VIEWPOINT

PREVENTIVE ATTACKS AGAINST NUCLEAR PROGRAMS AND THE "SUCCESS" AT OSIRAQ

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Advocates of the preventive use of force against emerging nuclear, biological, or chemical programs often look to the allegedly successful 1981 Israeli airstrike against Iraqi nuclear facilities at Osiraq. According to the conventional wisdom, this attack may have prevented Iraq from going nuclear before Operation Desert Storm in 1991. This article assesses the claim that the 1981 attack substantially delayed Iraqi acquisition of nuclear weapons, both by revisiting older debates and by introducing new evidence from Iraqi scientists. The article casts doubt on the conclusion that the attack was successful for three reasons: (1) the reactor itself was not well equipped to generate plutonium for a nuclear weapon; (2) illegal plutonium production would likely have caused a cutoff in the supply of nuclear fuel and an end to weapons activities; and (3) the attack may have actually increased Saddam's commitment to acquiring weapons. These conclusions have implications for the Bush Doctrine, as the lack of success in 1981 casts doubt on the possible success of future attacks against nuclear programs.

KEYWORDS: Osiraq; Nuclear proliferation; Bush Doctrine; National Security Strategy; Preventive war; Iraq; Israel; Nuclear weapons

The September 2002 National Security Strategy, also known as the Bush Doctrine, describes a number of tools available for U.S. counterproliferation policy. Perhaps the most controversial is the preventive use of force against emerging nuclear, biological, and chemical weapons programs.[1] Faith in the success of such attacks, especially limited strikes rather than massive invasions, rests largely on a favorable account of a single historical episode: the June 7, 1981, Israeli attack against an Iraqi nuclear reactor at an installation known as Osiraq. This attack would seem to fit the critical criteria for success: It involved the minimal application of force (an airstrike from a handful of F-16s), there were no friendly casualties, there was minimal collateral damage, and, most importantly, a dangerous leader's nuclear program was substantially delayed by as many as 15 years according to the 2002 estimate of former Israeli Prime Minister Ehud Barak.[2]

Conventional wisdom holds that this delay in Iraq's nuclear program had great political benefits. Many people believe that the attack prevented Iraq from acquiring nuclear weapons by the time the 1991 Gulf War broke out, which meant both that Iraq could not use nuclear weapons during the war itself and that Saddam Hussein was permanently prevented from acquiring nuclear weapons, since the post-Gulf War

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sanctions/inspections regime prevented Iraq from pursuing nuclear weapons. Former U.S. National Security Council member Kenneth Pollack made these points, proposing that the Osiraq raid "merely set back Saddam's nuclear program, but in doing so, it ensured that Saddam did not have a nuclear weapon in time for either the Iran-Iraq War or the Gulf War, and that was just enough of a delay to prevent him from ever acquiring one."[3]

One columnist was quite stark in his portrayal of what would have happened had Israel not attacked in 1981: "Iraq would have gained nuclear weapons in the 1980s, it might now have a province called Kuwait and a chunk of Iran, and the region might have suffered nuclear devastation."[4] Prominent government officials from the George W. Bush administration—including former Secretary of State Colin Powell, Secretary of Defense Donald Rumsfeld, Vice President Richard Cheney (who as secretary of defense in 1991 personally thanked the Osiraq pilots for making "our job easier in Desert Storm"), and former Press Secretary Ari Fleischer—have publicly subscribed to the conventional wisdom that the Osiraq attacks worked and probably prevented the United States from facing a nuclear Iraq in 1991.[5] Others have speculated that the 1981 attack may have prevented the Iraqi use of nuclear weapons against Israel or Iran.[6]

The perceived success of the 1981 attack continues to affect policy debates. In late 2004, the "success" of the attack was invoked by both the United States and Israel as these two countries considered military action against Iranian nuclear facilities amid mounting fears of Iranian nuclear breakout. Even skeptics of military action against Iran framed their argument against the assumption that the 1981 Osiraq attack had been successful and that its accomplishments might not be repeated.[7] Similarly, the possibility of a limited airstrike against North Korean nuclear facilities is often considered in the context of the "success" at Osiraq.[8]

But was the attack at Osiraq successful? Did it substantially delay the Iraqi nuclear program? Though current policy debates frequently invoke the Osiraq episode, there has been relatively little recent analysis of the effects of the attack. In light of the potential for such attacks in the future, developing as complete and accurate an account as possible of the Osiraq episode is critical for informing future policy decisions. If the Osiraq attack was successful, then we may be encouraged that future, similar limited strikes against nuclear facilities might also produce positive results, granted not under all conditions. However, a conclusion that the attack was largely unsuccessful would cast grave doubt over the potential success of any future such attacks, given that the historical record includes almost no other such uses of force that have had moderate or, arguably, even marginal success.[9]

This viewpoint argues that the conventional wisdom is wrong: The 1981 Israeli attack did not substantially delay the Iraqi nuclear weapons program. Had the attack not occurred, Iraq would not have rapidly constructed nuclear weapons, because (1) the reactor itself was not well designed for plutonium production, (2) inspections would likely have detected any weapons activity, and (3) such detection would have triggered a cutoff in the supply of nuclear fuel and halted weapons activity. Further, there is some reason to believe that the attack might have even accelerated the Iraqi nuclear weapons program, since after the attack, Saddam Hussein increased his material commitment to the program and pushed it underground, out of the view of the international community.

