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Iraq's Arsenal Was Only on Paper

Since Gulf War, Nonconventional Weapons Never Got Past the Planning Stage

By Barton Gellman
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BAGHDAD -- Of all Iraq's rocket scientists, none drew warier scrutiny abroad than Modher Sadeq-Saba Tamimi.

An engineering PhD known for outsized energy and gifts, Tamimi, 47, designed and built a new short-range missile during Iraq's four-year hiatus from United Nations arms inspections. Inspectors who returned in late 2002, enforcing Security Council limits, ruled that the Al Samoud missile's range was not quite short enough. The U.N. team crushed the missiles, bulldozed them into a pit and entombed the wreckage in concrete. In one of three interviews last month, Tamimi said "it was as if they were killing my sons."

But Tamimi had other brainchildren, and these stayed secret. Concealed at some remove from his Karama Co. factory here were concept drawings and computations for a family of much more capable missiles, designed to share parts and features with the openly declared Al Samoud. The largest was meant to fly six times as far.

"This was hidden during the UNMOVIC visits," Tamimi said, referring to inspectors from the U.N. Monitoring, Verification and Inspection Commission. Over a leisurely meal of lamb and sweet tea, he sketched diagrams. "It was forbidden for us to reveal this information," he said.

Tamimi's covert work, which he recounted publicly for the first time in five hours of interviews, offers fresh perspective on the question that led the nation to war. Iraq flouted a legal duty to report the designs. The weapons they depicted, however, did not exist. After years of development -- against significant obstacles -- they might have taken form as nine-ton missiles. In March they fit in Tamimi's pocket, on two digital compact discs.

The nine-month record of arms investigators since the fall of Baghdad includes discoveries of other concealed arms research, most of it less advanced. Iraq's former government engaged in abundant deception about its ambitions and, in some cases, early steps to prepare for development or production. Interviews here -- among Iraqi weaponeers and investigators from the U.S. and British governments -- turned up unreported records, facilities or materials that could have been used in unlawful weapons.

But investigators have found no support for the two main fears expressed in London and Washington before the war: that Iraq had a hidden arsenal of old weapons and built advanced programs for new ones. In public statements and unauthorized interviews, investigators said they have discovered no work on former germ-warfare agents such as anthrax bacteria, and no work on a new designer pathogen -- combining pox virus and snake venom -- that led U.S. scientists on a highly classified hunt for several

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months. The investigators assess that Iraq did not, as charged in London and Washington, resume production of its most lethal nerve agent, VX, or learn to make it last longer in storage. And they have found the former nuclear weapons program, described as a "grave and gathering danger" by President Bush and a "mortal threat" by Vice President Cheney, in much the same shattered state left by U.N. inspectors in the 1990s.

A review of available evidence, including some not known to coalition investigators and some they have not made public, portrays a nonconventional arms establishment that was far less capable than U.S. analysts judged before the war. Leading figures in Iraqi science and industry, supported by observations on the ground, described factories and institutes that were thoroughly beaten down by 12 years of conflict, arms embargo and strangling economic sanctions. The remnants of Iraq's biological, chemical and missile infrastructures were riven by internal strife, bled by schemes for personal gain and handicapped by deceit up and down lines of command. The broad picture emerging from the investigation to date suggests that, whatever its desire, Iraq did not possess the wherewithal to build a forbidden armory on anything like the scale it had before the 1991 Persian Gulf War.

David Kay, who directs the weapons hunt on behalf of the Bush administration, reported no discoveries last year of finished weapons, bulk agents or ready-to-start production lines. Members of his Iraq Survey Group, in unauthorized interviews, said the group holds out little prospect now of such a find. Kay and his spokesman, who report to Director of Central Intelligence George J. Tenet, declined to be interviewed.

Poxes and Professors

On Dec. 13, as a reporter waited to see the dean of Baghdad University's College of Science, two poker-faced men strode into the anteroom. One was an ex-Marine named Dan, clad in civilian clothes, body armor, a checkered Arab scarf and a bandolier of eight spare magazines for his M-16 rifle. The other identified himself to the receptionist only as Barry.

