laboratory later worked on stealth technology. Alternately, the head of PC-3 Group 2E attempted to set up a programmable logic control laboratory at the technical University of Baghdad, but the university refused to accept the laboratory because of the risk of being discovered by IAEA inspectors. All of these examples represent maintenance of knowledge and capabilities, but ISG has found no evidence that the laboratories continued work in support of a nuclear weapons program after 1991.

Hidden Enrichment Technology

Since Operation Iraqi Freedom, two scientists from Iraq's pre-1991 nuclear weapons program have emerged to provide ISG with uranium enrichment technology and components, which they kept hidden from inspectors. In August 2003, a former EMIS scientist told ISG during an interview that he had taken material and equipment that was related to EMIS and hid them in various places near his home in the 1990s. The scientist had not been specifically told to do this but believed his supervisors were cognizant of his actions. He chose items to hide that could be used in future reconstitution of the EMIS program. The scientist turned over to the Coalition a broad range of items that had been withheld from the UN inspectors, including technical reports on EMIS, a collection of foreign EMIS-related patents, a mass spectrometer, blocks of high-purity graphite, high-purity tantalum shielding sheets, and an indigenously designed collector piece from inside the EMIS machine. Some of these items are shown in Figure 34.

The former head of Iraq's pre-1991 centrifuge program also retained prohibited documents and components in apparent violation of the Regime's directives. Though this activity was isolated, it also had the potential to contribute to a possible restart of Iraq's uranium enrichment programs.

- In mid-2003, Dr. Mahdi Shakar Ghali Al 'Ubaydi provided Coalition forces with centrifuge components and a complete set of workable centrifuge blueprints, which he, reportedly, had hidden at his home for the purpose of reconstituting the centrifuge enrichment program after sanctions were lifted.
- Al 'Ubaydi reportedly hid these items in 1991, a move approved later that year by Husayn Kamil—Saddam's son-in-law and former head of Iraq's WMD programs. Qusay reportedly confirmed the order in 1992, but al 'Al 'Ubaydi had not been contacted since. ISG is not able to show that the Iraqi Government continued to be aware of Al 'Ubaydi's concealment activities or otherwise planned to use them as part of a plan to reconstitute the centrifuge program.
- According to a former PC-3 nuclear design scientist, he was surprised when he learned that Al 'Ubaydi had retained centrifuge program documents in his home. The scientist was very skeptical that orders were given to retain the documents and material associated with the former centrifuge program.
- Former Presidential Scientific Advisor Amir Hamudi Hasan al-Sadi stated that any Iraqi scientists that kept nuclear related material at their homes were acting on their own.



Figure 34. Items stored at former EMIS scientist's home—high-purity tantalum sheets (left), technical papers (center), and mass spectrometer (right).

Survey of Structures at Tuwaitha Nuclear Research Center

Scope

This report presents the findings of an Iraq Survey Group (ISG) survey mission between 20-22 November 2003, designed to clear all buildings at the Tuwaitha Nuclear Complex prior to their use by Ministry of Science and Technology (MOST) personnel. The survey investigated the buildings' probable research functionality, looked for any nuclear relevant or UN-labelled equipment, exploited documentation/electronic media, and determined the buildings physical status. The mission was one of the larger activities undertaken by ISG and the largest undertaken by ISG's nuclear team. This site was the most important to Iraq's nuclear research program and was one of hundreds of sites examined by ISG. The comments cited under the Team sections are from team notes taken on site and should not be considered authoritative, but indicative of the type of information collected.

Summary

- The status of all buildings and structures at the Tuwaitha Nuclear Research Center, known as at 22 November 2003, has been determined (see Conclusions and Annex B).
- Certain structures pose hazards from a radiological and unexploded ordnance point of view. These structures were not entered, and the precise hazards were not determined (see Annex D).
- A quantity of UN-labeled equipment was identified as well as other dual-use equipment including Anderson Samplers (see Results section and Annex E).
- Some 66 boxes of documentation and a large quantity of electronic media were collected and subsequently handed over to ISG for translation and exploitation (see Main Survey Procedure section and Results).

