



Iraq's Aluminum Tubes: Separating Fact from Fiction

By David Albright
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When David Kay, a senior advisor to the Director of Central Intelligence, presented the interim findings of the Iraq Survey Group on weapons of mass destruction in early October 2003, he said little about the attempts by Iraq to acquire over 100,000 high strength aluminum tubes. What he did say about the tubes in public, and in classified Congressional hearings, were in sharp contrast to his own and senior Bush Administration officials' statements in early September 2002.

Before the 2003 Iraq war, these tubes were widely described by President George W. Bush and senior administration officials as key gas centrifuge components, demonstrating that Iraq not only had reconstituted its nuclear weapons program but would soon be able to produce highly enriched uranium (HEU) for nuclear weapons. In September 2002 Kay told BBC's *Panorama* that Iraq's attempts to acquire several shipments of aluminum tubes meant that Iraq was "going for a large scale program." These tubes became central to the Bush Administration's pre-war claim that Iraq posed a menacing and growing threat to the United States and its allies.

But extensive evidence collected during recent International Atomic Energy Agency (IAEA) inspections and after the fall of Baghdad shows that Iraq did not plan to use the tubes in gas centrifuges. Three senior Iraqi nuclear scientists, one of whom later revealed banned nuclear items hidden from the UN inspectors, stated in interviews that Iraq had no efforts to use the tubes in centrifuges. U.S. investigators in Iraq have not produced any evidence to contradict these Iraqis' statements, despite months of investigations.

Long before the war, the US intelligence community knew enough to raise serious doubts about the assertion that these aluminum tubes were specifically intended for gas centrifuges. Key experts of the US intelligence community and experts at the International Atomic Energy Agency (IAEA) contested the claim that the tubes were for centrifuges, which was being pushed by the CIA.

The debate over the tubes started in 2001 during a US-led operation to stop an export of aluminum tubes to Iraq from China. The CIA became convinced that the tubes could be for an Iraqi nuclear program. As a result, the United States government told the Chinese government in 2001 that it was prepared to take military action to stop the shipment of tubes reaching Iraq. There has been a recent emphasis on gaining international support for seizing, militarily if necessary, illegal shipments of items that can be used to make nuclear weapons. This new focus is central to the Proliferation Security Initiative,

launched by the United States in 2003. This case points out the risks of this strategy which depends critically on intelligence information.

When senior Bush administration officials first went public with their claims about the purpose of the aluminum tubes in early September 2002, they spoke as if no opposition to their position existed. After ISIS revealed significant opposition from highly qualified analysts, the administration had to admit that was true, but it tried to discredit analysis by the US Department of Energy (DOE), the IAEA, and the State Department's Bureau of Intelligence and Research (INR). In addition, several analysts inside the government said they were under pressure not to say anything publicly.

A major reason for the administration's selective statements can be traced to its need to gain support for going to war against Iraq. When the administration first publicly raised the aluminum tubes in early September 2002, polls showed that the Congress and the US public were not convinced that the administration had made a compelling case against Iraq. The polls also demonstrated that the majority of the public wanted both Congressional and United Nations support for any US military assault.

People in general fear nuclear weapons far more than other weapons of mass destruction. Statements that Iraq was actively seeking nuclear weapons would be expected to increase the perception that the Iraqi threat was urgent and build support for attacking Iraq. Such a phenomenon happened when national security advisor Condoleezza Rice on September 8, 2002 said on CNN *Late Edition* that "we don't want the smoking gun to be a mushroom cloud." Although she admitted that there was uncertainty about how quickly Iraq could acquire nuclear weapons, she told CNN: "We do know that [Saddam Hussein] is actively pursuing a nuclear weapon." The first reason she gave for this assertion was "aluminum tubes that really are only suited for nuclear weapons programs, centrifuge programs." Other administration officials made similar statements, adding that the closer Saddam Hussein gets to a nuclear weapon, the more difficult to deal with him.¹ The Bush Administration played a "nuclear card" that it undoubtedly hoped would strengthen public support for war.

Although the administration exaggerated the nuclear threat and the case for the tubes, it also relied on controversial intelligence community assessments that were presented to policy makers in overly stark terms. A major failing was the manner in which the US intelligence community reached an agreement about the purpose of the tubes. The process permitted weak evidence to dominate strong evidence that the claim was false or at least questionable.

The debate over the tubes was fierce with analysts from the CIA advocating that the tubes were specifically intended for use in gas centrifuges aimed at making highly enriched uranium. Given the enormous size of the attempted procurements, the CIA concluded that Iraq planned to build a centrifuge plant with tens of thousands of operating centrifuges. On the other side were nuclear experts at the Energy Department's national

¹ See also Michael Gordon and Judith Miller, "US Says Hussein Intensifies Quest for A-Bomb Parts," *New York Times*, September 8, 2002, p. A1.

laboratories and the IAEA who did not believe that the tubes were specifically for centrifuges. They said that the tubes were more likely part of a declared Iraqi program to build short-range ground-to-ground rockets. They were particularly critical of the CIA's assertions that the tubes were unsuitable for use in rockets.

This polarized debate was formalized, but not resolved, in October 2002 with the release of a Director of Central Intelligence's National Intelligence Estimate (NIE). In this process, roughly ten individual intelligence agencies each have one vote, which pitted one agency against the other in a drive for a majority vote. The CIA won a majority, receiving the support of the Defense Intelligence Agency, the National Security Agency, and several military intelligence agencies. The Department of Energy, responsible for US centrifuge enrichment development, and the State Department dissented. The DOE assessed that the tubes were probably not part of a centrifuge program, and that conventional military uses were more plausible. The State Department accepted the judgment of technical experts at the DOE and wrote that the tubes were poorly suited for use in gas centrifuges. The State Department also found unpersuasive the arguments advanced by others to make the case the tubes were intended for gas centrifuges, considering artillery rockets a far more likely use for the tubes.

Besides coming late in the debate over the tubes, the NIE process itself was an inadequate method to deal with such a complicated technical issue. Outside experts complained that intelligence agencies with no technical expertise about centrifuges far outnumbered those that did. In addition, the final vote appears to have taken place after senior administration officials had already expressed their opinions, raising the question whether intelligence agencies decided to vote with the administration.

The vote further locked each side into its position. It also showed the difficulty of resolving such disputes in an interagency process. Peter Zimmerman, who was then on the staff of the Senate Foreign Relations Committee and organized classified briefings on the tubes for this committee, was quoted in an August 10, 2003 *Washington Post* article saying that majority votes make poor science.

An alternative method to resolve this conflict would have been for the Director of Central Intelligence (DCI) to ask for the judgement of the Joint Atomic Energy Intelligence Committee (JAEIC) which is officially part of the NIE process. JAEIC has been a standing DCI technical intelligence committee for several decades. This august scientific group did not evaluate the tubes, according to a knowledgeable US official.

Thus, a flawed intelligence finding on the tubes intersected in the summer and fall of 2002 with an administration in need of portraying Iraq as posing a grave threat. But the story began over a year earlier when the United States moved to stop a shipment of tubes from China to Jordan.

Part I: Determining the Purpose of the Tubes

During the late 1990s, western intelligence agencies suspected that Iraq might have restarted its nuclear weapons program, but the information was ambiguous. Some believed that an upsurge in production and procurement of dual-use items was related to a reconstituted nuclear weapons effort, but the evidence for this conclusion was weak. Saddam Hussein had also publicly assembled and praised parts of his former nuclear team on television.

UN Security Council inspections had ended in late 1998. With little information coming from inside Iraq, many CIA analysts became worried that Iraq had decided to restart a nuclear weapons program, with gas centrifuges as its basis. Against a background of little solid information, intelligence agencies and independent analysts started to generate worst-case analyses of possible Iraqi nuclear activities. Pressure mounted to find some concrete evidence of banned nuclear activities.

Discovery of an Aluminum Tube Order

The discovery of an order of high strength aluminum tubes placed by a Jordanian trading company on behalf of Iraq in late 2000 or early 2001 led the CIA to conclude that it had acquired the first “in your hands” proof of an Iraqi centrifuge program, according to several knowledgeable officials. Moreover, some CIA officials are reported to have concluded that the number of tubes in this order showed that Iraq was well along in its plans to build thousands or even tens of thousands of centrifuges. Australian intelligence, which played an important role in uncovering this illicit shipment in 2001, viewed the information as a “gem,” according to the Australian Broadcast Corporation’s news show *Four Corners*.²

Yet, the CIA’s conclusion was quickly questioned by centrifuge experts at the DOE, according to an expert at a national laboratory. Some experts concluded that the tubes were not intended for centrifuges as soon as they learned the details of the tubes in the order.

The order involved aluminum tubes designated as 7075-T6, which makes it a dual-use item with both nuclear and non-nuclear uses. Aluminum alloy with a 7000-series designation is very strong and hard, difficult to weld, and subject to corrosion from moisture. Few aluminum companies have adequate extrusion equipment to produce tubes out of it. The T6 refers to a specific tempering or heat treatment. These tubes had an outer diameter of 81 millimeters and were 900 millimeters long. They had a wall thickness of 3.3 millimeters and were anodized. On the inside, the finish was not specified. As a result, on at least the first tubes manufactured, the inner surface was rough. The tubes were carefully packed in paper in standard wooden open-sided maritime boxes.

² Four Corners, Australian Broadcasting Corporation, *Spinning the Tubes*, October 27, 2003. Transcript at www.abc.net.au

Under Security Council resolutions, Iraq was at that time banned from possessing aluminum tubing above a certain strength unless those items were imported through the UN, used for civilian or non-banned purposes, and subject to monitoring by inspectors. Since none of these conditions were met, Iraq was not allowed to import these tubes no matter what their purpose.

To obtain these tubes, Iraq's Military Industrialization Commission (MIC), its key military armaments production and procurement organization, secretly contacted a Baghdad-based trader in 2000. Unknown to the CIA at the time, MIC wanted to acquire 60,000 aluminum tubes with an outer diameter of 81-millimeter to revive an indigenous program to make ground-to-ground rockets. The tubes were for the rocket's combustion chamber, according to Iraqi declarations provided to the IAEA inspectors in 1996 and again after inspections resumed in December 2002.

The private trader was Ahmed al Barak, whose office was in Al Khellany Square in Baghdad. He received funds to purchase these tubes for a fixed price of about \$15 per tube, or a total of \$900,000. The funds were deposited into the National Bank of Jordan.

Barak in turn contacted companies in Jordan. The Atlantic Trading and Communications Corporation (AT&C) in Amman, Jordan received the bid to seek the aluminum tubes, according to the Iraqi, Bashir Ibrahim, in an interview in October 2003. Ibrahim, the general manager and owner of AT&C, is an Iraqi who had retired in 1994 after being involved with MIC for 20 years. Afterwards, his youngest brother was killed by Saddam's regime, and he left Iraq. He subsequently established AT&C, which was involved in a wide range of importing, exporting, and marketing services on behalf of manufacturing companies.³ The Ramada Import and Export Corporation, handling marketing and trading, was headed by Ahmed Kamel Hussein.