He asked to see the dean, Abdel Mehdi Taleb, immediately. Dan preceded Barry into Taleb's office, weapon ready, then stood sentry outside.

According to Taleb, Barry asked -- once again -- about the work of immunologist Alice Krikor Melconian. For months, Taleb said, the Americans had sent scientists and intelligence officers to investigate the compact, curly-haired chairman of the university's biotechnology department.

Three Iraqi scientists said U.S. investigators asserted they have reason to believe Melconian ran a covert research facility, location unknown. In July, colleagues said, Melconian emerged from her office with a burly American on each arm and was placed into the back seat of a car with darkened windows. U.S. investigators held her for 10 days in an open-air cell and then released her.

Described by associates as shaken by her arrest, Melconian said she has done no weapons research and knows of no secret labs. "I have never left the university," she said. "I have nothing more to say about this. I do not want to make any more trouble."

Like others on campus, and at a few elite institutes elsewhere, Melconian remains under scrutiny in part because investigators deem her capable of doing dangerous biological research. Investigators said they are casting a wide net at Iraq's "centers of scientific excellence" in an effort to confirm intelligence that is fragmentary and often lacks essential particulars.

Kay's Iraq Survey Group, which has numbered up to 1,400 personnel from the Defense Department, Energy Department national laboratories and intelligence agencies, is looking for biological weapons far more dangerous than those of Iraq's former arsenal. A U.S. National Intelligence Estimate, published in October 2002, said "chances are even" that Iraqi weaponeers were working with smallpox, one of history's mass killers. It also said Iraq "probably has developed genetically engineered BW agents."

As the Associated Press first reported, a scientific assessment panel known as Team Pox returned home in late July without finding reason to believe Iraq possessed the *variola* virus, which causes smallpox. Even so, interviews with Iraqi scientists led to a redoubled search for work on animal poxes, harmless to humans but potentially useful as substitutes for smallpox in weapons research.

Rihab Taha, the British-educated biologist known in the west as Dr. Germ, has generally been described by U.S. officials as uncooperative in custody since May 12. But according to one well-informed account of her debriefing, she acknowledged receiving an order from superiors in 1990 to develop a biological weapon based on a virus. That same year, a virologist who worked for her, Hazem Ali, commenced research on camelpox.

If truthful and correctly recounted, Taha's statement exposed a long-standing lie. Iraq's government denied offensive viral research. One analyst familiar with the debriefing report, declining to be identified by name or nationality, said investigators believe that Taha's remarks demonstrate an intent to use smallpox, since camelpox resembles no other human pathogen.

"Hearing that from the lips of the people involved is kind of like that MasterCard commercial: 'Priceless,' " the analyst said.

There is no corresponding record, however, that Iraq had the capability or made the effort to carry out such an intent.

Taha, according to the same debriefing account, said Iraq had no access to smallpox. Ali's research halted after 45 days, with the August 1990 outbreak of war in Kuwait, and did not resume. And Taha, like all those in custody, continues to assert that biowar programs ceased entirely the following year.

Chimeras, Science Fiction

More alarming even than Taha's statement, investigators said, were highly classified indications that Iraq sought to produce a genetically altered virus. Australian scientists reported in 2001 that an apparently innocent change in mousepox DNA transformed the virus into a rampant killer of mice. Investigators spent months probing for evidence that Iraq sought to master the technique, then apply it to *vaccinia* -- a readily available virus used to inoculate against smallpox -- and finally to smallpox itself.

Survey group scientists discovered no sign of pox research save at the Baghdad College of Veterinary Medicine, which declared the work to U.N. inspectors in 2002. Researchers there were manipulating the viruses that cause goatpox and sheeppox, in well-documented efforts to develop vaccines. U.S. investigators arrested Antoine Banna, the Cornell-trained dean, but soon released him. Much the same result followed a probe of avian virus research at the Ghazi Institute.

"It was legitimate research, but if they wanted to swing the other way they had some of the wherewithal to do that," said an analyst apprised of the results.

When investigators paid a call on Noria Ali, a genetic engineer who wears the head cover and long robes

of an observant Muslim, "they said they knew there was [genetic] research on these viruses, and we had secret labs for this work," Ali said.