- The mission completed its objectives and at present ISG has no plans for further exploitation at the complex. However, it is possible that, if further information comes to light, ISG may need to revisit Tuwaitha.

Introduction

Tuwaitha is located on the east bank of the Tigris River, 18 kilometers southeast of Baghdad, 2 kilometers southwest of Zaafaraniyah, and approximately 1 kilometer west-southwest from a two-lane improved highway. The facility is protected by large berms that surround and divide it into four distinct areas: the former Soviet Reactor Complex and Administration/The Agricultural and Biological Research Center (TABRC) area in the northern quadrant, the former French Reactor Complex area in the eastern quadrant, the Research and Development area in the western quadrant, and the former Italian Laboratory area in the southern quadrant. For the purposes of this survey, the area within the berms was divided into five zones, A to E; the area immediately outside the berms was zone F; and the wider area surrounding the complex was zone G. A workshop facility near the site entrance was zone H, (see Figure 36).

ISG representatives were asked to produce a series of maps from imagery to support the mission as there had been a number of differing building numbering schemes; these were rationalized into the existing building numbering system used as a reference standard for the mission. The comprehensive nature of the products assisted greatly in accomplishing the mission.

The mission was conducted in a number of stages. Initially, a series of consultative meetings were held. These accumulated available knowledge of the Tuwaitha site. They were followed by a two-day video reconnaissance (VR) of the site with the aims of identifying any unknown hazards and to assist in the planning of a final document exploitation (DOCEX) mission as well as the main survey (MS).

The initial stage of the main mission was also assisted by a meeting with Black List #99, Dr. Fadil Muslim Abd Al-Janabi, current head of the Iraqi Atomic Energy Commission (IAEC), which had its

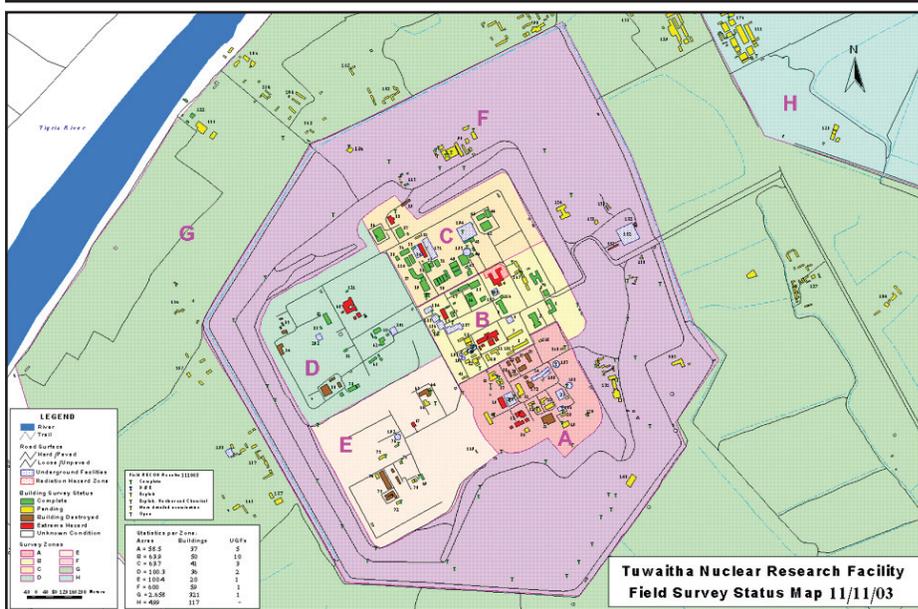


Figure 36. Tuwaitha Complex showing survey zones.

headquarters at Tuwaitha. Dr. Fadil was asked about the location and functionality of various assets at Tuwaitha, and his information was assimilated into the list of targeted buildings for Tuwaitha. He was also asked, and he agreed, to accompany the author to the Tuwaitha site and provide information that was of significant assistance to the planning of the mission.

Prior to the VR, a target list of buildings was compiled, and those facilities (surface and subsurface), where it was safe to do so, were visited during the VR. The finalized target list was used as a database to record the mission progress.

The video reconnaissance (VR) of a number of buildings at the site was undertaken on 5-6 November 2003 using four multidisciplinary teams to cover the site quickly on a zone-by-zone basis. Analysis of the videotapes and commentary produced is included at Annex C, which was instrumental in the detailed planning of the main mission.