Ibrahim said in the interview that he searched for firms on the internet that could build the tubes. He said he tried to find a company in Bahrain, but the company could not extrude this special kind of aluminum. He found Chinese and Russian companies but did not contact them. He said that the Russian companies wanted too much money for each tube, up to \$37 per tube.

Eventually, he found International Aluminum Supply, an Australian company headed by Garry Cordukes, willing to give a good price. Cordukes' company was half owned by the Australian subsidiary of the Kangartec Company, which represented, and is owned by, the Chinese aluminum manufacturing company Kam Kiu Aluminum Extrusion Company in Tai Shen, near Hong Kong. Ibrahim said that he contacted International Aluminum Supply by telephone and started arranging a deal. The final deal had a cost of \$15 per tube.

Cordukes says that he made contact with AT&C in a somewhat different manner. Every few weeks officials in his company search internet sites looking for business. He said

³ The companies website is <http://www.atctrading.bizland.com/index.html>.

company officials found the offer by AT&C to build the tubes on an aluminum industry web site called www.aluminet.com.

Kam Kiu did not make tubes of this diameter. Samples sent by Cordukes to AT&C were of a smaller, 70 millimeter diameter, but AT&C representatives insisted on the original diameter, and Kam Kiu agreed. An outside diameter of 70 millimeters is the standard dimension for rockets used by the United States and Canada in NATO.

In addition, Ibrahim wanted the tubes coated with a chromate anodization instead of the more common type of anodization. The former is a common procedure used on 7000-series aluminum that is thinner and more suitable for use in the aircraft industry. Kam Kiu, however, did not produce this type of anodization, according to Cordukes.

By the end of 2000 or early 2001, Cordukes said that he had negotiated a contract to provide 60,000 tubes. He said he dealt mainly with Kamel Hussein, who served as AT&C's commercial manager. Ibrahim and Kamel opened a letter of credit at the Jordanian Philadelphia Investment Bank, but Cordukes insisted that the letter of credit be transferred to the Bank of New York in Shanghai.

In trying to make the tubes Kam Kiu experienced several problems, and by May had only made about 2,000, according to Cordukes. For example, it had trouble applying the chromate anodization, leading the company to apply a more traditional anodized coating, he said.

Cordukes said that sometime in April or early May 2001, he was contacted by an Australian defense official asking for a meeting. At the meeting a few days later, the man told Cordukes that the tubes might be sent from Jordan to Iraq where they could serve a military purpose. Cordukes was surprised by this information, but the man did not ask him to cancel the order. It is unclear when Cordukes learned that the purpose of the tubes was believed to be nuclear.

Soon afterward, he met the man again. This time he asked Cordukes to get him a sample of the tubes ordered by AT&C.

Cordukes was already scheduled to fly to China. He brought back one or two samples and gave them to a man at the Sydney airport upon his return. He said he did not hear anymore from the Australian government.

Cordukes did not know how the Australian government learned of the order. He said that the negotiations and the subsequent communications via telephone, e-mail, and facsimile were conducted in a routine manner and probably relatively easy for US and Australian intelligence agencies to monitor.

After meeting with the Australian official, Cordukes passed this information to the top management of Kam Kiu in Tai Shen. But with nothing further from any government,

Kam Kiu decided to ship the first container of about 2,000 tubes to Jordan.⁴ The shipping document, a copy of a facsimile that was attached to the container, gave the date of the shipment as May 26, 2001 and the port of embarkation as Hong Kong, according to Cordukes and other knowledgeable sources.

Two or three days after the shipment left the plant, the director of the Kam Kiu plant was telephoned by an official of the Chinese government. Cordukes, who was at the mill that day, was contacted by his employers and told what the Chinese government official had told his superiors. The Chinese official said that the United Nations had approached the Chinese government on behalf of the United States, which objected to the tube order. This official said that the United Nations told the Chinese government that the tubes could be used for inappropriate purposes, and he added that the US government was prepared to take whatever actions were necessary to prevent the shipment reaching Jordan.⁵ In a telephone interview in October 2003, Cordukes said that plant officials told him that the United States was prepared to go as far as taking military action to stop the shipment reaching Jordan.

The Chinese government asked the company to stop making the tubes, which it did. The government did not order the company to stop. Cordukes interpreted the lack of an order as a way for the government to avoid any future financial liability. In any case, the company had little choice but to stop the order. Although Kam Kiu could not stop the first shipment, it did not send AT&C the original “bill of lading,” without which the shipment could not be claimed after its arrival in Jordan.

Cordukes also said that he contacted Kamel and told him that the Chinese government had said that the tubes could be used for inappropriate purposes. Cordukes asked him for details about end-use of the tubes. Ibrahim responded that the tubes were to be re-machined in Canada for flanges and pulleys in cars. Cordukes also received a letter from a Canadian firm, TE Canada International Co., stating more precisely the end use of the tubes.⁶ Cordukes said he was skeptical about this letter, but the order was over in any case. He said that Kam Kiu was never paid for this shipment.

The letter from TE Canada was signed by Bob Abraham. Cordukes denied knowing him. After learning Abraham’s telephone number in October 2003, I telephoned him. It was apparent from his accent that he was Arabic, and upon questioning he said he was Bashir Ibrahim, the owner of AT&C.

Before the shipment arrived in Jordan, Ibrahim was contacted in Amman by two officials from the Chinese embassy, who asked him to turn back the container. He refused, stating that he wanted to be paid first.

⁴ The number of tubes in this order has been variously reported by participants in this case from 2,000 to 3,000 tubes. The number used here is based on interviews with Cordukes and Ibrahim.

⁵ *Four Corners*, op. cit.

⁶ *Four Corners* producers, private communication.

Subsequently, the Jordanian government seized the container of tubes. According to *Four Corners*, quoting intelligence officials, as the US and Jordanian officials approached the gates to the customs area containing the crates of tubes, CIA operations officers saw a couple of men who turned out to be Iraqis. These Iraqis appear to have been waiting for the tubes to clear customs. When they saw the officials arrive, they made some quick calls on their mobile telephones. They were subsequently told to leave by the CIA officers.

Ibrahim was surprised originally to hear that the tubes could have a nuclear end use. He said that Jordanian government officials informed his Jordanian employees when the tubes were seized that the tubes were for a nuclear purpose.

In the interview, he acknowledged believing that the tubes were for rockets and was quite knowledgeable about the Iraqi program to make short range rockets from the tubes. It is unclear whether he knew that at the time he was procuring tubes for rockets.

He said that sometime after the seizure of the tubes, Iraq contacted him about his interest in procuring the wherewithal for Iraq to make these tubes itself. The order was for an extrusion machine and aluminum billets. Ibrahim thought the business was too dangerous and turned down the offer.

The seizure in Jordan left the United States and Australia intelligence community elated. Australian officials told *Four Corners* about their pride that Australia had been able to contribute to such an important seizure that pointed to a secret nuclear weapons program.

Barak never obtained any tubes, according to Iraqi declarations. Another Iraqi trading company subsequently took over this original contract (see Part III). Because of strict financial liability stipulations in Iraqi law, however, the Iraqi government threatened to put Barak in jail if he did not complete the contract. Under Iraqi law, the government is entitled to obtain the same number of items which he failed to acquire using the money allocated to him. However, the price of the tubes subsequently rose, leaving Barak liable to buy roughly 6,000 tubes to make up for the shortfall. He decided to flee Iraq rather than pay or go to jail.

CIA Rationale for centrifuge components

The administration to date has offered few details publicly about its case that the tubes were for centrifuges.⁷ It has typically restated its views without describing its rationale for its conclusion. CIA spokespeople have leaked information to the media, although in most cases this information has been vague or incomplete. Nonetheless, a large number of sources in the United States and abroad have provided insight into the CIA's initial assessment.

⁷ When I contacted the CIA public affairs office in September 2002 for additional information about the tubes, a spokesperson responded that his office would not speak with me about this subject.

Determining an exact use of the aluminum tubing was impossible in 2001. Thus, any assertion that the tubes were for centrifuges had to be based on evaluating the tubes' dimensions and specifications, conducting, in essence, a theoretical analysis. The basic CIA analysis appears to have been based on a comparison of the aluminum tubes to known rotors in old centrifuge designs.

A key player in claiming that the tubes were for centrifuges was a CIA analyst who was a former member of the US gas centrifuge program at Oak Ridge prior to its cancellation in 1985. In the media, he has been referred to as Joe. The *Washington Post* reported on August 10, 2003 that the CIA gave him an award for exceptional performance.

Joe came to believe in early 2001 that the aluminum tube was for use as the wall of a centrifuge rotor, which is a thin-walled tube closed at each end that spins at high speeds, causing the uranium gas (uranium hexafluoride) to enrich in the isotope uranium 235. A centrifuge rotor is a highly stressed object that requires specialized high strength material (see figures 1 and 2).

Because the aluminum tubes were ordered in large numbers, the CIA concluded that the tubes were intended for the serial production of centrifuges. Because each centrifuge enriches a relatively small amount of uranium, many centrifuges must be connected by pipes into "cascades" in order to produce enough highly enriched uranium for nuclear weapons. However, the centrifuge based on these tubes was so inefficient that Iraq needed to build tens of thousands of centrifuges. The CIA estimated in the October 2002 National Intelligence Estimate that Iraq would need 25,000 operating centrifuges to make enough highly enriched uranium for two nuclear weapons a year.

Many old centrifuges used aluminum rotors, and Iraq pursued at least one of them in the 1980s, although it abandoned this design in 1989 before it had been able to fully develop it. Starting in the summer of 1988, Iraq received substantial foreign assistance permitting it to build more advanced designs that had rotors made from maraging steel and carbon fiber, materials resulting in a rotor that spins substantially faster and thus enriches uranium considerably better.

When the Iraqi centrifuge program started in 1987, it focused on an archaic "Beams-type" centrifuge design, named after its U.S. originator, Jessie Beams. A common Beams-type design in the early 1940s used a duralumin tube that had a length of 40 inches (1016 millimeters). Duralumin is an old aluminum alloy that is equivalent to 2000-series aluminum. The inner diameter was about three inches (78 millimeters) and had wall thickness of about 6.3 millimeters.⁸ Two-thousand-series aluminum is not as strong as 7000-series aluminum, but Iraq could replace the 2000-series aluminum in the Beams-design with 7000-series aluminum without a major impact on the centrifuge's operation.

⁸ J. W. Beams, A. C. Hagg, and E. V. Murphee, *Developments in the Centrifuge Separation Project*, Atomic Energy Commission, Office of Technical Information, Washington, DC, TID-5230, 1951.

Iraq decided in the late 1980s to shorten and widen the rotor of this Beams-type design. It tested a rotor that had a diameter of four inches (100 millimeters) and a length of less than 500 millimeters, according to Iraqi declarations to UN inspectors.