Ali acknowledged a history that attracted suspicion. In 1990, she said, Rihab Taha ordered her to build a genetic engineering lab at Iraq's principal bioweapons research center. The Special Security Organization warned her that "any person who talks about his work will be executed," Ali said. But Iraq's invasion of Kuwait left the lab unfinished, an account confirmed by U.S. and European experts.

"We could have done a lot in this lab, but the fact is that this lab never existed," Ali said.

The survey group's most exotic line of investigation sought evidence that Iraq tried to create a pathogen combining pox virus with cobra venom. A 1986 study in the *Journal of Microbiology* reported that fowlpox spread faster and killed more chickens in the presence of venom extract. Investigators received a secondhand report that Iraq sought to splice them together.

Such an artificial life form -- created by inserting genetic sequences from one organism into another -- is called a "chimera," after the fire-breathing monster of Greek mythology commingling lion, serpent and goat.

"They have asked about developing some kind of chimera, a pox with snake-venom gene," said Ali Zaag, dean of the university's Institute for Biotechnology. "You have seen our labs. For us, these capabilities are science fiction."

Investigators also searched for what one of them termed "starter sets" of pathogens, laboratory samples that could be used for later production. For each suspected weapon, the investigators carried a supply of "labeled antibodies," a classified technology used in field kits that resemble home pregnancy tests. "We didn't find anything, so certainly not anything engineered," a coalition scientist said.

Team Pox, as the group of investigators dubbed itself, eventually dropped the chimera investigation.

"You've got to learn to walk before you start running," said a European government scientist who studied Iraq's biological programs last year. "The evidence we have about the virus program is they hadn't started to walk yet."

Recently, Zaag said, the chimera hunt resumed. This time the investigators are intelligence officers. Their approach, Zaag said, is "We'll give you a few more days to reveal something, and then we'll have to take you." Spokesmen for the CIA and the Defense Intelligence Agency declined requests for interviews.

What 'the Traitor' Knew

Late last month, fresh evidence emerged on a very old question about Iraq's illegal arms: Did the Baghdad government, as it said, rid itself of all the biological arms it produced before 1991? The answer matters, because the Bush administration's most concrete prewar assertions about Iraqi germ weapons referred to stocks allegedly hidden from that old arsenal.

The new evidence appears to be a contemporary record, from inside the Iraqi government, of a pivotal moment in Baghdad's long struggle to shield arms programs from outside scrutiny. The document, written just after the defection of Saddam Hussein's son-in-law on Aug. 8, 1995, anticipates the collapse of cover stories for weapons that had yet to be disclosed. Read alongside subsequent discoveries made

by U.N. inspectors, the document supports Iraq's claim that it destroyed all production stocks of lethal pathogens before inspectors knew they existed.

The defection of Hussein Kamel was a turning point in the U.N.-imposed disarmament of Iraq in the 1990s. Kamel, who had married one of Saddam Hussein's daughters, Raghda, and controlled Baghdad's Military Industrial Commission, told his Western debriefers about major programs in biological and nuclear weaponry that had gone undetected or unconfirmed. Iraq was forced to acknowledge what he exposed, but neither inspectors nor U.S. officials were sure Kamel had told all there was to tell.

A handwritten Iraqi damage report, composed five days after the defection, now suggests that Kamel left little or nothing out.

The author is Hossam Amin, then -- and until his April 27 arrest -- the head of Iraq's National Monitoring Directorate. As liaison to the inspectors he provided information and logistical support, but he also concealed the government's remaining secrets.

Sufiyan Taha Mahmoud, who was private secretary to Amin in 1995, said in an interview that Amin flew into a rage when he learned Kamel had slipped across the border to Jordan. "It was as if he was hit with a hammer," Mahmoud said.

Five days later, Amin dispatched a six-page letter to the president's son Qusay.

The person who provided a copy to The Washington Post had postwar access to the presidential office where he said he found the original. Iraqis who know Amin well and experienced government investigators from the United States and Europe, who analyzed the document for this article, said they believe it to be authentic. They cited handwriting, syntax, contemporary details and annotations that match those of previous samples. Markings on the letter say that Qusay read it, summarized it for his father and filed it with presidential secretary Abed Hamid Mahmoud.