The rest of this viewpoint surveys the historical record surrounding the 1981 Osiraq attack, focusing on three questions: What was the physical capacity of the Osiraq reactor to produce fissile material? Would international inspections have detected the production of plutonium at Osiraq had the reactor not been destroyed? What course did the Iraqi nuclear program take after the attack? Beyond reviewing older debates about these issues, this viewpoint also brings to bear some new evidence, coming in part from the accounts of four former Iraqi nuclear scientists, Jafar Dhia Jafar, Khidhir Hamza, Imad Khadduri, and Mahdi Obeidi, as well as the testimony of Saddam Hussein's defector son-in-law, Hussein Kamal. Though there are some disagreements among these new accounts, they do help to flesh out our understanding of the pre-1981 Iraqi nuclear program as well as what happened after the attack.[10]

The Iraqi Nuclear Program before the 1981 Raid

Iraq acquired its first nuclear reactor, supplied by the Soviet Union, in 1968. The following year, it signed the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), though it began to consider acquiring nuclear weapons as early as 1971 in reaction to fears of an Israeli nuclear arsenal. Starting around the end of 1974, Iraq began negotiating with France to purchase an additional nuclear reactor. The Iraqis wished to purchase a gas-graphite reactor, which would have generated enough plutonium to produce five to eight nuclear warheads per year. The French did not supply the gas-graphite reactor, and instead agreed in 1975 to supply a 70-megawatt (-MW) material-test research reactor called the Osiris model, supplemented with a smaller Isis reactor; this pair of reactors came to be known as Osiraq. The French-supplied reactor, less efficient at plutonium production than a gas-graphite model, was a light water-moderated swimming-pool reactor, meaning that the reactor elements were submerged in a container of plain water.[11]

The reactor was part of Iraq's quest for a nuclear weapon. On September 8, 1975, then-Vice President Saddam Hussein declared publicly that the purchase of the French reactors "was the first actual step in the production of an Arab atomic weapon, despite the fact that the declared purpose for the establishment of the reactor is not the production of atomic weapons."[12] The Iranian revolution accelerated Iraqi interest in acquiring an atomic bomb. In December 1979, Hussein directly commanded his nuclear scientists to defy NPT commitments and build a nuclear weapon.[13]

At the same time, Israel made efforts to delay the Iraqi nuclear program. The Israelis filed a false laser patent in the late 1970s to mislead Arab nuclear research. Their intelligence agents triggered explosions in April 1979 at a French production plant near Toulouse, damaging the two reactor cores destined for the Iraqi reactors. Israeli agents may also have been behind the murders of an Egyptian nuclear engineer in Paris as well as two Iraqi engineers, all working for the Iraqi nuclear program.[14]

On June 7, 1981, eight Israeli F-16s attacked Osiraq, destroying the larger 70-MW reactor before it went operational. The attack lasted less than two minutes, and there were no Israeli casualties.[15] In assessing whether the attack was a success, three questions must be answered. First, what was the physical capacity of the reactor to produce plutonium, and more generally, at the time of the attack how close was Iraq to constructing a nuclear

weapon? Second and relatedly, would international inspections have prevented plutonium production at Osiraq? Third, what course did the Iraqi nuclear program take after the attack? These three questions are each addressed in turn.

Iraqi Nuclear Capability before the Attack

The Iraqi weapons program before the Osiraq attack included plans to manufacture a nuclear weapon with plutonium—rather than enriched uranium—produced by the larger, 70-MW reactor. How could plutonium have been produced? Memoirs by former Iraqi nuclear physicists do not go into detail, but there has been discussion about possible means. The more effective method would have been to remove ''reflector'' components from the reactor and to introduce 15–20 ''fertile'' uranium elements into the core itself. The core also would have been surrounded by a blanket of fertile uranium elements. A less efficient means would have been to produce plutonium in the neutron hall below the reactor; this hall was also destroyed in the attack.[16]

There is disagreement about exactly how much plutonium could have been produced per year from the reactor using either or both of these strategies (though, as discussed below, engineering hurdles would have delayed the building of a working bomb even if a bomb's worth of fissile material had become available).[17] As noted, light water reactors, such as the one at Osiraq, are relatively inefficient producers of plutonium, in part because there are relatively few ''spare'' neutrons to produce plutonium, especially compared to reactors such as the Dimona installation in Israel. Khadduri goes so far as to claim that the reactor ''was specifically designed to be unsuitable for the production of plutonium for a bomb.''[18] In late 1979, the Iraqis themselves estimated they could produce roughly 2 kilograms (kg) of plutonium per year (an atomic bomb needs several kilograms of plutonium; the most sophisticated, miniaturized design, which the Iraqis may not have been capable of producing, requires 5 kg), though in his memoirs Obeidi doubted the ability of the reactor to produce fissile material quickly, describing ''a mismatch between idea and reality.''

The French estimated the reactor could produce about 4 kg per year, and the Israelis estimated the reactor could produce about 8 kg per year.[19] An International Atomic Energy Agency (IAEA) official estimated that the reactor might be able to produce enough plutonium for a bomb every four years, assuming of course that inspections were eluded; the Central Intelligence Agency (CIA) produced a roughly similar estimate, predicting that the reactor could have produced 1 kg of plutonium per year.[20] The U.S. Congressional Research Service estimated shortly after the attack that, assuming evasion of all inspections, under the most likely circumstances it would have taken 10–30 years to produce enough plutonium for a single nuclear warhead.[21] Notably, most of those estimates were made in the 1980s by outside observers. We now know that technical difficulties may have introduced further delays: Obeidi reported in 2004 that at the time of the attack there were flaws in the aluminum pipes leading to the reactor that would have eventually required repair at the cost of some $25 million.[22]

An additional technical issue is the nature of the fuel the French provided to the Iraqis. The initial agreement was to fuel the reactor with French-supplied uranium enriched

to 93 percent U-235, the remainder being U-238 (in nature, the concentration of U235 in pure uranium is about .7 percent). However, the French in the late 1970s had developed a new kind of reactor fuel, called Caramel fuel. This fuel was enriched to substantially lower levels, ultimately 7 percent, which permits operation of the reactor but lends itself less well to the production of plutonium and could not be used as the heart of a nuclear weapon. The French decided in the late 1970s to alter the terms of their deal with the Iraqis, electing to provide the lower-enriched Caramel fuel. The Iraqis at first refused, and the French held to the terms of their original agreement (largely because Caramel fuel was not yet commercially available), sending Iraq a shipment of about 12 kg of highly enriched uranium in 1980. By December 1981, six months after the attack, the French decided to hold their ground on providing the lower-enriched uranium, and they soon declared that any future fuel shipments sent to a rebuilt reactor would be Caramel fuel.[23] Hence, if the reactor had not been destroyed, then throughout the 1980s Iraq could have been supplied with a reactor fuel that did not lend itself well to plutonium production, to be used in a reactor not designed for efficient plutonium production.