Aluminum was also used in a more advanced centrifuge design that was developed in the late 1940s and early 1950s in Russia. In the West, this design is often called a "Zippe-type" centrifuge, named after one of its main developers, Gernot Zippe. The first centrifuges of this type also used duralumin rotors. Zippe said that the aluminum rotors he built in the 1960s in Germany used something equivalent to 2000-series aluminum with a T6 hardening.

The dimensions of Zippe-type centrifuges made with aluminum rotors are publicly available.⁹ The rotors typically had various diameters; the published diameters of the rotors are about 58, 70, 76, and 100 millimeters. The lengths varied but were proportional to the diameter. For example, the rotor tube with a diameter of 100 millimeters was less than 500 millimeters in length.¹⁰ A rotor with an outer diameter of 81 millimeters would have a length less than about 400 millimeters, requiring the tubes Iraq sought to be cut. When built in the former Soviet Union in the early 1950s, the rotors had a wall thickness of about 0.3 millimeter, although later designs used a wall thickness of about one millimeter, according to Zippe.

The aluminum tubes Zippe used were not anodized and did not have any other type of coating. Uncoated aluminum works well in a centrifuge both in a rotor assembly and as cascade piping. An anodized coating on the tube would likely be removed during final fabrication of the rotor.

Thus, the dimensions of the aluminum tubes Iraq sought are consistent with centrifuge use, assuming that the tubes would be cut and other modifications made. But nothing known about this Iraqi order of tubes in 2001 points to a use as a centrifuge rotor. In the end, the CIA conducted a highly theoretical assessment based on extrapolating from a limited set of data. Its extrapolation required the assumption of certain, unproven behaviors by Iraqi engineers and centrifuge experts, including abandoning their tested centrifuge designs for unproven, less capable designs.

Initial US Expert Assessment in the Nuclear Community

Review of the CIA assessment started soon after the tube order was discovered. An influential set of experts was at the Department of Energy (DOE). Oak Ridge, Livermore, and Los Alamos national laboratories all had knowledge of the CIA assessment.

⁹ Gernot Zippe, J. W. Beams, and A. R. Kuhlthau, *The Development of the Short Bowl Ultra Centrifuge*, University of Virginia, Report UVA/ORL-2400-58, PR No. 1, December 1, 1958; and *The Problem of Uranium Isotope Separation by Means of Ultracentrifuge in the USSR*, October 8, 1957, obtained from the CIA under the Freedom of Information Act.

¹⁰ Longer rotors could be built, for so called "supercritical" centrifuges. The rotors would need a specialized flexible joint called a bellows that would be inserted between rotor segments.

Many of these scientists and experts were deeply knowledgeable not only of gas centrifuges but also of the Iraqi gas centrifuge program. They rejected the CIA view that the tubes were specifically intended for use in a centrifuge, although many agreed that the tubes could have been modified for use in an inefficient centrifuge. Some gas centrifuge experts believed that the centrifuge could work poorly in a cascade.

In addition, this design was far inferior to the designs Iraq had proven by 1991. DOE experts did not believe Iraq would bother with such a crude design, particularly when Iraq would need to build five times more of these aluminum-rotor centrifuges to make the same amount of weapon-grade uranium as the more advanced machines Iraq had developed prior to the first Persian Gulf War. This approach would also require the procurement of a huge number of other items and would cause significant delays in building a centrifuge plant. For example, if Iraq were to build 25,000 centrifuges, it would also need 25,000 upper bearings, 25,000 lower bearings, 25,000 outer casings, and 50,000 end caps. These items require materials, such as high strength aluminum or other specialized metals, and specialized oils, many of which would have been illegal for Iraq to import.

The large number of centrifuges required in the CIA estimate highlighted the lack of detection of other centrifuge components. Because Iraq's procurement of tubes was not particularly clandestine, other procurements of sensitive centrifuge components or materials would have been expected. No such procurements, however, were detected. In addition, the IAEA inspections in 2002 and 2003 and the post-war US investigations have not uncovered any indication of the procurement of large numbers of other centrifuge components or materials.

Complicating the realization of a Zippe-type centrifuge design is that the tubes' diameter is not optimal for such a centrifuge. Some centrifuge experts believed that this design would not work as the basis of a centrifuge plant. They assessed that this type of relatively narrow centrifuge would lose uranium hexafluoride at a significantly greater rate from the top of the rotor assembly than Iraq's proven designs. If that were so, then Iraq would need to build significantly more centrifuges than if there were no losses of uranium hexafluoride from inside the rotor of the centrifuge.¹¹

¹¹ The increase in the number of required centrifuges has been assessed theoretically by E. Von Halle, a leading uranium enrichment expert from Oak Ridge, who is now retired [see E. von Halle, "Multicomponent Isotope Separation in Matched Abundance Ratio Cascades with Losses from Each Stage," presentation at the 8th Workshop on Separation Phenomena of Liquid and Gases, Oak Ridge, TN, October 12-16, 2003]. Von Halle looked at a comparable centrifuge and derived the impact of losses on both a cascade to make 5% enriched product and one designed to make 90% product. If the loss rate were 0.1 percent, the number of centrifuges needed to make a fixed amount of 90% enriched uranium would increase by a factor of about 1.7. In comparison, the increase for the production of 5% product would increase by a factor of about 1.06. Thus, if Iraq had zero losses and needed 25,000 centrifuges (as in the CIA estimate) to make enough weapon-grade uranium for two nuclear weapons, it would need roughly 43,000 if the loss rate were 0.1 percent. A 0.2 percent loss would raise the number of necessary centrifuges to over 65,000.

Given the large number of aluminum-rotor centrifuges needed, experts at Oak Ridge believed that Iraq would be unlikely to abandon its more advanced designs. Because far fewer of these centrifuges are needed, significantly fewer additional machines would need to be constructed.

In addition, no one ever built large numbers of Beams' centrifuges or produced significant amounts of enriched uranium in a cascade of such machines. Although the Beams machine was being developed into a production machine during the Manhattan Project, only single production machines were operated before the program was cancelled in favor of the gaseous diffusion uranium enrichment project. Iraq operated two experimental Beams-type centrifuges, but it never reached the point of introducing uranium hexafluoride into either machine before it abandoned this design in 1989.

Houston Wood, a leading US expert on centrifuges and a University of Virginia Professor, was also skeptical of the tubes being for centrifuges. He had learned about the shipment of tubes in the spring of 2001. He said that his colleagues at Oak Ridge asked him to evaluate independently the purpose of the tubes. He concluded that the tubes were unlikely to be for gas centrifuges.

Given the large number of procurements and the additional time to develop a new centrifuge design and build a plant, Iraq would have to assume its program would be discovered before it was able to produce significant quantities of highly enriched uranium. Given Iraq's need for both speed and secrecy, its choice of such a strategy would be odd to say the least. Critics started to believe that the CIA analysts had designed a centrifuge around the tubes rather than determined the use of the tubes from their characteristics.

IAEA Reacts

Members of the IAEA Action Team, responsible for inspections in Iraq under the UN Security Council, started to learn about the aluminum tubes early in the summer of 2001. The Action Team, now called the Iraq Nuclear Verification Office (INVO), became deeply skeptical of Joe's assessment about the purpose of the tubes.

IAEA experts quickly realized that Iraq had imported in the 1980s large numbers of tubes with identical dimensions for use in short-range rocket motors in multiple rocket launch systems (MRLS). Inspectors had seen thousands of these tubes in the 1990s. In their files, the inspectors had extensive information about Iraqi procurement of these high strength tubes dating to the late 1980s.

After the 1991 Persian Gulf war, Iraq declared an inventory of 160,000 grade 7075 aluminum tubes of length 900 millimeters, outer diameter 81 millimeters, and wall thickness 3.3 millimeter. Iraq said these tubes were for short-range rockets, including the combustion chamber of an 81 millimeter rocket. By 1998, Iraq had reduced this inventory to about 50,000 tubes because of the production of rockets and spoilage of tubes.

The most important characteristics of the tubes are assembled in table 1, which compares an old Zippe-type and Beams centrifuge with a 81-millimeter rocket. Some of the characteristics of the tubes are compatible with a centrifuge use, but all of the characteristics fit a use in a rocket that Iraq was known to have produced or planned to produce indigenously. The tubes' length, wall thickness, and diameter in particular are identical to a use in this rocket.

Based on this information, the initial tube order would reasonably be expected to be a new order related to rockets. At least, the inspectors argued that the tubes may not be for centrifuge use exclusively.

The CIA downplayed any non-nuclear use for the aluminum tubing. In particular, the CIA argued that this particular high strength aluminum tubing would have been "exquisite," far in advance of what is needed for a MRLS.

The media learned in the fall of 2002 that the use of the tubing was investigated by the U.S. Army National Ground Intelligence Center (NGIC), which concluded that these tubes were poor choices for rocket motor bodies. One knowledgeable expert criticized this analysis as incomplete. He blamed the CIA, saying that he did not believe the CIA analysts presented NGIC with complete information about this case.

For example, the US Navy builds a rocket motor (Mark 66) used in the Hydra 70 that is used in MRLS helicopter rockets. That rocket has a smaller diameter, about 2.75 inches (70 millimeters), but its rocket motor chamber uses 7075-T6 aluminum tubing. Thus, the exact same type of aluminum ordered by Iraq is used in US rockets.

Joe Visits the IAEA

In July 2001, Joe traveled to Vienna with a DOE expert and gave a presentation about his results to IAEA experts, according to a knowledgeable official. Joe made a case that after cutting each tube to the proper length and machining down the wall thickness, the resulting tube looked like it was part of an old Zippe centrifuge design. In particular, it had a similar mass.

DOE experts had earlier pointed out to Joe that he had failed to include the end caps and a baffle in his calculation of the rotor mass (see figures 1 and 2). These items are essential parts of a rotor assembly. With the two end caps and baffle, the assembled rotor had a mass greater than the mass of the rotor assembly in the particular Zippe-type design Joe concocted. Joe responded by adding the missing mass in the end caps, and he compensated by thinning the wall thickness from 3.3 millimeters to 1.0 millimeter. He had to reject his original assumption that the tubes could be used without significant modification other than reducing their length. The tubes could be used in a gas centrifuge, but Iraq would need to make major modifications to the tubes in order to do so.

Some of the participants in the meeting spent a considerable amount of time explaining to him the flaws in his analysis. The IAEA experts who interacted with Joe had worked for many years in Urenco, the European centrifuge consortium, and had built and operated successful aluminum Zippe-type centrifuges in the 1970s. Joe had worked in the US centrifuge program on a significantly different centrifuge design and technology and had no first hand knowledge of aluminum rotors in a Zippe-type machine. One knowledgeable expert complained to me later in the summer of 2001 that Joe's analysis was "really bad."

One official said that Joe was unaware of earlier Iraqi orders for tubes or their intended use in rockets, although that had been known as early as 1996 based on UNSCOM inspections. Joe also did not raise the issue about tightened tolerances that was to figure so prominently in the debates in 2002 and 2003.