Just before his "sudden and regrettable flight and surrender to the bosom of the enemy," Amin wrote, "the traitor Hussein Kamel" received a detailed briefing on "the points of weakness and the points of strength" in Iraq's concealment efforts.

Amin then listed, in numbered points, "the matters that are known to the traitor and not declared" to U.N. inspectors.

Inspectors knew Iraq tried to enrich uranium for a nuclear weapon, but not, Amin wrote, about the "crash program" to fabricate a bomb with French reactor fuel by 1991. They knew Iraq made biological toxins, but not that it put them in Scud missile warheads. There were major facilities -- Dawrah Foot and Mouth Disease Institute, a centrifuge factory in Rashdiya, and the Al Atheer bomb-fabrication plant -- whose true purposes were unacknowledged to inspectors.

Shortly after Amin sent the letter, Kamel's debriefings and subsequent inspections exposed every item in Amin's catalogue.

Until now, Kamel's debriefers suspected that "maybe he decided to keep something for himself," said Ali Shukri, a Jordanian military officer who debriefed Kamel on behalf of the late King Hussein, speaking in an interview in Amman. After reading Amin's letter in silence and then rereading it, Shukri looked up and said Kamel had held back nothing.

The most significant point in Amin's letter, U.S. and European experts said, is his unambiguous report that Iraq destroyed its entire inventory of biological weapons. Amin reminded Qusay Hussein of the government's claim that it possessed no such arms after 1990, then wrote that in truth "destruction of the biological weapons agents took place in the summer of 1991."

It was those weapons to which Secretary of State Colin L. Powell referred in the Security Council on Feb. 5 when he said, for example, that Iraq still had an estimated 8,500 to 25,000 liters of anthrax bacteria.

Some things Amin's letter did not say may also be meaningful. If Iraq had succeeded in spray-drying anthrax spores to extend their life and lethality, that would have been among the most important secrets of its wide-ranging weapons program. The letter did not speak of it. The letter also enumerated Baghdad's nuclear secrets, but mentioned nothing to suggest Iraq manufactured unknown parts of an "implosion device" to detonate uranium.

There was only one important thing, Amin said, that Hussein Kamel did not know: some of the locations where Iraq hid its library of arms research. That supports long-standing suspicions that Iraq held back portions of a knowledge base that could speed revival of development and production one day.

A U.S. intelligence official, who was provided with a copy of Amin's letter for comment, said the government would not discuss it in detail. He said an initial check of records "suggests that we have not previously seen the letter." Without the original and an account of its origins, he said, government analysts "cannot verify the authenticity of the letter." He added, "It is plausible and, from a quick scan of it, presents no immediate surprises."

'The Stupid Army'

Thair Anwar Masraf, an affable project engineer, made an appointment last summer to see an investigator from David Kay's survey group. He had information, he said in an interview, that might help the Americans interpret two trailer-mounted production plants found near Mosul in April and May.

"I waited more than one hour in the Palestine Hotel," Masraf said. "He did not show up."

Masraf watched with curiosity, in coming months, as the Bush administration touted its discovery of mobile germ-weapon factories.

A joint study released May 28 by the CIA and Defense Intelligence Agency called the trailers "the strongest evidence to date that Iraq was hiding a biological warfare program." Two days later, in Poland, President Bush announced: "For those who say we haven't found the banned manufacturing devices or banned weapons, they're wrong. We found them."

When Iraqi engineers told investigators that the discovered trailers were meant for hydrogen, the CIA dismissed the "cover story."

By July, with contrary evidence piling up, Kay described the trailer episode as a "fiasco." He told BBC Television, which broadcast the tape Nov. 23: "I think it was premature and embarrassing."

Even so, Kay's October report to Congress left the question unresolved. Kay said he could not corroborate a mobile germ factory, but he restated the CIA argument that the trailers were not "ideally suited" for hydrogen.