Some experts have speculated that the 1981 Israeli attack might have caused the French to hold the line on the Caramel issue, though there is no solid evidence to support this speculation.[24] Had the attack not occurred, France might have supplied only Caramel fuel anyway once it had become commercially available. Indeed, the shift toward holding fast on the Caramel issue could have been because François Mitterrand, who was more pro-Israel and more committed to tightening controls on nuclear exports than previous French leaders, became the president of France in May 1981.[25] A critic might reply that absent the attack, the French would never have upheld their threat to supply only Caramel fuel once it became commercially available, as doing so might have jeopardized the reactor contract and cost the French income from the deal. However, if the French were putting financial gain ahead of nonproliferation values, then it could be argued they would have agreed to rebuild Osiraq to maintain the revenue stream after the 1981 attack (Saudi Arabia agreed to help pay to rebuild Osiraq) and did not because they put nonproliferation concerns first.[26]

International Inspections and Osiraq

Aside from nuclear capability, a second issue is whether international inspections, by both French technicians and IAEA inspectors, would have prevented Iraq from diverting plutonium from the reactor. By agreement, French technicians were at the reactor continuously, filing daily reports.[27] Importantly, France seemed committed to preventing Iraq from acquiring nuclear weapons, a conclusion drawn from its public statements, signature to the NPT, decision not to provide Iraq with a gas-graphite reactor, and decision to provide Iraq with Caramel fuel. Further, there is some evidence that the French actually knew of and may have even facilitated the 1981 Israeli attack.[28]

IAEA inspectors would visit less frequently, ranging from monthly to biweekly schedules.[29] It is also likely that surveillance cameras inside the reactor pool would have been installed, providing monitoring around the clock.[30] Moreover, the diversion of plutonium would have been a cumbersome, highly unusual operation essentially

impossible to disguise. Placing a uranium blanket around the core would have been easily detectable.[31] Diversion of enough plutonium to produce a single weapon would have required some 1,200 separate movements of highly radioactive uranium rods (each about 1 meter by 8 centimeters, weighing up to 20 kg) in and out of the reactor pool. It would also have been necessary to rearrange the array of core elements to remove suspicion, shut down the reactor, and falsify operation records. Plutonium diversion would have consumed more fuel than would be consumed during normal research operations, a development sure to have been noticed by the French, who were supplying the fuel—detection of plutonium diversion would have triggered a cut off in the supply of fuel, ending progress toward constructing a weapon.[32]

In short, inspection would likely have prevented substantial Iraqi diversion of plutonium from Osiraq to build a bomb. Such is the conclusion of an array of observers, including IAEA officials, French atomic energy officials, an American physicist who visited the site after the attack, an American physicist who worked at the Brookhaven weapons laboratory, a U.S. government arms control official, and former Iraqi nuclear scientist Khadduri, who wrote,

> The possibility of such an undertaking [of producing plutonium] is delusional. The tight refueling schedule for such an endeavor, which is required to prevent poisonous plutonium 238 from developing, would be impossible to hide from the French scientists who would have been collaborating with us for years and the IAEA inspectors. Had we even diabolically thought of kicking both out and running the reactor ourselves for such a purpose, the limited fresh fuel that was allowed for us would have aborted any such attempt at the outset. Neither would the unique design of the reactor core for the ''Caramel'' fuel allow for fuel designs specific for plutonium production.[33]

Hamza, another former Iraqi nuclear physicist, has taken varying public stances on whether he thinks inspections could have worked. In a 1998 article, David Albright and Hamza claimed that the Iraqis believed they could evade outside inspections by withdrawing unsafeguarded uranium assemblies between visits and using unspecified techniques for defeating camera surveillance. In a 2000 interview, however, Hamza indicated that the 1981 attack on the Osiraq reactor ''relieved Saddam of any problems with the Non-Proliferation Treaty,'' implying that inspectors were at least something of a concern. In the same interview, in reference to the reprocessing plant, he mentioned that ''the IAEA restrictions were too high so we decided to build a small [secret] reactor'' (this secret reactor is discussed in greater detail below), again pointing to restrictions posed by international inspections. In a 2003 interview, Hamza took a more straightforward position on inspections, conceding that, ''It was difficult to cheat using that reactor.'' He also critiqued the estimate that the reactor could make a bomb's worth of plutonium each year, saying the plutonium production potential was actually ''much less.''[34]

After the attack, some observers argued that international inspections would likely have failed. There were some important critiques of the inspection plans made by Roger Richter, a former IAEA official, and others that should be considered and addressed.[35] One critique was that inspections simply could have been blocked under invented pretenses, such as when Iraq blocked IAEA inspectors from access for a few months in 1980 after an

Iranian bombing raid, arguing that the plant was physically unstable and unsafe for visitors.[36] However, the operation of the reactor required the presence of foreign technicians. During the 1980 episode, some French technicians remained on site and did have access to the uranium fuel, and after the episode all fuel was accounted for by the IAEA.[37] Further, this incident occurred before the placement of surveillance cameras; a later installation of cameras would have made verification of the uranium fuel easier, even if the inspectors themselves had been blocked from entering the reactor.

A second critique was that the IAEA could be blocked from inspecting non-reactor facilities with the potential to contribute to weaponization, such as the Italian-supplied "hot cells," in which plutonium could be reprocessed from irradiated elements removed from the reactor.[38] However, cameras, technicians, and inspectors would probably have observed the removal of the elements from the reactor, and technicians were regularly near the hot cells as well, meaning that such reprocessing "could not occur without their [foreign technicians'] knowledge."[39]

A third critique was that plutonium could be produced between inspections. That is, inspections were to take place on a biweekly basis at most, and plutonium could be processed between inspections. Further, camera surveillance could be evaded by, for example, imposing blackout conditions with the argument that wartime demanded such measures (as was done during January 1981), rendering the reactor cameras useless. Moreover, the frequent removal of irradiated targets from the reactor would not have been utterly extraordinary, as such actions were not uncommon in the context of running an experimental reactor like Osiraq.[40] However, such concerns are probably exaggerated. IAEA inspectors aside, there were several (in one estimate, hundreds) of foreign technicians constantly present at the reactor, filing daily reports.[41] They were nationals of IAEA signatories and, as noted, motivated to report evidence of Iraqi weaponization moves, which would have resulted in a cutoff of the supply of uranium fuel. Also, the production of plutonium would have consumed substantially greater amounts of uranium, meaning that even if the plutonium reactor activity had gone unnoticed onsite, the greater demand for fuel would have indicated illegal plutonium activity to both IAEA inspectors and France as uranium supplier, triggering a cutoff of supply.[42]