Despite explaining their opposition to Joe's analysis, the IAEA's position appears to have been misrepresented back in Washington. Two senior IAEA officials told me in the summer of 2003 that they had learned that Joe after returning to Washington falsely reported that the IAEA was supportive of his conclusions about the tubes.

To one critical IAEA participant in the debate, Joe always came back with the "same answer, no matter what the objections were." The IAEA's critical comments were not welcomed and certainly not incorporated into a more rigorous analysis of the purpose of the tubes. Despite knowing little about the manner in which the tubes order was discovered and subsequently intercepted in Jordan, the IAEA was becoming aware that this debate was not a typical analysts' disagreement.

The general excitement at the CIA about the seizure in Jordan also signaled to critics that any subsequent debate about the tubes was not a simple, calm discussion among analysts. CIA operations people, or the "do something guys," were obviously involved. They were at the seizure in Jordan. They were apparently depending on Joe's analysis to execute the seizure because they have no skills in the area of gas centrifuges. Any backtracking about the underlying purpose of the seizure was unwelcome and bound to make them look foolish, one knowledgeable expert added. If a major operation turned out to have seized only short-range rocket parts rather than centrifuge components, questions would undoubtedly be raised about the operation. What would China or Jordan say, for example? Such an admission could also raise questions about the ability of the United States to use intelligence information to intercept shipments related to WMD or other dangerous goods.

Four Corners reported that CIA officials came to Australia in late 2001 to make a case that the tubes were for centrifuges. After the seizure in Jordan, Australian officials secretly discussed the purpose of the tubes, and skeptics emerged. In addition, the IAEA's views spread that the tubes were unlikely centrifuge rotors. The CIA officials were sent to firm up support for its case among Australian intelligence agencies and political leaders. The CIA officials made what was described as a compelling case. Although they acknowledged that the tubes could be used in rockets, they said that the

specifications sought by Iraq were far greater than it would need for rockets. Nonetheless, Australian government nuclear scientists later obtained samples of the tubes seized in Jordan, and they became skeptical of the CIA's claim.

Several analysts noticed that the CIA was controlling the internal debate inside the government, particularly on the issue of the tubes being suitable for rockets. Others noticed that colleagues did not have all the information to make an independent judgement. The media reported that a senior Pentagon official, who was also a nuclear weapons expert, was told in 2002 that the tubes were of a perfect dimension for centrifuges and that their dimensions fitted no known Iraqi rockets. Hence, he concluded that a rocket explanation was bogus. This episode occurred after the IAEA had reminded the US government about the 160,000 tubes Iraq had declared for rockets at the Nassr Plant.

Analysts outside the CIA were increasingly isolated and unwelcome. The CIA tried to discredit them. In response to DOE's analysis, CIA officials attacked the DOE's record. One person who received classified briefings on Iraq's suspected nuclear activities said in September 2003 that the debate was affected by the CIA's belief that the DOE had underestimated Iraq's pre-1991 nuclear weapons program, leading the CIA to adopt a similar position. After the war and the start of intrusive UN Security Council inspections, the CIA was harshly criticized for missing many Iraqi nuclear weapon activities. The CIA believed that the DOE was again underestimating Iraqi nuclear programs, and it was not going to let this happen to it again, the person said.

When told that the IAEA disagreed with the CIA's analysis, some intelligence analysts said "Well, he's Egyptian," a disparaging reference to the IAEA's Director General Mohamed El Baradei.

After a year of debate, virtually all of the gas centrifuge experts in the United States and abroad who evaluated this case rejected the CIA's case and did not believe that the tubes were destined for gas centrifuges. The CIA was unwilling to bend. Moreover, the tubes were becoming the centerpiece of the administration's case that Iraq had stepped up its efforts to get nuclear weapons program.

As the debate intensified, two criticisms stood out. The first one was that the CIA could not make a compelling case that the tubes were only for centrifuges, when in fact, they could also have been for rockets. Another was that these procurements had a lack of attention to operational security, contrary to what Iraq did before the 1991 Persian Gulf War when it acquired a large number of centrifuge components in secret. Given the relatively poor security, other centrifuge components and materials should have likewise been detected, and they were not.

Fueling the debate, the United States learned of other attempted procurements of aluminum tubes. These tubes had tighter tolerances than the tubes in the order

intercepted in Jordan.¹² The CIA and administration officials leaked to the media in September 2002 that earlier shipments [in this 14-month time frame] differed from later ones and the specifications of the earlier shipments were not as clearly suited for nuclear purposes; and "there are tubes and then there are tubes." The tubes intercepted in Jordan were rough inside and later shipments had tighter tolerances on various dimensions. Although these statements tended to undermine the CIA's earlier case that the shipment intercepted in Jordan contained centrifuge parts, they foreshadowed the next main CIA argument for the tubes.

Part II: The Tubes Leak

The first public report of the aluminum tubing was not until September 8, 2002 when *The New York Times* published a front page article by Judy Miller and Michael Gordon. This report quoted unnamed administration officials stating that the tubes were believed to be intended for centrifuges. The link to centrifuges, according to this report, was based on the number, specification, and dimensions of the tubes the Iraqis sought to purchase. Administration officials told Miller and Gordon that no other explanation was likely.

The Washington Times actually first reported this story about the tubes. But in its July report it erroneously listed the material as stainless steel instead of aluminum. Because stainless steel is not a material critical to gas centrifuges, the story was viewed as inaccurate and did not attract much interest.

In the *New York Times* article, administration officials publicly linked the tubes to a stepped up Iraqi quest for nuclear weapons. They first raised the frightening prospect that the first sign of a smoking gun being a mushroom cloud, arguing that the United States could not wait any longer to act.

The leak to the *New York Times* was quickly used by the Bush Administration to help build its case that Iraq was close to getting nuclear weapons. Senior administration officials mentioned the tubes as they made their rounds on the Sunday television talk shows on September 8, the day the story was published. Condoleezza Rice, the National Security Advisor, made her comment that the tubes are really only suited for a centrifuge program on CNN *Late Edition*. Vice President Dick Cheney reinforced this point on NBC's *Meet the Press*, stating that Saddam Hussein "now is trying, through his illicit procurement network, to acquire the equipment he needs to be able to enrich uranium--specifically aluminum tubes."

On September 12, President George W. Bush told the UN General Assembly that "Iraq has made several attempts to buy high-strength aluminum tubes used to enrich uranium for a nuclear weapon." The administration's steady drumbeat in the following weeks and

¹² The specification refers to a dimension of the tube, such as its length or wall thickness. The tolerance refers to how precise that dimension must be achieved during manufacturing. For example, a wall thickness could be given as 3.0 mm \pm 0.1 mm. This means that the wall thickness must be between 2.9 mm and 3.1 mm everywhere on the tube.

months about the unique suitability of the tubes for gas centrifuges became a fixture of its case for war against Iraq.

The Truth Starts to Emerge

Judy Miller had called me at home and left a message before her September 8th story, but I was out of town and only got home on the day the story appeared. I called her back and alerted her to the internal expert criticism of the administration's public claims. Partly in response, she decided to do another article, which appeared on September 13. In a surprising development, however, the article was heavily slanted to the CIA's position, and the views of the other side were trivialized. An administration official was quoted as saying that "the best" technical experts and nuclear scientists at laboratories like Oak Ridge supported the CIA assessment. These inaccuracies made their way into the story despite several discussions that I had with Miller on the day before the story appeared—some well into the night. In the end, nobody was quoted questioning the CIA's position, as I would have expected.

Nonetheless, a positive development of the new story was that the CIA and White House had to backtrack and admit that significant dissent existed. Reflecting this uncertainty, another intelligence official told the media that the aluminum tubing was "not a smoking gun."

My concern with the second *New York Times* article led me to start a careful scrutiny of the administration's claims and seek a fair hearing for the experts outside the CIA. Although I had been aware of this case for sometime, I had not believed that the administration would so willfully distort the debate over the tubes for its own purposes.

I wrote a series of ISIS reports criticizing the administration's claims about the tubes and its misuse of information to build a case for war. A draft of the first report was finished about a week after the original *New York Times* articles. Its findings were featured in a *Washington Post* article on September 19. The main points of this report were that the tubes were not specific to centrifuges; other uses including in rockets were possible. In addition, I reported that government scientists were expected not to make their dissent known publicly.

In talking to a number of government experts after the article in the *New York Times*, I was surprised by their nervousness to discuss this case. One said that the President has said what he has said, end of story. I even received an anonymous telephone call where the government expert said that I was on the right track to question the administration's claim. He added that the press had an obligation to follow up this controversy. He said that people in the administration can "release whatever they like, and they expect us to be silent."

The *New York Times* articles were noted by Peter Zimmerman, the scientific advisor to the Senate Foreign Relations Committee. He spent the next several weeks carefully scrutinizing the issue for the chairman of the committee, Senator Joseph Biden. In the

process, Zimmerman helped organize two classified briefings for the committee and its staff in late September. Both sides presented their findings, and many on the committee became convinced that the tubes were more likely for rockets than centrifuges. However, most members of Congress heard little of the actual debate over the purpose of the tubes. This lack of balanced information about the tubes helped the administration in its quest to build both public and Congressional support for going to war against Iraq.

The hearings helped sharpen the positions of both sides. In brief, the CIA case rested fundamentally on its assessment that the strength and tolerances of the aluminum tubing far exceeded what is needed for rockets. In essence, “why unnecessarily raise the cost of a rocket motor?” The DOE experts argued that the tubes’ characteristics, such as their dimensions and anodization, result in a poor centrifuge. The sheer size of the order involving tens of thousands of tubes cut both ways. The CIA analysts saw the size as evidence that Iraq was on the verge of building a massive centrifuge plant. The DOE, State, and IAEA analysts saw the size of the order as far in excess of the number of centrifuges Iraq would need to make enough HEU for nuclear weapons and as supportive of Iraq wanting the tubes for rockets. These analysts questioned where were the other centrifuge rotor assembly components that would be made of specialty materials. Neither side, however, could produce a piece of information that could make the other side back down. But the debate in front of the committee showed that the CIA did not have a smoking gun or even a compelling case the tubes were intended for centrifuges.

British Dossier

Suspicious that the CIA had secret, as-yet-unreported, intelligence information supporting its case about the intended use of these tubes were laid to rest with the September 24, 2002 publication of the British government dossier, *Iraq’s Weapons of Mass Destruction*. The report concluded that “the specialized aluminium in question is subject to international export controls because of its potential application in the construction of gas centrifuges used to enrich uranium, although there is no definitive intelligence evidence that it is destined for a nuclear program.”

This statement did not stop Tony Blair from trying to link the tubes to a nuclear purpose in his speech to the British Parliament on the day the dossier was released publicly. In the section on Iraqi nuclear weapons and possible procurements for gas centrifuges, Blair omitted the key caveat about the lack of evidence connecting the tubes to a gas centrifuge program, listing the tubes as another procurement possibly linked to gas centrifuges. He said that Iraq “has attempted, covertly, to acquire 60,000 or more specialized aluminum tubes, which are subject to strict controls due to their potential use in the construction of gas centrifuges.”