Had Masraf found Kay's investigator at the Palestine Hotel, he said he would have explained that Iraq actually used such trailers to generate hydrogen during the eight-year war with Iran. Masraf and his former supervisor at the Saad Co. said Masraf managed a contract to refurbish some of the units beginning in 1997.

According to the two men, Iraq bought mobile hydrogen generators from Britain in 1982 and mounted them on trucks. The Republican Guard used one type, Iraq's 2nd Army Corps another.

Iraqi artillery units relied on hydrogen-filled weather balloons to measure wind and temperature, which affect targeting. Munqith Qaisi, then a senior manager at Saad Co. and now its American-appointed director-general, said the trailers used a chemical -- not biological -- process to make hydrogen from methanol and demineralized water.

The feature that analysts found most suspicious in May -- the compression and recapture of exhaust gases -- is a necessity, Masraf said, when gas is the intended product.

In the late 1990s, the Republican Guard sent some of its trailers for refurbishment at the Kindi Co. The 2nd Army Corps signed a similar contract with Saad Co. Masraf said the first units were finished in 2001, including the two discovered by coalition forces around Mosul.

Qaisi's account may also clear up an unexplained detail from the May 28 intelligence report: traces of urea in the reaction vessel aboard one of the trailers. Qaisi said the vessels corroded badly because Iraqi troops disregarded strict orders to use only demineralized water.

"The stupid army pissed in it, or used river water," he said.

Said's Last Experiment

On Thursday, Dec. 11, a ruffled man with a high, balding crown arrived late for work at the University of Technology. In his unpainted office, about the size of a family sedan, electrical fixtures drooped from cement walls.

Sabah Abdul Noor once moved among the nation's elites. He played a part in the most ambitious undertaking of Iraqi industrial science: creation from scratch, and largely in secret, of the wherewithal to design and manufacture an atomic bomb. When the 1991 Gulf War intervened, an Iraqi bomb was -- informed estimates vary -- six months to two years from completion.

Abdul Noor watched as that multibillion-dollar enterprise was reduced to slag under the cutting torches of U.N. inspectors, who arrived under Security Council mandate after Iraq's defeat in Kuwait. Since the fall of Saddam Hussein, Abdul Noor said, U.S. forces have been questioning him for indications that the nuclear program was secretly revived.

"I have just come from such an interview," he said, apologizing for the hour. "They didn't give names. They did not say where they were from. I am kept as long as they wish to keep me."

What the Americans want to talk about, almost always, is Khalid Ibrahim Said.

Until 1991, Said was going to be the man who built Iraq's atomic bomb. Other leading figures were responsible for uranium enrichment. Said led the team -- "PC-3, Group 4," in Iraq's cryptic organization chart -- that would form 40 pounds of uranium into a working nuclear device. Abdul Noor was Said's

powder metallurgist.

Said died on April 8 when Marines opened fire on his moving car near a newly established checkpoint. His loss grieved Kay's nuclear investigators, who had many questions for him. When they came across Said's last experiment, the late bomb designer moved to the center of their probe.

Said spent his final days in a warehouse filled with capacitors and powerful magnets. He and his team were building what they described -- in a mandatory disclosure to the International Atomic Energy Agency -- as a "linear engine." The purpose, Iraq declared, was air defense.

The machine in Said's warehouse was more commonly known as a "rail gun." It used electromagnetic pulses to accelerate a small object to very high speed.

When U.S. investigators arrived, they found the gun had been "shooting an aluminum projectile at an aluminum target plate like the skin of an airplane," said an analyst who reviewed their report. But rail gun technology is thought to be decades from use in a practical weapon, and investigators believed Said might have something else in mind.

Impact of an extremely high-velocity projectile in a target chamber, they said, might be used to measure the behavior of materials under pressures that compare to a nuclear implosion. Such "equation of state" experiments, as physicists call them, could be applied to nuclear warhead design. When the U.S. nuclear team looked closely at that question, however, it "saw no evidence of equation of state work" with the rail gun, according to an authoritative summary of the team's report.