The Actual Post-1981 Iraqi Nuclear Weapons Program

Would Iraq have been closer to acquiring a nuclear weapon in 1991 had Israel not attacked? There is reason to believe that the attack may have actually increased Saddam's commitment to acquiring nuclear weapons, perhaps because it could have raised Saddam's estimation of the importance of acquiring nuclear weapons.[43] Khadduri goes so far as to claim that the Iraqi weapons program began only *after* the Israeli attack.[44] Though this is probably an overstatement, others have made the more general point that Saddam's commitment to the nuclear program substantially increased after the attack.[45]

Specifically, after the attack Saddam rehabilitated the leading Iraqi nuclear physicist Jafar, who had been imprisoned since 1979 on suspicion of collaborating with the opposition. Saddam brought Jafar back in September 1981 to work on and eventually run the nuclear program. After the attack, Saddam met with Jafar and told him, "How is it that

Israel is allowed to develop nuclear technology and nuclear weapons, while we aren't? In the future, we will not be able to keep the Israelis' aggression at bay without something to deter them with!'' Saddam stressed the importance of recovering from the bombing and building a nuclear weapon in secret, declaring that, ''From today, that's our goal.''[46] After the attack, the Iraqi nuclear program increased from a program of 400 scientists and $400 million to one of 7,000 scientists and $10 billion.[47]

The size of the program aside, another important change in Iraq's nuclear program after 1981 is that it went completely underground, outside of the view of international inspectors. Iraq's strategy was to remain a member of the NPT so that IAEA inspectors could verify that Osiraq essentially had been destroyed, while Iraq built an unknown and undetected weapons program. Jafar successfully persuaded Saddam to remain a member of the NPT, arguing that, ''If we walk out now, our enemies will say this is proof of our real intentions. I say we keep them guessing. Better we stay inside and learn how to deceive them.''[48] Indeed, Iraq used the attack to feign that its nuclear projects had been destroyed, removing international suspicion of its weapons ambitions.

The Iraqis reached out to the KGB to learn how to decrease their vulnerability to future attacks. Specifically, the KGB taught them how to disguise and disperse industrial facilities, using techniques such as blocking heat sources from being detected by strategic reconnaissance. They also taught the Iraqis how to build in ''blow-away'' walls to new structures, such that if the building is hit the structure is left sufficiently in place to permit rapid reconstruction.[49] In his 2000 book, Hamza remarked of the 1981 attack that, ''Israel made a mistake. They destroyed the Osirak reactor and this relieved Saddam of any problems with the Non-Proliferation Treaty.''[50]

Nonetheless, despite Iraq's efforts and the acceleration of the program after the August 1990 Iraqi invasion of Kuwait, the nuclear program in the 1980s failed to produce a weapon by 1991.[51] Jeremy Tamsett, in what is to date the most well-argued defense of the proposition that the 1981 attack substantially delayed the Iraqi nuclear weapons program, proposed that the failure to produce a bomb by 1991 proves the success of the 1981 attack. For Tamsett, the attack critically delayed Iraqi weaponization, principally because the destruction of the Osiraq reactor forced Iraq to shift from a plutonium production strategy to a uranium enrichment strategy, which ultimately presented insuperable supply, scientific, and engineering problems.[52]

A few points should be made about Tamsett's account. First, he overestimates the plutonium production capabilities of the Osiraq reactor, projecting it at 25 kg per year, when the actual production capabilities were probably much lower (see estimates, above).[53] He cites comments in a 1983 CIA report that Iraq's weapons program ''depends critically on the foreign supply of a nuclear reactor,'' though the report makes that comment in the context of a plutonium production approach, not the uranium enrichment strategy that was adopted after the attack.[54] Further, because (as described above) plutonium production activities at Osiraq would have triggered a cutoff of the supply of reactor fuel, there is no reason to believe that Iraq would have enjoyed a larger supply of bomb fissile material in the 1980s if Osiraq had not been destroyed. Second, Tamsett underestimates the progress Iraq made toward acquiring uranium and building the facilities necessary for uranium enrichment. Iraq explored a number of different routes

to uranium enrichment in the 1980s, ultimately focusing principally on the use of gas centrifuges. By August 1990, Iraq had one working centrifuge, the equipment to make more, and plans to construct secretly 1,000 centrifuges. In that year, Jafar estimated that the centrifuges would have been ready by 1993 or 1994, at which point Iraq would have had enough fissile material for one bomb and the facilities to produce 10 kg of enriched uranium per year, roughly half a bomb's worth every other year.[55] Former weapons inspector David Albright estimates that between the centrifuges and the smaller electromagnetic isotope separation program, Iraq would have had enough enriched uranium for two bombs by 1995, though by 1997 their annual enriched uranium production would have reached 55 kg, enough for three bombs per year.[56] On the supply side, aside from the several kilograms of enriched uranium on Iraqi soil and under IAEA supervision, Iraq had created a separate, covert stream of uranium ore in the 1980s, both through mining and imports from Brazil, Portugal, and Niger.[57]

On the effects of the attack, Tamsett argues that a tremendous number of resources had to be invested in developing uranium enrichment because Osiraq had been destroyed, and, without the attack, those resources might have been spent on building covert plutonium-producing reactors.[58] Specifically, in 1985 Iraq began Project 182, the secret construction of a plutonium-producing reactor, after France declined to rebuild the Osiraq reactor. At least one source indicates that the program was essentially abandoned in 1988 because of resource competition, particularly with the uranium electromagnetic isotope separation program.[59]