The misleading statement may have reflected a desire of Alastair Campbell, Tony Blair’s then Director of Communications and Strategy, to highlight the tubes. The British Foreign Affairs Committee, in its 2003 investigation of the dossier concluded that “in only one case did Mr. Campbell seek to interfere with the draft [dossier] in a substantive

way, by seeking to have the issue of the aluminum tubes included in the executive summary.”¹³ He failed.

Mounting Criticism

After the IAEA inspectors returned to Iraq in December 2002, they started to collect strong evidence that cast doubt on the administration’s case about the tubes. Increasingly, the IAEA became convinced that the tubes were for rockets and not centrifuges. On January 27, 2003 the IAEA’s Director General Mohamed El Baradei briefed the UN Security Council on the status of nuclear inspections in Iraq. He said that the “specifications of the aluminum tubes recently sought by Iraq appear to be consistent with reverse engineering of rockets.” He added that although the tubes could be modified for use in a centrifuge, “they are not directly suitable for such use.” But he added that the IAEA investigation continued (see Part III).

The IAEA had arrived at this conclusion despite a visit from the US government about a week earlier. The CIA again sent Joe to Vienna to challenge the IAEA’s assessments. During a January 22nd briefing, he reiterated that the tubes were too good for rockets. According to an August 10, 2003 *Washington Post* article, Joe told the IAEA experts that they were making a serious mistake and described the rocket story as a transparent Iraqi lie. According to this article, which quotes people familiar with the slide presentation that afterwards circulated among government and outside specialists, Joe said that the aluminum tubes were “overspecified.” He added that the high-strength aluminum was “inappropriate” and “excessively strong.”

One DOE expert, who reviewed Joe’s briefing, was surprised and angered that DOE’s comments on Joe’s presentation had not been accepted by the CIA. Normally, any briefing presented to a UN agency would be subject to interagency review. DOE had provided corrections to Joe’s presentations and all were ignored. This expert said that part of the briefing was intellectually dishonest. Joe was specifically referring to a table in the briefing that compared certain characteristics, such as the length, diameter, and material, of the tubes Iraq was trying to buy. He specifically showed the Beams and older Zippe centrifuge in this table, but he did not make a comparison to the rockets Iraq bought, despite those numbers matching in every respect (see table 1). In the table in the briefing, the centrifuge matches were only partial. There were no good matches in any dimension, and every match required that Iraq would have to make some major modification to get an exact match. Joe was known to have had the values for the rocket, but he omitted it from his table, sparking the dishonesty comment.

One knowledgeable US participant said Joe’s table was shown to senior US officials. The table did not include the one item with the best match, the rocket, and US officials were unlikely to be able distinguish what had been conveniently omitted from the table, he added.

In addition, the briefing table referred to "The Zippe" centrifuge. A participant asked Joe,

¹³ House of Commons, Foreign Affairs Committee, *The Decision to Go to War in Iraq*, vol. 1, p. 29..

"Which Zippe Centrifuge"? Joe repeated, "THE Zippe centrifuge."

Joe was then asked, "There were several Zippe centrifuges that varied in diameter and length; which one did you choose?" Only then did he admit that he knew there were several, and he selected the one that matched his pre-selected conclusions.

This briefing also highlighted differences between oral and written presentations. The written presentation never said that the tubes couldn't be for rockets. It said that the tubes were unsuited for that use and much likelier to be for centrifuges. Although a participant said those were probably the exact written words, he said that this written presentation did not match Joe's oral conversations at this briefing and others during the previous two years in the intelligence community.

Powell's Speech to the UN Security Council

Despite the increasing dubiousness of the claims about the tubes, senior administration officials persisted in arguing that the tubes were for centrifuges. Secretary of State Colin Powell gave the most ardent defense of the tubes on February 5, 2003 before the UN Security Council. His presentation was promoted as providing the best intelligence case that Iraq had weapons of mass destruction. Because of Powell's credibility, his speech was widely viewed as containing the most credible US evidence about Iraqi WMD. For example, Powell did not mention attempted Iraqi uranium purchases in Africa, which were seen as based on weak or questionable evidence.

On the Iraqi nuclear weapons program, Powell's case rested fundamentally on the aluminum tubes. He started by asserting that "Saddam Hussein is determined to get his hands on a nuclear bomb." Powell said that Saddam is "so determined that he has made repeated covert attempts to acquire high-specification aluminum tubes from 11 countries." He concluded: "Most US experts think they are intended to serve as rotors in centrifuges used to enrich uranium." Powell was in fact stating that several Defense Department agencies reporting to Donald Rumsfeld had sided with the CIA. He did not say that most individual experts agreed that the conclusion was false.

He said:

"I am no expert on centrifuge tubes, but just as an old army trooper, I can tell you a couple of things. First, it strikes me as quite odd that these tubes are manufactured to a tolerance that far exceeds US requirements for comparable rockets. Maybe the Iraqis just manufacture their conventional weapons to a higher standard than we do, but I don't think so. Second, we actually have examined tubes from several different batches that were seized clandestinely before they reached Baghdad. What we notice in these different batches is a progression to higher and higher levels of specification, including in the latest batch an anodized coating on extremely smooth inner and outer surfaces. Why would they continue refining the specifications, go to all that trouble for something that, if it was a rocket, would soon be blown into shrapnel when it went off?"

Powell ignored the growing body of criticism about the administration's view on the tubes. He did not mention the existence of the reverse-engineered Iraqi rocket that was under production in Iraq, or information that contradicted his claims about the significance of the tighter tolerances. He also did not mention that the tubes are rocket motors and not the warhead. The motor must be anodized or carefully painted to prevent corrosion. Even a small pit caused by corrosion can cause the rocket motor to fail and kill the person launching it. By then, the IAEA had established an alternative, logical explanation for the tightened tolerances that supported the use of the tubes in rockets. In addition, both the Department of Energy and the State Department's intelligence branch provided significant comments on drafts of Powell's speech. Their comments were ignored.

Senior IAEA officials had personally briefed Powell about many of their findings in December 2002, when El Baradei and Jacques Baute, the head of the IAEA's Iraq Nuclear Verification Office, met Powell in Washington. Powell told them that the tubes were giving him a headache. He appeared well aware that there was a controversy about the tubes. The IAEA officials reported on their findings that raised serious doubts about the CIA's claim.

According to the August 10, 2003 *Washington Post*, Powell's CIA briefers, using information originating from Joe, told him that Iraq had over-specified the tubes, increasing expense without making them more useful for rockets. Reportedly, that argument helped persuade Powell that Iraq had another purpose for the tubes.

Powell continued the administration's strategy of attacking critics. He mentioned that disagreement existed among experts about the purpose of the tubes, but he then dismissed it as a minority view. He said, "Other experts, and the Iraqis themselves, argue that they are really to produce the rocket bodies for a conventional weapon, a multiple rocket launcher."

Many experts, including DOE scientists, felt insulted and accused of being disloyal for their technical assessments. Houston Wood captured their sentiment in the October 2003 *Four Corners* television program. He said:

That really was like a slap in the face. And I think that my friends in the Department of Energy felt shocked by that. He said, "the Iraqis and other experts". We were thrown in the same camp as the Iraqis. We were trying to argue with the Iraqis. And that was hurtful when he said it in that way.

Looking back, US officials who were critical of the speech believe that Powell in the end was following orders. Greg Thielman, a former senior State Department intelligence official in INR, told *Four Corners* that Powell was in a delicate position. He said: "He serves the President of the United States and the President had made very clear what he wanted to convince the world of."

Part III: IAEA Inspection Results

When inspections resumed in December 2002, the IAEA focused on Iraq's actual and potential use of aluminum tubes. In particular, the inspectors investigated Iraq's past use of similar aluminum tubes, its short-range 81-mm rocket programs, recent attempted procurements of aluminum tubes, and the status of any Iraqi gas centrifuge program.

The inspectors found that the Iraqi decision-making process about the design of these rockets was well documented. Iraq provided the inspectors with copies of design documents, procurement records, minutes of committee meetings, and supporting data and samples. Some of this information was obtained during no-notice inspections of Iraqi facilities. The inspectors also interviewed several Iraqis involved in the rocket and former gas centrifuge programs.

On March 7, 2003, El Baradei reported the IAEA's major findings on the aluminum tubes to the Security Council. After conducting a thorough investigation of Iraq's attempts to purchase large quantities of high-strength aluminum tubes, he said that extensive field investigation and document analysis failed to uncover any evidence that Iraq intended to use these 81 millimeter tubes for any project other than the reverse engineering of rockets. He said that the IAEA had found no evidence or plausible indication of the revival of a nuclear weapons program in Iraq. The IAEA also did not find any evidence that any of the 160,000 tubes Iraq imported in the 1980's had been diverted to centrifuges.

The IAEA assembled a specially qualified team of international centrifuge manufacturing experts from the United States, Germany, the Netherlands, and the United Kingdom. This team concluded that Iraq's efforts to import these aluminum tubes "were not likely to have been related to the manufacture of centrifuges and, moreover, that it was highly unlikely that Iraq could have achieved the considerable re-design needed to use them in a revived centrifuge program."

Iraq's Declaration to the IAEA

In 1985 Iraq purchased over 100,000 helicopter launched "Medusa" air-to-ground rockets from Italy's SNIA BPD through Jordan's defense ministry. The Italian rockets had a combustion chamber made of 7075-T6 high strength aluminum. Most of the rockets were used by Iraq in a helicopter air-to-ground launch system in the Iran-Iraq war.

In 1986, Iraq's Military Industrial Commission decided to reverse engineer the Medusa air-to-ground rockets and produce its own surface-to-surface infantry support rockets fired from launcher systems consisting of 48 tubes. The initial copying of the rocket took place in 1987. Because the Iraqis did not have design drawings for this rocket, they measured the various components deriving both specifications and tolerances of the tubes.

As mentioned above Iraq then purchased 160,000 aluminum tubes from European suppliers. These tubes were not anodized or coated, and they were raw in the sense that

Iraq would cut the tubes slightly in length and machine threads. Iraq's strategy was to apply a protective coat after machining, figuring that applying one initially would be a waste of money.

Iraq made only tentative progress on building these rockets prior to the 1991 Persian Gulf War, when the program was halted. The tubes were stored outdoors in wooden shipping boxes at the Nassr complex north of Baghdad. Because the tubes did not have a protective coating or were not otherwise protected against the weather, they suffered extensive corrosion damage.

After the inspectors left Iraq in 1998, Iraq decided to restart its program to make 81-mm rockets indigenously. In about 2000, a high level committee was formed to deal with production problems. Among the most important members were General Hosam Amin and General Kamel, the director and deputy director, respectively, of the National Monitoring Directorate (NMD), which was the liaison organization to the inspectors. After UNSCOM inspections ended, work at the NMD became part-time, and Amin decided to find work for himself and other senior members of the NMD.

One of the first challenges was to try to identify damaged tubes and salvage the good ones. The damaged tubes caused rockets to stick in the launch tubes when fired. In addition, many of the tubes failed hydrostatic testing because of deep pitting in their surface.