During the VR, an optical spectrometer and Andersen samplers were identified, and a one-day mission was mounted to recover that equipment and to carry out a DOCEX on three target buildings on 11 November 2003. The one-day mission also provided the facility to test some of the procedures planned for the main survey. Following analysis of the VR results, the buildings' target list was revised, and relevant discipline subject matter experts (SMEs) lead teams were tasked to review those buildings in the main survey (MS).

The MS was conducted by moving 61 ISG personnel, SMEs, and force protection staff to create 5 teams with delegated responsibility for a set of buildings. The teams lived on site for 3 days in order to avoid force protection risks of daily travel.

The teams were tasked to pretriage any documents in their buildings and the team leaders were asked to sign preprinted sheets to confirm the status of each building for ISG purposes. Over the 3 days of the MS duration, an up-to-date list of building status was compiled, which is presented as Annex D to this document.

Factors Affecting the Survey

All buildings identified at the Tuwaitha complex whose status was uncertain were included in the target list as pending survey. Buildings that were hazardous in respect of their structural status from bomb damage, radiological, or other reasons were not entered and were marked as a hazard on the target list. Areas or underground facilities (UGFs) flooded with water possibly contaminated with coolant from the damaged reactors were also not visited. Where possible, visual inspection was made using a video camera. Sealed containers were examined by drilling small holes and inserting optical fiber-viewing aids into the container to examine the contents and, if necessary, the provision of larger holes to enable SME access.

Main Survey Procedure

DOCEX Procedures for Combined Media-Processing Center, Baghdad (CMPC-B)

It was important to use the limited linguist resource effectively in the triage of documents and to minimise the duration of this process. Consequently, a new list of mission-relevant keywords was produced and procedures introduced to locate precisely any media identified as sensitive. The teams were told to collect any form of electronic media and personnel files if seen. Blueprints and management diagrams were also targeted.

Mission planning allowed one CMPC batch number per building; document boxes were identified by: batch number, building number, and serial number of box. Separators were used to link documents to room numbers. The boxes were assigned a starting batch number of 3326 – 2, which would increment with building number so, for example, the Nth building would be 3326 – (N + 1).

A US Army Major was given the responsibility of monitoring and, if necessary, driving the DOCEX part of the mission. A US Air force LTC was asked to run the Command Post (CP) and to issue building targets to the teams as required.

The mission was conducted by fielding five survey teams, all of which were led by a nuclear technology discipline SME. Four of the teams contained a linguist, a second discipline SME, a document gatherer, and a force protection person. On arrival on site, each of the teams was allocated a large DOCEX task and a caution task. Following the clearing of those buildings, the teams were allocated buildings on a team-availability basis designed to work around the outstanding buildings of the Tuwaitha inner zones on a clockwise basis. The mission was controlled via the CP and the target list updated as the building status survey proceeded. A mission log of all significant events was maintained by the CP.

Four teams were deployed in zones A to E; a fifth team, led by the Author, surveyed zones F, G, and H with the aim of dealing with the more difficult building targets, until such time as it could be supported by other teams on an availability basis.

Using the given definitions (found in Annex A), building status was updated from pending or caution to either clear or triaged, and the presence of any mission-relevant equipment similarly recorded.

Results

It is quite possible that some sensitive information will be forthcoming once all exploitation is completed. However, the primary results of the mission are:

- Some 66 boxes of documentation and a quantity of electronic media were found, which were handed over to CMPC-B for exploitation post mission.
- Three Andersen Sampler bases and two tops were recovered.
- A quantity of UN-labeled equipment was identified. The information obtained was included in and used to update the “Summary of Known UN Tagged Equipment” presented at Annex E.
- All personnel completed the mission safely and free from any radiological contamination.

[ISG Note: Further exploitation produced no additional information to contradict these results.]

Discussion

A group of unknown Iraqis were spotted by Team Bravo loading documents and equipment onto a vehicle on the morning of 22 November. Detail is provided under Team Bravo comments in Annex B.