Absent the attack, would Iraq have had the resources to build the secret reactor fast enough to produce sufficient plutonium for a bomb by 1991? The answer is probably not. Project 182 probably began only in reaction to the destruction of Osiraq, meaning that had the attack not occurred, it would likely have taken Iraq some years to commit to the secret reactor, after plutonium production at Osiraq had been thwarted by inspectors.[60] Additionally, when the program was terminated, the secret reactor was far from being built. It would have been based on the Canadian NRX design, which relied on heavy water, and "studies on the indigenous production of heavy water had not progressed beyond surveys of technical literature and preliminary laboratory measurements." A 1997 IAEA report indicated that the reactor never progressed beyond "theoretical studies." Finally, Iraq had planned on cannibalizing parts from the damaged Osiraq reactor for the secret reactor, including heat exchangers, primary circuit pumps, and electric generators, raising doubts as to whether the secret reactor could have been built had the attack on Osiraq not made some of its parts available for 182.[61]

Tamsett also proposes that the 1981 attack increased international attention on the Iraqi weapons program, making the acquisition of sensitive weapons-related production materials more difficult after the attack than before it. This point is a bit puzzling, as the attack itself did not provide any new evidence of a covert Iraqi nuclear weapons program (actors like the Israeli government had been complaining publicly about a possible secret Iraqi nuclear weapons program since the late 1970s), Iraq certainly did not confess to the existence of a covert weapons program after the attack, and those international actors (such as the French government) who believed prior to the attack that Iraq had no weapons program retained this belief.[62]

Further, the only specific examples Tamsett provides of the attack succeeding in cutting Iraq off from sources of international support are (1) the fact that the attack caused the French to balk at rebuilding the Osiraq reactor and (2) a claim made in a 1984 article that the attack caused the French to insist on providing only the proliferation-resistant Caramel reactor fuel.[63] However, as described above, whether or not the Iraqis would have rebuilt the reactor is somewhat moot, given that the reactor itself was not well designed for plutonium production and that international inspectors would have prevented plutonium production. In addition, as described above, the French might have supplied only Caramel even without the attack.

Last, contrary to Tamsett's claims, Iraq was able to acquire substantial amounts of weapons-related items from foreign sources during the 1980s, including a Japanese streak camera, a German flash X-ray, explosive lenses, a Yugoslav-constructed electromagnetic isotope separation facility, and perhaps most critically, centrifuge and centrifuge-producing technology from West Germany.[64]

In sum, without the Osiraq attack, Iraq would have had the physical ability to produce small amounts of fissile material (plutonium) by the early 1980s, though international inspectors would likely have detected this activity and shut down the reactor by stopping the fuel supply. With the Osiraq attack, Iraq would have had the physical ability to produce larger amounts of fissile material (enriched uranium) by the early 1990s, without any impediment from international inspectors. Notably, even if one accepts the most generous assumptions about the reactor's ability to produce plutonium and Iraq's abilities to dodge inspections, Saddam would likely still not have been able to build a working bomb until some years after the Gulf War because of other technical problems. By 1991 Iraqi scientists had not yet solved completely an array of thorny issues of weapons design and development—such as designing high-explosive lenses for implosion, constructing a neutron initiator, converting the highly enriched uranium into bomb components, learning how to miniaturize the weapons enough to allow delivery by plane or missile, developing guidance systems, and finding an appropriate nuclear test site—issues that would have been relevant whether the Iraqis built a uranium or plutonium bomb.[65] That is, even without the attack, Iraq would likely not have had a nuclear weapon by 1991 because of technical barriers separate from the production of fissile material.

Conclusions

The 1981 Israeli attack on the Iraqi reactor on Osiraq did not substantially slow the Iraqi acquisition of nuclear weapons. The reactor itself and the fuel it would have consumed were not well suited for plutonium production. The presence of international inspectors, foreign technicians, and constant camera surveillance would have at least substantially slowed down Iraqi plutonium production, and probably, in concert with the French ability to cut off the supply of uranium fuel, prevented it altogether. A critic might reply that a successful inspection regime would have ultimately encouraged Iraq to produce plutonium or enrich uranium in secret. However, this point does not justify the attack, because of course it caused Iraq to pursue a secret nuclear weapons program anyway,

probably sooner than it would have without the attack. Finally, the attack ironically may have stimulated the Iraqi pursuit of nuclear weapons by increasing Saddam's motivation for acquiring such weapons which led him to release a key Iraqi scientist from prison and expand the program. The attack also pushed the Iraqi program underground, removing it from the observation of international inspectors and technicians.

What are the lessons of Osiraq for possible future attacks against nuclear facilities? If the 1981 raid is the most successful of such preventive, anti-nuclear attacks, even this raid had, at best, dubious success in comparison to much less successful attacks, such as the 1991 coalition air strikes against the Iraqi nuclear program and the 1980 Iranian raids on Osiraq. It must therefore serve as a cautionary note for future endeavors. Indeed, even the limited successes at Osiraq are unlikely to be repeated, as many states (including Iraq, North Korea, and Iran) learned the lessons of Osiraq and after 1981 sought to disperse and conceal their nuclear facilities, making future raids even less likely to succeed.

Last, policymakers must recognize that future airstrikes may incur much higher costs for the United States than did the 1981 attack for the Israelis. Such attacks against Iran would substantially undermine U.S.–Iranian relations, perhaps leading to increased terrorism, to disruptions in the world oil market, or to an Iranian decision to intervene in Iraq in support of the Shiites. The CIA reported in 2004 that Hizballah "would likely react to an attack against it, Syria, or Iran with attacks against U.S. and Israeli targets worldwide."[66] Striking North Korean nuclear facilities could be even worse; as General Gary Luck put it, "If we pull an Osirak [against North Korea], they will be coming south."[67] American policymakers may be better off relying on more peaceful means of counter-proliferation, such as diplomacy, inspections, and economic sanctions. These tools promise fewer costs and dangers and have demonstrated more success than military action.