The Iraqi Al Raya Company was contracted to develop methods to salvage the tubes for use in rockets. Its work and subsequent reports were unclassified, contrary to practices of Iraq's pre-1991 gas centrifuge program. The final process developed by this company required the tubes to be machined and then anodized. If the anodization showed white pits through the clear coating, the tube was rejected. Large numbers of tubes were machined and anodized, and then they were rejected as scrap.

A few hundred prototype rockets were manufactured in the year 2000. Afterwards, the al Rasheed Company took the lead in making the rockets using salvaged tubes. Production was in full swing by 2001.

The rocket production rate was about 50 rockets per day, or roughly 10,000 a year. Iraq managed to salvage fewer than 20,000 tubes from the 1980s order, or about 10 percent of that order.

By the end of 2002, Iraq had only about 7,000 good tubes left, less than enough for another year of production. In total, al Rasheed finished about 13,000 rockets. Most were painted green and shipped to military depots.

Anticipating a shortage of tubes for rockets, Iraq decided in 2000 to acquire 60,000 aluminum tubes from abroad. The first private trader was Ahmed Al Barak and was discussed above.

After Barak failed to acquire the tubes, Iraq turned to the Al Najah General Trading Company owned by Muntasir Awni. Al Najah represented the Indian company NEC and the Dubai branch of the Indian company TT S.A., which was the main company involved in actually trying to obtain the tubes. NEC and TT S.A. are closely linked, however, because TT S.A. was owned by the son of the owner of NEC. NEC was publicly identified in 2002 or 2003 as a major contributor to various Iraqi procurement efforts, including an ammonium perchlorate plant in Iraq.

Al Najah inherited Barak's original contract for 60,000 tubes and received an additional order of 60,000 more tubes. In the process of investigating overseas purchases, Najah found that the cost of tubes had increased. Only 54,000 could be now purchased instead of 60,000 using the funds originally given to Barak. Thus, Al Najah sought a total of 114,000 tubes. The remaining 6,000 tubes were to be purchased at Mr. Barak's expense. His inability to do so was the reason he fled Iraq.

Muntasir claimed to the IAEA that he acted only as a conduit between the two companies he represented and the Rasheed Company. He did not normally approach foreign suppliers directly himself, but he facilitated communication between TT S.A. in Dubai and Rasheed in Iraq. Muntasir was usually identified in his messages and faxes as Abu Arjun. He admitted to the IAEA that this was a code name he selected for himself. In internal letters and margin notes on documents he was also identified as Abu Qa'ed.

Despite the use of codenames, Muntasir said that the contracts were not that secret. Documents did not have security markings, and there were no specific security instructions on his aluminum tube contract with Rasheed. He also said that the acquisition of the tubes was not nearly as high of a priority for the Iraqis as completing the ammonium perchlorate plant. Pressure to successfully complete that project was "100 percent" higher than getting the tubes, he told inspectors. The profit for this plant was also considerably higher than for the tube order.

He was also free to disseminate the specifications of the tubes. He normally faxed all communications to Dubai. Sometimes he would send items by hand with a courier, but only for convenience, not security.

Letters found in the Najah office by the IAEA indicate that TT S.A. tried to procure the aluminum tubes from Austria, France, Italy, Germany, and Turkey. All these efforts were unsuccessful.

Later, Muntasir tried to order tubes with the help of friends in Italy. He sent a letter with the tubes' specifications in October 2002. He indicated to the IAEA that he did not receive an answer.

By the end of 2002, Al Najah also failed to acquire any tubes or find a reasonable supplier. With the end of the contract period, Najah went into default on its contract with Rasheed.

Tightened Tolerances

The IAEA found that the tolerances were adjusted during later years as part of an effort to revitalize the rocket program and improve the rocket's operational efficiency. In addition, the program languished for long periods and was studied by several Iraqi committees, each of which changed the specifications and tolerances of the tubes.

Based on an examination of ordering records in Baghdad, the IAEA learned of five versions of the same order. Barak's original order had typed specifications with handwritten annotations. The tolerances for the dimension of the outer diameter and wall thickness were tighter than the original 1980's order, and a roundness tolerance was added. Several specifications became tighter between tenders from Barak and TT S.A. A specification for straightness was also added after Barak's tender. There is also a qualitative specification that the interior and exterior surfaces be free from scratches and defects.

TT S.A. also added a condition that the tubes must be shipped vertically. The IAEA suspected that a reason was probably based on Iraq's bad experiences with rain water that did not drain from the tubes when they were stored horizontally. This procedure was not new, since many of the tubes Iraq received in the 1980s were shipped and stored vertically. This is further supported by the fact that finished rockets, with heavy warheads and other components are only supported at two thin points in their horizontal shipping boxes. It seems very unlikely therefore that the new condition by TT S.A. is for reducing any chance that the tubes will be slightly bent if shipped horizontally.

A major focus of the IAEA was to determine why the tolerances in general improved over time. In some cases, the tolerances actually fluctuated. For example, the tolerance on the wall thickness in Barak's order decreased by a factor of ten from the original 1980s order but this tolerance decreased only fivefold in subsequent orders by TT S.A. compared to the original 1980s order.

The inspectors located and interviewed the Iraqi responsible for setting the tolerances. He told the IAEA inspectors that he wanted to ensure that the rocket did not stick in the launch tube and to increase the accuracy of the rocket. In a test firing, a rocket did stick in the launch tube and blew up. These types of rockets are relatively inaccurate, often missing the target. By tightening the tolerances, the accuracy can also be improved without any machining of the walls of the tube.

He also said that he did not want any flaws in the tubes, because of concerns that a flaw would cause the tube to expand when it was fired and stick in the tube. Each tube was to be subjected to a hydrostatic test to ensure that any remaining flaws were detected.

The Iraqi who made the decisions about the tolerances was not responsible for overall costs. So, the tubes did become more expensive. The extra cost, however, did not significantly increase the cost of the tubes or the finished rocket system. For example, the cost increased by a few dollars per tube from the Barak to the TT S.A. order. Both of

these orders were comparable in cost to the original 1980s orders. The Iraqis also believed that any extra cost was justified to achieve a more reliable, accurate rocket.

Other engineers elsewhere confronted with similar problems may have chosen another solution. For example, US Navy specialists at the Naval Surface Warfare Center, Indian Head, Maryland studied ways to improve the unguided performance of the rocket motor of the 2.75 inch (70 millimeter) Hydra 70. This unguided rocket also uses a 7075-T6 aluminum combustion chamber with tolerances similar to those listed in the original Iraqi tube order in the 1980's. In particular, Navy researchers wanted to find ways so that the rockets would disperse less. Although they considered tightening the tolerances in the back portion of the tube, they opted instead for increasing the rocket motor launcher exit spin rate as a more effective and less costly strategy. Spinning the tube faster increases its accuracy, but too much spinning can destroy the motor. Therefore, the spinning must be stopped after a set period of time, and accomplishing such a halt can be difficult. A Navy researcher said in a telephone interview in the fall of 2003 that a strategy of tightening the tolerances of the tube would improve the accuracy of the rocket. Other strategies, such as those pursued by the US military, may have been too challenging for Iraq to discover or implement.

In addition, past Iraqi behavior on setting tolerances of parts undermines confidence in drawing conclusions about the purpose of these tubes from the tolerances. In many cases involving the overseas manufacture of high precision components in the 1980s, Iraqi scientists and technicians had difficulty determining adequate tolerances of components. As a result, they would often over-specify the tolerances of components and apply tolerances to dimensions that did not need them.¹⁴ The growing number and the tightening of tolerances in these orders appear to be consistent with past Iraqi practices.

The IAEA concluded that the Iraqi engineers made a local decision to improve the rocket. The Iraqi explanation of why they changed the tolerances was both coherent and consistent.

The IAEA also concluded that the tightened tolerances do not point to a use in centrifuges. A DOE expert said that in general the tolerances of an object are not a good indicator of the purpose of an object. Its dimensions are a better indicator of an end use.

In addition, the argument over tolerances is somewhat exaggerated. Few have argued that the tubes could be simply cut to proper length, fixed with end caps and baffles, and spun in a centrifuge.¹⁵ In fact, doing so may not even be possible with any of these tubes. Most have said that the tubes would need to be machined before they could be used in a centrifuge, particularly a Zippe-type machine. One reason is that the walls of the tubes have to be shaved to achieve proper balancing, which is necessary for high speed rotation. Shaving would also remove the anodization from the shaved surface. In some

¹⁴ See for example, www.exportcontrols.org , "Case Studies."

¹⁵ A CIA official leaked to the media in early 2003 that a tube could be cut to proper length and used without shaving the wall. The basis for this claim could not be learned, and the claim was not repeated.

situations, Joe argued that the wall would be cut to a thickness of one millimeter, furthering undermining the importance of the tolerances. The tubes in the Barak order had rough interiors and would have required machining. In fact, many of the tubes ordered from Inwako in the 1980's could be modified for use in a centrifuge.

Given that the tubes required machining before their use in a centrifuge, one expert said that tightening the tolerances would undermine an argument that the tubes were for centrifuges. He asked, why would Iraq needlessly keep improving the tolerances?. However, the tightening of the tolerances would result in a more accurate rocket.

One has to be further skeptical of the CIA's emphasis on tolerances, because the CIA had already concluded that the tubes in the 2001 Barak order stopped in Jordan were definitely for a centrifuge, despite having a rough interior and less stringent tolerances than later orders. The later CIA argument over improving tolerances thus appears contrived.

Anodized coating

Iraq stated that it wanted the tubes anodized to protect them during storage. Anodization is a common practice in military and commercial equipment to protect against weather and the environment. For example, bicycle handlebars are anodized.

As mentioned above, the Barak order called for a chromate anodization, which is normally applied to 7000-series aluminum. This type of coating is thinner than the other common type of anodization and often used in the aircraft industry. The type of anodization requested in subsequent orders is unknown.

Iraq did not want to lose tubes to corrosion during relatively long periods of storage prior to their manufacture into rockets. Because the rocket production rate was only 10,000 per year, most of the tubes would need up to tens years of storage.

The process of machining the ends of the tubes for use in rockets would damage the anodized coating, requiring a new coating to be re-applied to a portion of the tube. This process was viewed as considerably cheaper than letting the tubes corrode during storage.

The relevance of anodization to a claim that the tubes are specifically for centrifuges is difficult to determine. It is a well known unclassified fact that aluminum centrifuge rotors do not need to be anodized. Bare aluminum without any coating is resistant to corrosion by uranium hexafluoride, the process gas in a centrifuge. According to Zippe, the anodized layer would be removed in any case by fluorine.

The Mark 66 rocket motor of the Hydra 70 has never been anodized. It is painted white instead. One rocket expert said that the Hydra 70 is a "legacy system" that does not get changed easily. The point is that its lack of anodization does not mean that other rocket systems are not anodized.