A sad look crossed Abdul Noor's face when he tried to explain his bafflement at suspicions that Iraq had secretly rebuilt -- "reconstituted," as the Bush administration put it in the summer and fall of 2002 -- a nuclear weapons program. He and his colleagues still know what they learned, Abdul Noor said, but their material condition is incomparably worse than it was when they began in 1987. "We would have had to start from less than zero," he said, with thousands of irreplaceable tools banned from import. "The country was cornered," he said. "We were boycotted. We were embargoed. The truth is, we disintegrated."

Of his late friend Said, Abdul Noor said: "I don't know what was in his heart. Probably he wanted to return to [nuclear weapons work] one day. That is in the category of dreams."

A common view among investigators today is that Said had the motive but not the means. One Western physicist who knew Said well said the rail gun enabled Said to maintain his team and "hone their skills on diagnostics, flash X-ray cameras, measuring very high speeds, and measuring impacts of ramming things together." The physicist added, "It's basic science. There's no relation to actual [bomb] design and fabrication."

Some investigators have yet to be convinced. They continue to look for warhead research in the guise of the rail gun.

"Today they were asking me that again," Abdul Noor said. "I was not on the same wavelength. I could see they were not pleased with me."

Red on Red on Blue

There is another explanation for the rail gun, according to one man who worked on it and does not want

to be named. It was, he said, a deception operation against Saddam Hussein.

Hussein resented U.S. air patrols over "no-fly zones" where Iraqi aircraft were forbidden in northern and southern Iraq. After trying for years to challenge the patrols, another Iraqi said, "we had yet to scratch the wing of one American F-15."

Said gave the president an answer involving futuristic technology. He was a good enough applied physicist to understand the long odds against success, Said's anonymous colleague said, but the project earned him favor, prestige and a substantial budget.

In every field of special weaponry, Iraqi designers and foreign investigators said, such deceit was endemic. Program managers promised more than they could deliver, or things they could not deliver at all, to advance careers, preserve jobs or conduct intrigues against rivals. Sometimes they did so from ignorance, failing to grasp the challenges they took on.

Lying to an absolute ruler was hazardous, Iraqi weaponeers said, but less so in some cases than the alternatives. "No one will tell Saddam Hussein to his face, 'I can't do this,' " said an Iraqi brigadier general who supervised work on some of the technologies used in the rail gun.

David Kay's survey group has turned up other such cases. Analysts are calling the phenomenon "red-on-red deception," after the U.S. practice of using red to stand for enemy forces and blue to stand for friendly ones. In some cases, they said, "red on red" amounted to "red on blue" -- because Western intelligence collected the same false reports that fooled Hussein.

Sufiyan Taha Mahmoud, who worked for Iraq's National Monitoring Directorate throughout its 12 years, said spurious programs also led to needless conflict with U.N. arms inspectors.

"They couldn't build anything," Mahmoud said of overpromising weaponeers, "but they had to hide the documents because they related to prohibited activities."

Secrecy and a procurement system based on smuggling, Iraqi scientists said, abetted those who inflated their reports.

George Healey, a Canadian nuclear physicist and longtime inspector in Iraq, said entire programs were devised, or their design choices distorted, in order to siphon funds.

"They had a system to graft money out of oil-for-food," he said, referring to the U.N. program that supervised Iraqi exports and imports after 1991. "What you had to have was a project -- the more expensive the better, because the more you can buy, the more you can graft out of it. You'd have difficulty believing how much that explains."

Intertwined with internal deception, many analysts now believe, was deception aimed overseas. Hussein plainly hid actual programs over the years, but Kay, among others, said it appears possible he also hinted at programs that did not exist.

Hans Blix, who was executive chairman of UNMOVIC, the U.N. arms inspection team, said in a telephone interview from Sweden that he has devoted much thought to why Hussein might have exaggerated his arsenal. One explanation that appeals to him: "You can put a sign on your door, 'Beware of the dog,' without having a dog. They did not mind looking a little bit serious and a little bit dangerous."

Defectors who sold false or exaggerated stories in Washington, Iraqi and American experts said, layered on still another coat of deception.

"You end up with a Picasso-like drawing -- distorted," said Ali Zaag, the Baghdad University biotechnologist.