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8. See, for example, Ann Scott Tyson, "Use of Force in Korea is Tricky Proposition," *Christian Science Monitor*, Feb. 12, 2003, p. 2.
9. Dan Reiter, "Preventive Wars Against Nuclear, Biological, and Chemical Weapons Programs," paper presented at the "Preventive and Preemptive Military Intervention Workshop," Ridgway Center for International Security Studies, University of Pittsburgh, Oct. 9–10, 2004.
10. Most centrally, Hamza, who has provided the most detailed information on many aspects of the pre-1991 Iraqi nuclear program, has come under personal attack. Kamal has declared that some of the documents Hamza has provided are fakes and that Hamza himself is a "professional liar." Khadduri and former weapons inspector Scott Ritter claim that Hamza was generally uninvolved in weapons-related research. Former weapons inspector David Albright, who coauthored a journal article with Hamza, eventually came to conclude that Hamza had "started exaggerating his experiences in Iraq." Others have defended Hamza, including former assistant secretary of defense Richard Perle and former CIA director James Woolsey. See Hussein Kamal, interview with UN officials, Aug. 22, 1995, Iraq Watch website, <www.iraqwatch.org/un/UNSCOM/unmovic-kamalmeeting-082295. pdf>; Imad Khadduri, *Iraq's Nuclear Mirage: Memoirs and Delusions* (Toronto: Springhead Publishers, 2004), pp. 72–73, 92; William Rivers Pitt with Scott Ritter, *War On Iraq: What Team Bush Doesn't Want You to Know on Iraq* (New York: Context Books, 2002), pp. 52–53; Albright quote and Stein, Perle, and Woolsey references from Seymour M. Hersh, *Chain of Command: The Road from 9/11 to Abu Ghraib* (New York: HarperCollins, 2004), p. 213. Insight from other sources inside the Iraqi nuclear program such as the Iraqi scientist Hussein Shahristani come from Shyam Bhatia and Daniel McGrory, *Brighter Than the Baghdad Sun: Saddam Hussein's Nuclear Threat to the United States* (Washington, D.C.: Regnery Publishing, 2000).

11. Nakdimon, *First Strike*, pp. 40–45, 52; Khidhir Hamza with Jeff Stein, *Saddam's Bombmaker: The Terrifying Inside Story of the Iraqi Nuclear and Biological Weapons Agenda* (New York: Touchstone, 2000), pp. 61–66, 69; Richard Wilson, foreword to Jafar D. Jafar, *Oppdraget: Innsidehistorien Om Saddams Atomvapen* (Oslo: Spartacus, 2005). English language version of foreword provided by publisher.
12. Quoted in Nakdimon, *First Strike*, p. 59. See also Hamza, *Saddam's Bombmaker*, pp. 80–83. The Iraqis referred to the reactors as Tammuz 1 and Tammuz 2, though sources differ over which was which, Nakdimon (p. 62) claims that the larger reactor was Tammuz 1, and Richard Wilson claims that the larger reactor was called Tammuz 2. Richard Wilson, "A Visit to the Bombed Nuclear Reactor at Tuwaitha, Iraq," *Nature*, March 31, 1983, pp. 374.
13. Hamza, *Saddam's Bombmaker*, pp. 115–117.
14. Ibid. pp. 97–101; 106; 109; 132–35; Mahdi Obeidi and Kurt Pitzer, *The Bomb in My Garden: The Secrets of Saddam's Nuclear Mastermind* (New York: Wiley, 2004), pp. 46–47.
15. For an extensive account of the Israeli side of the raid, see Claire, *Raid on the Sun*.
16. The 70-MW reactor could only have been run at 40 MW because a heavy water moderator had been attached. Wilson, "A Visit," p. 374; H. Gruemm, "Safeguards and Tamuz: Setting the Record Straight," *IAEA Bulletin* 23 (Dec. 1981), pp. 12–13. The smaller reactor was "almost useless" for plutonium production. Hamza, *Saddam's Bombmaker*, p. 128.
17. Nakdimon cites IAEA Director General Hans Gruemm as estimating that enough plutonium could be produced for one to two bombs per year. However, Gruemm notes this estimate assumes a higher-than-normal input of fuel, which would be noticed about the international community, triggering cutoff of the fuel supply. Nakdimon, *First Strike*, p. 69; Gruemm, "Safeguards and Tamuz," p. 12.
18. Wilson, "A Visit," p. 376; Michael Jansen, Baghdad's Bomb—An Inside View," *Middle East International*, Jan. 10, 2003, p. 11.
19. David Albright, "Iraq's Programs to Make Highly Enriched Uranium and Plutonium for Nuclear Weapons Prior to the Gulf War," Institute for Science and International Security, Oct. 2002, <www.exportcontrols.org/iraqs_fm_history.html>; Obeidi and Pitzer, *A Bomb in My Garden*, p. 49.
20. Christopher Herzig, "Correspondence: IAEA Safeguards," *International Security* 7 (Spring 1983), p. 196; Central Intelligence Agency, Directorate of Intelligence, Intelligence Assessment, *The Iraqi Nuclear Program: Progress Despite Setbacks*, June 1983, p. 13, <www.gwu.edu/%7Ensarchiv/NSAEBB/NSAEBB82/iraq19.pdf>. The CIA report says that putting a blanket around the core could increase that output to 10 kg per year, but notes that, "We strongly believe that building a blanket . . . would be difficult for Iraq to do without being detected by the IAEA or the French."
21. U.S. House of Representatives, Committee on Foreign Affairs, *Israeli Attack on Iraqi Nuclear Facilities*, 97th Cong., 1st sess., June 17 and 25, 1981, p. 88. Lucien S. Vandenbroucke estimates that enough plutonium for one to two bombs could have been produced in ten years. "The Israeli Strike Against Osiraq," *Air University Review* 35 (Sept.–Oct. 1984), pp. 35–47.
22. Obeidi and Pitzer, *The Bomb in My Garden*, p. 50.