Material Properties

The CIA believed that Iraq would have selected a less strong aluminum, in particular a 6000-series aluminum. In fact, Joe is reported to have argued that the aluminum was excessively strong for use in a rocket. On March 7, 2003, Secretary Powell told the UN Security Council that the “material properties and manufacturing tolerances required by Iraq are more exact, by a factor of 50 percent or more, than those usually specified for rocket motor casings.” Type 7075 aluminum is about 50 percent stronger than 6000-series aluminum. Such an argument, however, ignores that the Italian Medusa and the US Hydra-70 use 7075-T6 aluminum. In addition, the total extra cost for the stronger aluminum is about 30 percent. Given that the cost of the rocket is significantly more expensive than the cost of the tube, this cost penalty is not significant. Powell’s statement also ignores that Iraq was copying the Medusa rocket as closely as it could. Iraqi engineers are unlikely to have decided to use a weaker aluminum, particularly when the tube was already operating near its material limit.

Other CIA Arguments

The IAEA investigated several other arguments put forward by the CIA. The CIA said that the procurements were highly secret. But these orders were not that secret. The second trading company charged with ordering the tubes often sent facsimiles from its Baghdad office to foreign companies that included the exact dimensions and tolerances in its request. In addition, tenders were sometimes placed on aluminum industry websites seeking bidders. This method is very different from Iraq's well documented, highly clandestine procurement techniques for its pre-1991 nuclear weapons program.¹⁶

The CIA said the Iraqis were planning to pay a "super price" for the tubes. In fact, the Iraqis were not planning on paying an exorbitant price for these tubes, as discussed above. One expert said that Iraq was expecting to pay prices in line with those it was paying for other illicit procurements. In particular, Iraq planned to pay prices consistent with those it paid during the Iran/Iraq war for similar tubes. In addition, increasing the tubes' tolerances did not lead to a "super price."

Other CIA leaks to the media suggested that the United States or another nation had spun a tube, implying that it was ideal for a centrifuge or at least too finely made for a rocket motor casing. Based on a range of interviews with knowledgeable officials, the United States may have spun a tube on a lathe in air, at a speed far below that of a rotor spinning under a vacuum in an operating centrifuge. A report in the *Financial Times* on June 6, 2003 wrote that the French had spun one of the tubes in a later order at 98,000 revolutions per minute, which would mean a wall speed of about 400 meters per second. This speed is close to the maximum speed achievable with this type of aluminum and would require operation in a vacuum to reach. A senior IAEA official checked with French officials about this story and was told that this particular experiment was never done. He said that it could have been an estimate.

¹⁶ See www.exportcontrols.org “Case Studies”

Part IV Post War Findings

Since the fall of Baghdad last spring, no evidence has emerged that Iraq planned to use the aluminum tubes in centrifuges. Despite months of searching, the Iraqi Survey Group (ISG) has not found any link between the tubes and a gas centrifuge program. In fact, the ISG has not found evidence that Iraq reconstituted a gas centrifuge program in any serious way after 1991.

David Kay has maintained that the ISG may eventually find evidence linking the tubes to centrifuges, but he has offered no evidence supporting his hunch. In a letter to the *Washington Post* that appeared November 1, 2003, he said that the ISG is investigating the “reason for the constant raising of the specifications of the tubes the Iraqis were importing clandestinely.” He failed to mention the exhaustive investigation the IAEA conducted on this issue before the war.

He also failed to mention the growing body of evidence that has accumulated during the last six months that undermines the CIA’s and administration’s case about the tubes. The CIA has collected some of this information but has not released it publicly.

One piece of negative evidence that Kay did release publicly, but did not comment on its potential significance, is in his October 2, 2003 statement to Congressional intelligence committees. The testimony states that the ISG found indications of Iraqi interest, beginning in 2002, in reconstituting a centrifuge program. Because the aluminum tube orders date to 2000, well before this possible Iraqi interest in centrifuges, the tubes could hardly be for such a centrifuge program.

Iraqi Statements After the Fall of Baghdad

After Baghdad fell to US troops, many Iraqis could be interviewed for the first time without being under threat from Saddam Hussein’s regime. One key group comprised former members of Iraq’s pre-1991 gas centrifuge program.

In April 2003, ISIS sought out these Iraqis as part of a project to contact former members of Iraq’s nuclear weapons program. Working with members of the media in Baghdad, we were successful in locating and interviewing several key Iraqis.

While searching for former members of Iraq’s gas centrifuge program, I was contacted by Mahdi Obeidi, the former head of Iraq’s pre-1991 gas centrifuge program.¹⁷ In late April, he called me in the United States from Baghdad using the satellite phone of a free lance journalist he had met. I knew Obeidi from my work in the 1990s with the IAEA Action Team. After this initial contact, we had numerous satellite telephone conversations covering a wide range of topics during the next several months.

¹⁷ There are different transliterations of his name. In www.exportcontrols.org, his name is spelled Ubeidy.

He told me that he knew of no significant efforts to restart a gas centrifuge program after 1991 or use the aluminum tubes in such a program. I also talked with two of his top technical aides, who said the same things.

Adding to the credibility of Obeidi's statement was his revelation that he had hidden a set of key centrifuge documents, designs, and components from the inspectors. He now wanted to turn them over to the US government. In fact, he had contacted me originally to seek my help in this effort. In return, he wanted to be taken with his family from Iraq.

Obeidi took these items from the Engineering Design Center near Rashdiya, Iraq's centrifuge research and development facility on the northern outskirts of Baghdad, on the night that the Allied bombings started in January 1991. He worried that Rashdiya could be targets and these items destroyed. In the end, it was not, but he was told by his superiors to continue to hide these items. He said that he did not believe anyone else had such a complete set of documents.

His collection included about 200 design drawings of centrifuge components, 180 reports on manufacturing and operating centrifuges, and about a half dozen key centrifuge components. Obeidi said that this collection represented Iraq's critical knowledge about centrifuges and was sufficient to reconstitute a gas centrifuge program. The existence of this collection was suspected by inspectors, and one of the reasons ISIS started its outreach to Iraqi scientists was to find these records.

Obeidi never developed a detailed plan to restart a gas centrifuge program. If the order came, however, he did want the ability to restart manufacturing centrifuges as soon as possible. Thus, he wanted to stick with proven designs that did not require any more research or development. If ordered to reconstitute, he believed that he could have built these proven designs.

He was dismissive of claims that he would have selected an aluminum rotor centrifuge. He said that too many centrifuges would have been required. He also said that the security of the tube procurements was poor, and he would have organized far better security for any centrifuge procurements.

CIA and Obeidi

As mentioned above, Obeidi wanted me to contact the US government for him. After some initial problems, I was successful in interesting the CIA in his case.

A complete accounting of what occurred afterwards is beyond the scope of this report. Nonetheless, part of the experience is directly relevant to a discussion of the aluminum tubes.

Obeidi told his CIA interviewers in Baghdad what he had told me. He turned over his collection of centrifuge items to the US government, and he was eventually brought to the United States with his family.

He told me that he found that the United States had developed several misperceptions about Iraq's nuclear program, particularly concerning any gas centrifuge program. These misperceptions were not limited to the tubes.

For example, Obeidi had risen to senior positions in the 1990s in Iraq's military industrialization complex. He had taken over Saad Establishment, the engineering design center of the Military Industrialization Commission. Obeidi told me that he had learned from one of his US government interviewers in Baghdad that the CIA falsely concluded that his appointment to this position in the late 1990s signified that he was restarting a gas centrifuge program.

The CIA analysts' preconceived belief that the tubes were for centrifuges further complicated an already difficult situation. These analysts had a tendency to mistrust Obeidi and were unprepared to accept what Obeidi said about the tubes or a lack of a significant centrifuge program. Although the CIA was far better positioned to obtain the cooperation of Iraqi scientists than the Pentagon, in the end, it was in a conflict of interest when it came to Obeidi.

This conflict was demonstrated to me when I learned that Joe was apparently the main centrifuge expert the CIA sent to interview Obeidi and make judgments about his veracity. Joe told Obeidi that he was the one who sold the idea about the tubes being for centrifuges. Obeidi was convinced that Joe remained a firm believer in the tubes being for centrifuges. The CIA appeared determined to prove the existence of a significant and active gas centrifuge program rather than evaluating the new post-war evidence objectively. Because of the controversy about the aluminum tubes, Joe's personal involvement in this sensitive operation was questionable.

The information that Obeidi provided the CIA appears to have created a serious problem to those advocating the essential role of the aluminum tubes in a reconstituted Iraqi gas centrifuge program. In what can only be described as self-serving, CIA officials incorrectly represented Obeidi's comments and his past role in the pre-1991 gas centrifuge program.

Obeidi's case became public in late June 2003 because of the CIA's refusal to remove him from Iraq, CIA analysts' attacks on his veracity, and their statements that the US government was going to release publicly a portion of the information Obeidi provided. Impending CNN television reports, which I initiated, broke an apparent impasse in the US government, and Obeidi and his family were quickly moved out of Iraq.

When CNN interviewed CIA officials at Langley in June about Obeidi, these officials gave a version of events that differed sharply with what Obeidi recounted. CNN interviewed a CIA official named "Mike" about Obeidi in June. The interview never showed Mike's front, but a viewer identified him as Joe.

Joe claimed that Obeidi received one of four sets of centrifuge documents and had actually seen the other three sets. Thus, Joe said that Obeidi was one of four people who took a set of documents and hid them. Kay repeated to CNN what Joe said, adding that Obeidi was the source of this information. Kay said that Obeidi claimed not to have known who took these three sets, or where the documents may be located, but Kay added they were exploring how his memory can be improved. Obeidi told me repeatedly that he never made these statements to his interrogators.

Joe and Kay also falsely characterized Iraq's pre-1991 Beams-type, aluminum-rotor centrifuge program to CNN. Joe told CNN that the Beams program was separate or parallel to the one involving more advanced centrifuges, and Obeidi had nothing to do with the Beams-type centrifuge. In fact, Obeidi headed this program as well. When the Iraqis were able to obtain classified information about more advanced European-type centrifuges in the summer of 1988, they shifted their efforts to these centrifuges and phased out their work on a Beams-type machine, which was proving difficult to operate in any case. For example, as mentioned above, Iraq never introduced the process gas uranium hexafluoride into either of its two Beams centrifuges.

Joe and Kay appear to have tried to create a case that parallel centrifuge programs existed after 1998 and that Obeidi was not in a position to know about them. However, Joe's and Kay's statements about parallel programs prior to 1991 are incorrect. Their attempt to create a case that parallel centrifuge programs existed after 1998 is contrary to what Obeidi has said.

When a CNN correspondent subsequently interviewed Obeidi in Kuwait, he asked Obeidi about picking up his particular centrifuge kit out of a total of three other copies. Obeidi did not appear to understand the question and talked about the existence of more than three other copies of documents. When I asked him about this comment later, he said that he was talking about individual copies of documents that he believes still exist. He explained that the security services took away all remaining centrifuge documents at Rashdiya in early 1991. Many of those documents were destroyed or were given to UN inspectors in 1995 after the defection of Hussein Kamel, Saddam's son-in-law. Others may have remained hidden. Although Obeidi believed such documents may still exist, he did not know where those documents could be. He reiterated that there was no meeting where he and three others were told to take a set of documents and hide them.

