

BELFER CENTER REPORT

The Iran Nuclear Archive: Impressions and Implications

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HARVARD Kennedy School

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for Science and International Affairs

REPORT

APRIL 2019



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Layout by Jacob Carozza

Cover photo: The nuclear archive warehouse outside Tehran (satellite image via Google).

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Printed in the United States of America

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Cover Image

The nuclear archive warehouse outside Tehran
(satellite image via Google).



Introduction

On April 30, 2018, Israeli Prime Minister Benjamin Netanyahu revealed in a speech that Israel had succeeded in removing from Iran an enormous collection of material from an archive Iran had compiled related to Tehran’s nuclear program.¹ Israeli officials estimate that they took approximately twenty percent of the entire archive. This trove included some 55,000 pages of documents and a further 55,000 files on CDs—files that included photos and videos in addition to documents. These materials permit a detailed examination of Iran’s nuclear activities in the period 1999 to 2003, when Iran issued a “halt order” that curtailed its full-blown weapons program (though as discussed below, some activities continued).

In January 2019, the authors traveled to Israel to receive a briefing on the archive from senior Israeli intelligence officials. The Israeli officials provided a detailed summary of their conclusions on the archive’s history, contents, and implications, which included showing copies of some archive documents and photographs along with a few original documents that Israeli officials believed to be critical to a broader understanding of the archive. Officials also provided us with copies of selected documents and photographs.

We did not have access to the entire archive. Nor did we have any authentication experts in our group. Moreover, many of the documents shown or provided to us are written in Farsi, and our group did not include Farsi speakers. For these reasons, we cannot validate the authenticity of the materials with certainty. Moreover, we cannot judge whether or not exculpatory information for some portions of the activities covered might exist within the archive. We do judge, however, that the scope and detail of the documents provided, and the degree to which they dovetail with publicly available records on Iran’s nuclear weapons program, make a convincing case that the archive is real, though reflective of a discrete period of time now more than a decade

¹ The transcript of Netanyahu’s remarks can be found in “Full Text: Netanyahu Claims Iran Nuclear Deal Based on Lies,” *Haaretz*, April 30, 2018.

in the past.² It is our understanding that the U.S. government and the International Atomic Energy Agency (IAEA), both of which have received full copies of what Israel acquired, have been going through their own painstaking processes of assessment and confirmation of authenticity.

Not everything in the archive is new. For several decades, officials and analysts in Washington and elsewhere have known that Tehran was interested in and was making efforts to work toward a nuclear weapons capability, so the existence of Iran's nuclear weapons program is neither new nor surprising. However, the Israeli officials who have been through the material in detail believe the archive provides an unprecedented and extensive look back at the organization, the scale, the objectives, the capabilities, and the progress of Iran's nuclear program. This appears to be by far the fullest picture that exists of where Iran was headed and what it had achieved. Broadly, what the archive shows is that in the period 1999-2003 Iran had a well-organized, purposeful, and impressive nuclear weapons program that had made considerable progress. While the Israelis believe they acquired only 20 percent of the total archive, they believe the materials they seized provide a reasonably complete picture of the total program, in part because they include overall program management documents.

Israel has provided materials from the archive to several parties, including national governments, international organizations, academic researchers, and journalists.³ In his speech (which was accompanied by a slide presentation), Prime Minister Netanyahu made public many of the key revelations and documents in the archive. Subsequently, Israel shared the entire collection with the IAEA, the United States, the United Kingdom, and France. Still other governments have been briefed on the contents of the archive, as

2 Iran has categorically denied the authenticity of the archive since its revelation. According to a statement released by Iran's U.N. mission in New York, "Iran has always been clear that creating indiscriminate weapons of mass destruction is against what we stand for as a country and the notion that Iran would abandon any kind of sensitive information in some random warehouse in Tehran is laughably absurd." See Joby Warrick, "Papers Stolen in a Daring Israeli Raid on Tehran Archive Reveal the Extent of Iran's Past Weapons Research," *The Washington Post*, July 15, 2018. https://www.washingtonpost.com/world/national-security/papers-stolen-in-a-daring-israeli-raid-on-tehran-archive-reveal-the-extent-of-irans-past-weapons-research/2018/07/15/0f7911c8-877c-11e8-8553-a3ce89036c78_story.html.

3 The Institute for Science and International Security in Washington, D.C., for example, has produced a series of papers based on documentation obtained from the Iran nuclear archive. Available at isis-online.org.

have journalists from Israel and elsewhere.⁴ Some prominent Israeli figures have even proposed putting the entire archive on the internet in order to facilitate analysis of the vast trove of materials, though as it includes detailed nuclear weapon designs, we would strongly recommend against complete disclosure.⁵

This brief report summarizes the group's conclusions about what the archive reveals about Iran's program. The report is in three parts. First, the main body offers six overall impressions and implications from our briefings on and review of the archive materials. Second, Appendix A offers a table comparing what was publicly known before the archive to what the archive appears to reveal, in each of the several key elements of a nuclear weapons program. Third, Appendix B summarizes important questions that remain open.