'Long Pole in the Tent'

One line of thought in the survey group now, as it constructs a narrative of the Iraqi threat, is that the Baghdad government set out to revive its nonconventional programs in sequence. Instead of beginning with "weapons of mass destruction" -- nuclear, biological or chemical -- Iraq began with the means to deliver them .

"Missiles are very significant to us because they're the long pole in the tent," Kay told "BBC Panorama." "They're the thing that takes the longest to produce. . . . The Iraqis had started in late '99, 2000, to produce a family of missiles that would have gotten to 1,000 kilometers [625 miles]."

Kay was referring to Tamimi's work, though the designer and details have not been made public before. If reached, a 625-mile range would have menaced Tel Aviv, Tehran, Istanbul, Riyadh, the world's richest oil fields and important U.S. military installations from Turkey to the Persian Gulf.

When that might have happened -- or whether -- is difficult to forecast. Of all Iraq's nascent programs, Tamimi's was among the most advanced. A closer look at its prospects helps answer a question common to all four fields of forbidden arms: Was the country capable of carrying out the presumed intentions of its leader?

Tamimi is a man of robust self-esteem, but he expressed no confidence about his long-range missile, which depended on clustering five engines in a single stage. (An intermediate version called for two engines.) Western missile experts, who suggested questions and reviewed answers from a reporter in multiple rounds of interviews with Tamimi, emerged uncertain of the timetable or outcome.

Their best estimate was that it would take six years -- if the missile worked at all -- to reach a successful flight test. Tamimi would need less time with major help from abroad, but considerably more if he had to conceal the work from U.N. monitoring that persisted until the United States invaded in March. U.S. government spokesmen declined to provide an estimate.

Tamimi "was the star" of Iraq's three rival rocket establishments, said a French expert who has known him for years. Another European rocket scientist said of Tamimi: "In our country he would be a very good design engineer."

But Tamimi lacked access to the modern tools and technical literature of his profession. He left Czechoslovakia's Antonin Zapoteky Military Academy in 1984 with a doctorate degree and a collection of Russian rocketry texts now entering their third decade in print. For the essential modeling of thrust, flight qualities, trajectory and range, he relied on unsophisticated software written in Baghdad. In an e-mail exchange, Tamimi expressed strong curiosity about what the "more accurate modeling programs" of overseas experts might show about his designs.

Tamimi faced challenges he had not encountered before, some of which he knew about and others he did not. He knew he would have difficulty lashing together multiple engines and igniting them at the same instant. "The main problem was synchronization, which we hadn't solved yet," he said.

To fit multiple engines in an airframe based on the existing Al Samoud missile, Tamimi's designs called for a flared missile that nearly doubled in diameter -- from 760mm (30 inches) to 1500mm (59 inches) -- from top to bottom. Foreign experts said the shape would produce enormous strains. "If it didn't break up going up, it would most likely do so on reentry," said a Western expert who did not want to be named, after submitting Tamimi's sketches and descriptions to an evaluation team. "To avoid that, they would have to develop some sort of separation system to abandon the wider bit, and also master terminal guidance after the separation."

Tamimi said "we did not consider the problem of separation." For terminal guidance, which steers a missile in its final approach to target, Tamimi pinned his hope on Russian technology he did not have in hand.

In test flights, the Al Samoud missile never landed -- literally -- within a mile of its target. In 2001, Tamimi obtained a small black-market supply of precision Russian gyroscopes. He hoped they would increase the missile's accuracy from about 1.5 miles to 500 yards. To increase accuracy still further, he said "we were near success" in negotiating a contract -- he would not say with whom -- for a complete Russian-built inertial navigation system.

"He knew very well where he was going, especially in guidance and gyroscope equipment," a foreign expert said.

An enormous problem for Tamimi's program, however, was that he designed it to allow procurement of parts under cover of the openly declared Al Samoud. When inspectors ruled the Al Samoud illegal and destroyed its production lines in March, Tamimi said, he began to doubt the project's viability.

"Saddam Hussein ordered this work, but where would we get the materials?" said an Iraqi general who declined to be named and who kept close tabs on Tamimi's missile designs. "This was the case in every field. People would prepare reports under the order of Saddam Hussein and the supervision of the people around Saddam Hussein. But it was not real."

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