Throughout the summer there continued to be delays in moving Obeidi to the United States. I heard in late July from Barton Gellman, a *Washington Post* correspondent, that Obeidi's removal to the United States remained controversial within the US government. Gellman subsequently published that Joe continued to accuse Obeidi of holding back the truth.¹⁸

The controversy was resolved in mid-to-late August when Obeidi and his family were finally moved to the United States. Kay wrote in his November 1 *Washington Post* letter that Obeidi and his family came to the United States under Public Law 110, which gives

¹⁸ Barton Gellman, "Search in Iraq Fails to Find Nuclear Threat," *Washington Post*, October 26, 2003.

the director of central intelligence the power to resettle those who provide valuable intelligence information.

Part V Conclusion

Most experts inside and outside governments now believe that the CIA was wrong about the tubes. It is increasingly doubtful that Iraq actually planned to make centrifuges out of aluminum tubes as the CIA claims. Equally doubtful is the more sophisticated argument that Iraq hid a centrifuge purchase in a rocket procurement program. In addition, the CIA is probably wrong that these tubes are inappropriate for short-range rockets. Such a use is, in fact, their most obvious and appropriate use.

After months of investigation since the fall of Baghdad, the administration has failed to prove its claim that the tubes were intended for use in an Iraqi gas centrifuge program. Despite having substantial evidence countering this claim, the administration has persisted in making misleading comments about the tubes.

The administration has refused to acknowledge that the tubes that Iraq was trying to order would be used in rockets. By failing to acknowledge this point, they are implying that Iraq sought all the tubes for centrifuges and planned to build over 100,000 centrifuges, a massive program for a country like Iraq. On its face, this claim is preposterous. But uncorrected, this implication leaves the impression among policy makers and the public that Iraq's nuclear weapons was far along and massive.

The CIA and the Bush Administration have implied since last spring that given time they will be proven right. Increasingly, their continued intransigence on this issue looks like an attempt to forestall the inevitable day of reckoning.

Even before September 2002, when the administration made some of its most strident claims about the tubes, enough information existed to seriously challenge the CIA's claim that the tubes were intended for gas centrifuges. The CIA's assessment was a worst-case theoretical analysis, based on little concrete information. Although a legitimate case could have been made prior to the restart of the UN inspections in late 2002 that these tubes were for both rocket and centrifuge programs, nothing points to the tubes being specifically intended for use in a centrifuge. The CIA's argument that the tubes were for centrifuges rested strongly on its selection of particular centrifuge designs, making it look as if it designed a centrifuge around the tubes rather than determined the use of the tubes from their characteristics.

This case shows the dangers of such assessments. With little known about Iraqi nuclear activities after 1998, analysts were under pressure to find something or prove categorically that no such programs existed. In that context, a worst-case assessment about the tubes by a minority was widely accepted as the most likely conclusion by a wide range of senior policy makers. One is forced to consider whether the administration's post-9/11 focus on the intelligence community "connecting the dots" encouraged an atmosphere that favored such speculation.

Credible alternative explanations for the tubes were declared by Iraq in 1996, namely use in rockets. These explanations were widely known in the intelligence community by the end of 2001 or early 2002. However, these explanations were shared only begrudgingly with policy makers, Congress, or the public. According to several participants, the CIA failed to brief senior policy makers that the tubes were an exact replacement for known rockets.

There was inadequate scientific peer review of the CIA's assessment about the tubes. An objective neutral scientific body did not mediate this dispute in the intelligence community. Although the Director of Central Intelligence's National Intelligence Estimate process includes a technical, impartial committee of nuclear experts, the Joint Atomic Energy Intelligence Committee, it was not used in this dispute.

The administration publicly started pushing its view about these tubes in the fall of 2002. The administration decided to put the tubes at the heart of its case that Iraq had a nuclear weapons program. In doing so, it misrepresented what was known about the tubes. Senior Bush administration officials cannot be expected to be aware of many of the details of a particular intelligence issue, but by late September 2002, this excuse was no longer valid. Several public reports about the dissent over the tubes had by then appeared in the media. The administration deserves special criticism for being intransigent about the tubes, both before and after the collapse of Saddam's regime.

Several of those who rejected the CIA's claim have expressed their fears privately about the threats to their careers or future funding if they continued to oppose the CIA's position. CIA officials were freely releasing information about the tubes to policy makers, Congress, and the media, but in each case spinning the information to support their case. One result was that Congress and the public was denied a full, fair debate about the purpose and significance of the tubes prior to the war in Iraq.

This case serves to remind us that senior decision-makers have a special responsibility to insist that the intelligence community properly vet information and to use intelligence community assessments fairly. This case shows that our leaders are not above misusing technical and scientific analysis to bolster their political goals.

Convinced that an order of aluminum tubes was destined for the Iraqi nuclear weapons program, the US government undertook strong diplomatic efforts in 2001 to stop an order of tubes from China. It told the Chinese government it was prepared to take military action to do so. The Bush Administration's strategies based on preventive war or interdiction to prevent countries from obtaining WMD depend critically on reliable intelligence on highly technical issues. This case has exposed a fallible intelligence community that developed and adjudicated its technical disputes poorly.

No military action was taken to seize the tubes, and an illegal conventional weapon export was stopped in the end. Nonetheless, the United States has undermined its own

credibility, likely making it harder to obtain international cooperation to stop future illicit shipments.

Looking back, this debate was between individuals and not agencies. A small number of CIA individuals incorrectly assessed that the tubes were most probably for centrifuges. Some of them were rewarded. A host of qualified experts were ignored and even disparaged. Efforts by centrifuge experts, the IAEA, and non-governmental organizations to correct the mistake were ignored or attacked. The Director of Central Intelligence failed both the US public and the world. The Bush administration used questionable intelligence information to build a case for war against Iraq. The past cannot be changed, but the administration, the intelligence community, and Congress have a responsibility to undertake a thorough, nonpartisan evaluation of what happened and institute procedures that can prevent recurrences. Such an investigation is critical to reestablishing the honesty and credibility of the intelligence process.

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Table 1 Comparing Characteristics of Aluminum (Al) Tubes Iraq Attempted to Procure Illegally, dimensions in millimeters

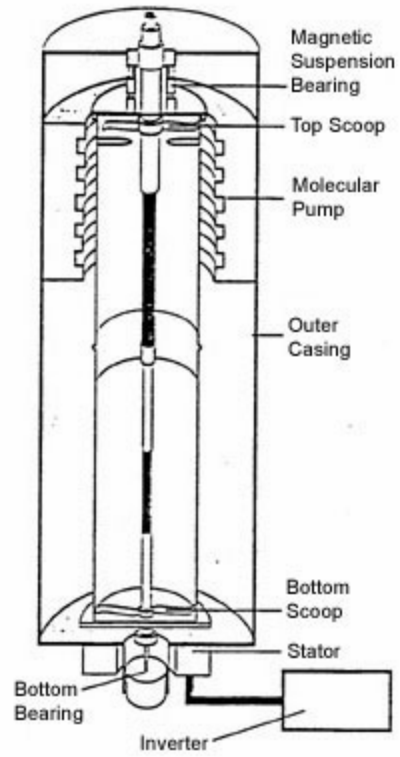
Characteristics	Tubes Iraq Seeking In 2000-2002	Medusa rocket Italian origin	Tubes Iraq Purchased in 1980s	<u>Beams Centrifuge*</u>		<u>Zippe Centrifuges of 1950s</u>			<u>Proven Iraqi Centrifuge Designs</u>		Hydra 70 (Mark 66)
				1940s Rotor	Iraqi Rotor	2.75" Rotor	3" Rotor	4" Rotor	Maraging Steel Rotor	Carbon Fiber Rotor	
Length	900	868	900, cut to 868	1016	<500	280	<400	<500	620	614	916
Diameter											
Outer	81.0	81	81	84	100	70	76	100			70
Inner	74.4	74.4	74.4	78					145.5	145.85	
Wall Thickness	3.3	3.3	3.3	6.4		1	1	1	0.35	1	1.8
Material	7075-T6 Al	7075-T6 Al	7075-T6 Al	Duralumin **		2000 or 7000 series			Maraging Steel	Carbon Fiber	7075-T6

* The Beams-type centrifuges are a family of designs. The one referred to as a 1940s design is one that was extensively used during the Manhattan Project to test a countercurrent-type centrifuge. Almost all the other designs used significantly wider and longer rotors. The Iraqi Beams-type or "oil" centrifuge was derived from a design similar to the one in this table. However, Iraq decided to both shorten and widen the rotor so that the centrifuge would be subcritical. Although the length of the rotor is unknown, it must be less than 500 millimeters to be subcritical. The wall thickness of the Iraqi design is unknown.

** An old name, most similar to aluminum type 2017.

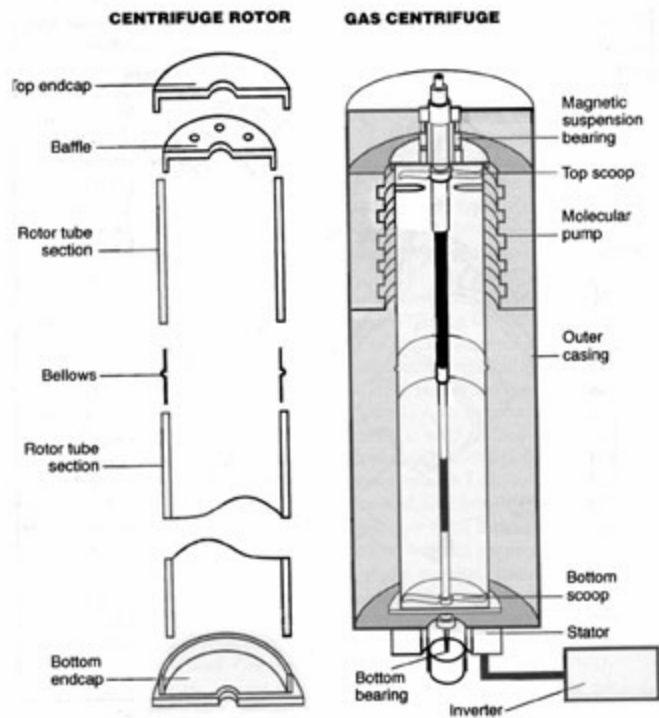
Note: Blanks in the table represent lack of specific data. The reader can estimate most of these values.

GAS CENTRIFUGE



Source: David Albright Drawing: Jandos Rothstein

Figure 1 Schematic of Zippe-type Gas Centrifuge (with bellows)



Source: Albright, D. and Hibbs, M., 'Iraq's shop-till-you-drop nuclear program', *Bulletin of the Atomic Scientists*, vol. 48, no. 3 (Apr. 1992), pp. 32 and 33.

Figure 2 Schematic of a Zippe-type Gas Centrifuge (with bellows)