The initial planning commenced with a list of approximately 206 structures; 58 of these had been previously surveyed and cleared by ISG video reconnaissance and/or previous missions. Furthermore, 28 structures had been previously destroyed, 8 deemed hazardous, and a number were not applicable for exploitation, such as air defense sites, and areas outside the Tuwaitha complex region. As such, 93 structures remained pending for exploitation. During

the main mission, these 93 structures were surveyed. ISG members also returned to a number of previously surveyed and unidentified structures. In all, the main three-day mission surveyed 106 structures, all but two were certified as either clear or triaged.

The buildings that were not cleared were the library (Building 42) and the fire station (Building 151). In the case of the former, the quantity of documents is vast, and all survey teams as they completed their normal task list, were dispatched to the library to facilitate the process. The teams were specifically instructed to target Ph.D. theses and to search for unusual document positioning or storage. Using this process, a best endeavors attempt was made to clear the library.

Building 151 is the fire station, which is operational. During the VR, a room full of binders was identified, and a team was dispatched on the last day of the MS to triage the binders. Initially, there was some difficulty in identifying the location of the room, and the fire station personnel denied the existence of any such room. The team withdrew to check their facts and then returned and identified the room, which was secured by a locked glass paneled door. Staff claimed that the material was commercial, belonged to the MOST, and that they did not have a key. They offered to contact MOST to ask for a representative to appear and give access.

After some discussion it was decided to approach MOST via ISG in order to gain access to the room as the team had no wish to force entry to an operational facility or indeed to damage one of the few undamaged buildings at Tuwaitha.

Postmission Activity

A mission was set up to go to Tuwaitha on 2 December 2003 with the aim of gaining access to the room of documents (Building 151). The party arrived at approximately 0815 and asked for MOST to be contacted for a keyholder to attend and open the door. After some discussion it was agreed to gain access to the room, and a full triage of the documents was undertaken. Prior to entry, a series of photographs

was taken to verify the status of the room, and this was repeated after the door was secured to demonstrate that no damage had been caused to the room or its fittings.

The records were drawings relating to the Tammuz reactor with little more recent than 1988. Nothing of significance to ISG was found, although a few documents were taken for further exploitation.

Another locked room containing documents was also entered and a full triage undertaken, using the procedures mentioned above. Again, nothing of significance to ISG was found although a few documents were taken for further exploitation. In view of the physical condition of the documents, covered with dust and vermin droppings, it was evident that the documents had been undisturbed for some time and no attempt had been made to introduce other documents into their content. Building 151 complex was considered clear.

Postmission action was also required on a number of issues, specifically:

- UN-labeled equipment.
- Unidentified equipment.
- Testing of samples collected.
- Use of the iridium pellets.
- Document referencing “heavy water.”

Note: These issues have since been resolved and found to be of no concern.

In view of the physical hazards at the Tuwaitha site, the planning detail, terminology, and methodology required to minimize risk to ISG personnel may be used as a template for future ISG missions to complexes of this nature.

The mission has demonstrated that ISG is capable of planning and undertaking the most complex of technical missions. The ability to mount a mission of this nature in such a hazardous area as the Tuwaitha Nuclear complex, without casualties and with the achievement demonstrated, is seen as a contribution to ISG’s reputation.

Conclusions

Following the three-day mission to Tuwaitha and a postmission visit on 2 December, the status of all buildings and structures known on 22 November 2003 has been determined, and it is suggested that the complex may be accepted as clear on the basis of best endeavours.

Best endeavours implies the best that could be achieved with available resources and equipment. The Tuwaitha site occupies some 20 km² and there are plenty of places; e.g., under radioactive water in basements or damaged buildings where documents, electronic media, or equipment could be hidden by those determined and where some risk to personnel would be involved in order to retrieve them. Without sound supporting HUMINT, missions surveying hazardous locations would be speculative and difficult to justify.

Future Work

This mission has attempted to incorporate HUMINT support suggesting the presence of hidden documents and equipment. The strongest hints were regarding a Building 6, which has not been found, and in the basement of Building 42/43, which has been burned. If additional HUMINT is forthcoming, then a ground radar survey may be appropriate for the future or the use of other high-tech equipment in order to examine all the flooded basements and water tanks.

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