23. Nakdimon, *First Strike*, pp. 74–78, 149, 335; Bhatia and McGrory, *Brighter Than the Baghdad Sun*.
24. Vandenbroucke, "The Israeli Strike Against Osiraq". The couple of newspaper articles Vandenbroucke cites shed little light on motivations, other than to point to a Dec. 1981 meeting of French ministers at which it was probably decided to hold fast on the Caramel issue in negotiations over reconstructing the reactor. Edward Cody, "France Plans to Bar Weapons-Grade Fuel for Iraq's Reactor," *Washington Post*, Jan. 13, 1982, p. A18; Ronald Koven and Jim Hoagland, "Mitterrand Says France Will Hold Iraq to Strict Conditions on Any New Reactor," *Washington Post*, June 18, 1981, p. A1.
25. Michael Dobbs, "France Delays on Iraqi Reactor," *Washington Post*, Dec. 3, 1984, p. A20; David March, "France Shelves Plans to Replace Iraqi Reactor," *Financial Times*, Jan. 19, 1984, p. 3.
26. On Saudi Arabia, see Dobbs, "France Delays."
27. Wilson, "A Visit," p. 376. The terms of the reactor agreement committed Iraq to allow French technicians to inspect the reactor site until 1989. Koven and Hoagland, "Mitterand Says France."
28. A guidance transmitter was found in the wreckage of the reactor, possibly planted by the French. The French technicians on site had also scheduled a meeting that day away from the site, and tried desperately to dissuade one of their colleagues from being at the reactor when the attack took place. That French technician ignored their pleas and was killed by the attack. Hamza, *Saddam's Bombmaker*, pp. 129–30.
29. Herzig, "Correspondence," p. 196.
30. Ibid. Former IAEA official Roger Richter claimed in front of a House subcommittee that there were no provisions for camera surveillance in the reactor. Richter's qualifications to make this and other critiques of the inspection regime have been challenged, as critics have pointed out that he presented no specific facts in his testimony and he was not assigned to Iraq when working with the IAEA. U.S. House of Representatives, *Israeli Attack on Iraqi Nuclear Facilities*, p. 59; Sigvard Eklund, "The IAEA on Safeguards," *Bulletin of the Atomic Scientists* 37 (Oct. 1981), p. 32. Additionally, the reactor was not yet operational when it was destroyed, and the specific Facility Attachment that would have drawn up the particulars of inspection (including, in all likelihood, camera surveillance) had not yet been drawn up. Hence, even if it was narrowly correct that no agreement had yet been reached to install cameras, it is reasonable to expect that cameras would have been installed before the reactor became operational. U.S. House of Representatives, *Israeli Attack on Iraqi Nuclear Facilities*, p. 68.
31. Herzig, "Correspondence"; Anthony, "Osirak and International Security," *Bulletin of the Atomic Scientists* 37 (Oct. 1981), pp. 33–34; Wilson, "A Visit," p. 376.
32. See Paul Lewis, "France Says Iraqis Couldn't Have Built A-Bomb Undetected," *New York Times*, June 18, 1981, p. A1; Wilson, p. 376; Fainberg, "Osirak and International Security," p. 34.
33. Gruemm, "Safeguards and Tamuz"; Herzig, "Correspondence"; Lewis, "France Says Iraqis Couldn't Have Built A-Bomb Undetected"; Eklund, "The IAEA on Safeguards"; Wilson, "A Visit"; Fainberg, "Osirak and International Security"; U.S. House of Representatives, *Israeli Attack on Iraqi Nuclear Facilities*, pp. 59–61; Khadduri, *Iraq's Nuclear Mirage*, pp. 81–82.

34. David Albright and Khidhir Hamza. ''Iraq's Reconstitution of its Nuclear Weapons Program,'' *Arms Control Today* 28 (Oct. 1998), pp. 9–15; Khidhir Hamza, ''National Terrorist Alert Goes Up; Interview With Saddam's Bomb Maker,'' CNN Crossfire, Feb. 7, 2003 <http://transcripts.cnn.com/TRANSCRIPTS/0302/07/cf.00.html>. The secret reactor was Project 182, discussed in the text.
35. Herzig, ''Correspondence''; Anthony, ''Osirak and International Security''; Wilson, ''A Visit,'' p. 376. Other inspection skeptics include Shai Feldman, ''The Bombing of Osiraq--Revisited,'' *International Security* 7 (Fall 1982), pp. 114–42 (who is in turn rebutted by Herzig, ''Correspondence''); Nakdimon, *First Strike*; Timothy L. H. McCormack, *Self-Defense in International Law: The Israeli Raid on the Iraqi Nuclear Reactor* (New York: St. Martin's Press, 1996), pp. 69–89.
36. Feldman, ''The Bombing of Osiraq,'' p. 121; Ronald Koven, ''Baghdad Blocks Inspection of Its Nuclear Reactors,'' *Washington Post*, Nov. 7, 1980, p. A1.
37. Koven, ''Baghdad Blocks''; Herzig, ''Correspondence,'' p. 198.
38. McCormack, *Self-Defence in International Law*, pp. 74–75.
39. Fainberg, ''Osirak and International Security,'' p. 34.
40. McCormack, *Self-Defense in International Law*, pp. 73–82.
41. Fainberg, ''Osirak and International Security,'' p. 34.
42. Herzig, ''Correspondence,'' p. 197.
43. Richard K. Betts predicted in 1981 that the raid would increase interest throughout the Arab world in acquiring nuclear weapons. ''Nuclear Proliferation after Osirak,'' *Arms Control Today* 11 (Sept. 1981), p. 1. Others have speculated that the 1981 attack may have stimulated Saddam's pursuit of biological and chemical weapons. King, ''Israel May Have Iran in Its Sights.''
44. Khadduri, *Iraq's Nuclear Mirage*, p. 82.
45. Feldman, *Nuclear Weapons*, p. 136; Michael Eisenstadt, ''Can the United States Influence the WMD Policies of Iraq and Iran?'' *Nonproliferation Review* 7 (Summer 2000), p. 66; Bhatia and McGrory, *Brighter than the Baghdad Sun*, p. 140.
46. Jafar, *Oppdraget*, pp. 55–56; Khadduri, *Iraq's Nuclear Mirage*, p. 82; Hamza, *Saddam's Bombmaker*, pp. 137–39. Thanks to Kristin Bakke for translation of portions of *Oppdraget* from the original Norwegian.
47. Hamza, ''National Terrorist Alert''; Jafar, *Oppdraget*. Khadduri says that after the attack Iraqi scientists ''went full speed ahead with our nuclear program, with unlimited resources.'' Quoted in Farah Stockman, ''Confronting Iraq: Hussein's Ex-Scientists Say Nuclear Bid Stymied,'' *Boston Globe*, Feb. 9, 2003, p. A1.
48. Quoted in Bhatia and McGrory, *Brighter Than the Baghdad Sun*, p. 144.
49. Scott Ritter, *Endgame: Solving the Iraq Crisis* (New York: Simon & Schuster, 2002), p. 75. See also Eisenstadt, ''Can the United States Influence,'' p. 66; Hamza, *Saddam's Bombmaker*, p. 221; Bhatia and McGrory, *Brighter Than the Baghdad Sun*.
50. Khidhir Hamza, interview with Joseph Cirincione, ''Presentation at the Carnegie Endowment Non-Proliferation Project,'' Nov. 2, 2000, <www.ceip.org/files/projects/npp/resour ces/hamzatranscript.htm>. See also Bhatia and McGrory, *Brighter Than the Baghdad Sun*, p. 143.

51. This crash program envisioned building some 50 centrifuges to enrich some 14 kg of 80-percent-enriched uranium up to the 93 percent that a bomb design requires; it would have been combined with the 12 kg of 93-percent-enriched uranium the French supplied in 1980. Though some UN inspectors speculated that with the crash program Iraq could have assembled an explosive device as early as mid-1991, the crash program was still likely farther away from succeeding, given that several scientific and engineering tasks remained to be mastered by spring 1991, including the production of uranium hexafluoride (a precursor for enrichment), a variety of bomb design issues, and the construction of the centrifuges themselves. Albright, ''Iraq's Programs''; Obedi, *Bomb in My Garden*, pp. 131–37; Hamza, *Saddam's Bombmaker*, p. 334.
52. Jeremy Tamsett, ''The Israeli Bombing of Osiraq Reconsidered: Successful Counter-proliferation?'' *Nonproliferation Review* 11 (Fall/Winter 2004), pp. 70–85. Hamza has also stated that absent the 1981 attack, Iraq would have had a nuclear weapon by 1990, though as discussed, this presumes that without the attack an array of technical problems in weapons design (aside from production of fissile material) which were not solved by 1991 would have been solved by 1990. This assumption is particularly questionable, as it predicts faster scientific breakthroughs with a much smaller set of scientists operating with a much smaller budget (as discussed, the budget and personnel assigned to the weapons program increased some 15-fold after the attack). Interestingly, Hamza argues without the attack Iraq would have had one nuclear weapon by 1990, but also that with the attack the Iraqi nuclear program was on track eventually to produce six nuclear weapons per year, before it was halted by the 1991 Gulf War. Hamza, ''National Terrorist Alert.''
53. Tamsett, ''The Israeli Bombing,'' p. 83, n. 2.
54. Central Intelligence Agency, *Iraqi Nuclear Program*, pp. 12–14.
55. Jafar, *Oppdraget*.
56. Albright, ''Iraq's Programs.''
57. Hamza, *Saddam's Bombmaker*, p. 334; U.S. Senate, Armed Services Committee, Testimony of Dr. David Kay, ''Iraqi Weapons of Mass Destruction Programs,'' Jan. 28, 2004, available at <www.ceip.org/files/projects/npp/pdf/Iraq/kaytestimony.pdf>; Bhatia and McGrory, *Brighter Than the Baghdad* Sun, p. 184.
58. Tamsett, ''The Israeli Bombing,'' p. 72. Tamsett also proposes (p. 71) that by forcing the weapons program underground into several facilities, the attack ''strained coordination between principals (weapons scientists and engineers) and substantially slowed progress.'' He provides no specific examples of this increased compartmentalization and its negative effects. More generally, under the paranoid rule of Saddam, there was widespread compartmentalization before the attack, and limits to compartmentalization after the attack, as when, for example, progress toward gaseous diffusion as a means of uranium enrichment was presented to a group of Iraqi nuclear physicists at a 1984 conference. Obeidi and Pitzer, *Bomb in My Garden*, pp. 54–55.
59. International Atomic Energy Agency, ''The Implementation of United Nations Security Council Resolutions Relating to Iraq: Report by the Director General,'' Aug. 12, 1996, <www.iaea.org/About/Policy/GC/GC40/Documents/gc40-13.html>.

60. Hamza implies that plans for Project 182 existed at least as far back as 1981, though this is in contrast to testimony given by Iraqi officials to UN inspectors. Hamza, *Saddam's Bombmaker*, p. 120.
61. IAEA, "Implementation"; Albright, "Iraq's Programs"; IAEA, "Fourth Consolidated Report of the Director General of the International Atomic Energy Agency under paragraph 16 of Security Council resolution 1051 (1996)," S/1997/779, Oct. 8, 1997, p. 53, <www.iaea.or.at/worldatom/Programmes/ActionTeam/reports/s_1997_779.pdf>.
62. Israel raised its concerns to the French government formally in 1977. Nakdimon, *First Strike*, pp. 77–80. Some two weeks after the attack French President François Mitterrand publicly denounced it, declaring there was no evidence that the reactor was part of a secret Iraqi weapons program. Koven and Hoagland, "Mitterand Says France."
63. Tamsett, "The Israeli Bombing," p. 77, citing Vandenbroucke.
64. Obeidi and Pitzer, *A Bomb in My Garden*; Hamza, *Saddam's Bombmaker*, p. 221; Albright, "Iraq's Programs."
65. Hamza, *Saddam's Bombmaker*, pp. 240, 334; Khadduri, *Iraq's Nuclear Mirage*, p. 122; Obeidi and Pitzer, *The Bomb in My Garden*, p. 136; Cirincione, *Deadly Arsenals*, p. 274; Central Intelligence Agency, *Comprehensive Report of the Special Advisor to the DCI on Iraq's WMD*, vol. 2, "Nuclear," Sept. 30, 2004, p. 4; Kamal interview; Albright, "Iraq's Programs." Notably, Hamza is probably the most optimistic in his assessment of Iraq's ability in 1991 to have solved these technical problems quickly once the fissile material became available. Hamza, "National Terrorist Alert"; Hamza and Cirincione, "Presentation at the Carnegie Endowment."
66. Graham Allison, *Nuclear Terrorism: The Ultimate Preventable Catastrophe* (New York: Times Books, 2004), p. 35.
67. James Fallows, "Will Iran Be Next?" *Atlantic* (Dec. 2004), p. 106; Joel S. Wit, Daniel B. Poneman, and Robert L. Gallucci, *Going Critical: The First North Korean Nuclear Crisis* (Washington, D.C.: Brookings 2004), p. 104.