All participants in the group agree on this report. Participants in the group represent a range of views on the Joint Comprehensive Plan of Action (JCPOA) and on what policies the United States and other countries should take now to address Iran's nuclear program; we do not believe that the facts in this report lead inexorably to any particular policy conclusion. Indeed, all potential policy choices appear fraught with difficulty and uncertainty. Nevertheless, we believe the policy discussion will be strengthened by having a common factual basis to draw on, and we hope this report will contribute to that objective.

4 See, for example, David Sanger and Ronen Bergman, "How Israel, in Dark of Night, Torched Its Way to Iran's Nuclear Secrets," *New York Times*, July 15, 2018, and Joby Warwick, "Papers Stolen in a Daring Israeli Raid." For an extensive account, including photos of many of the key documents, see Ronen Bergman, "Iran's Great Nuclear Deception," *YNetnews.com*, November 23, 2018, available at <https://www.ynetnews.com/articles/0,7340,L-5412157,00.html>.

5 Yonah Jeremy Bob, "Ex-Foreign Ministry Official: Put Secret Iran Nuke Archives on Internet," *Jerusalem Post*, February 18, 2019. In our discussions, details of nuclear weapons designs were fuzzed out to avoid revealing classified information.

Clarifying Iran's Nuclear Program

1. Strategic Intent: Iran's senior leadership approved a program to manufacture nuclear weapons and carry out an underground nuclear test. This was a coherent, organized, top-down program, not a rogue operation.

During the many years of the Iran nuclear controversy, there has been speculation about the nature of Iran's nuclear program. Was it aiming for a weapon or for a hedging option? Was there an unambiguous decision from the top or was this a loosely coordinated bottom-up effort? Did this program have a firm grounding in state policy or was it largely the product of efforts by relatively autonomous actors such as the Islamic Revolutionary Guard Corps (IRGC)? Could this be a case of technologists going further than authorized or understood by the political authorities?

If the archive documents are authentic, all such speculations can now be set aside. The materials make it clear that Iran's nuclear weapons program—known as Project AMAD—was unambiguously aimed at producing nuclear weapons. It had an approved and budgeted plan for manufacturing five nuclear weapons and carrying out an underground nuclear test. At least one document indicates that the decision to actually manufacture nuclear weapons and carry out a test was approved by a committee that at the time (though this is not noted in the document) included then-President Mohammad Khatami, then-Secretary of the Security Council Hassan Rouhani (now Iran's President), and then-Minister of Defense Ali Shamkhani (now Secretary of the Security Council), among others. Israeli officials report that the archive documents indicate that Shamkhani was regularly briefed on the program's progress. Supreme Leader Ayatollah Ali Khamenei was reportedly informed as well. The effort was implemented by a complex organization that had participation from several major elements of the Iranian government—including the Defense Ministry, the Atomic Energy Organization of Iran (AEOI), the defense industry, and the IRGC. This was a substantial, purposeful, sophisticated undertaking that operated with the approval of the political leadership in Iran.

The archive also reveals that the “stop work” order in 2003 did not stop all the work. Rather, when the decision was taken to stop work on large identifiable facilities, in a series of meetings, the program’s leaders decided to continue research to fill in some technical gaps they still believed needed work. They divided these continuing efforts into two parts—efforts that would be conducted openly under civilian rationales (such as a program to develop improved neutron measurement capability, related to neutron generator development) and other efforts that would be carried out covertly, because they had no plausible civilian rationale. The archive documents largely end in the mid-2000s, however, more than a decade ago. They do not reveal what Iran’s strategic intent or nuclear weapons-related activities may have been since then.

Israeli officials report that in 2015-2016, as the nuclear negotiations were winding down, Iran began to systematically organize and archive documents and other materials related to its nuclear weapons program. It was this archive that Israeli operatives clandestinely acquired. Iran carefully ordered and indexed the documents in hundreds of binders. In addition to the binders, there were a large number of CDs, which Israeli officials report appear to have been less carefully organized (and which include some repetitive or redundant information). The material was carefully hidden in a nondescript warehouse, in shipping containers on flatbed trailers that could be moved immediately, with very few officials aware of its existence and location. This decision appears to reflect a desire to at least maintain the option to return to weaponization at a later date.

In addition, in September 2018, Prime Minister Netanyahu publicly charged that at a different warehouse, Iran was storing not just information but equipment and material left over from the nuclear weapons program.⁶ Satellite imagery makes clear that Iran removed a large amount of material from the site Netanyahu described in the months following his April 2018 press conference about the archive—which may have highlighted to Iran the possibility that Israel might also have found out about the equip-

⁶ The transcript of Netanyahu’s remarks can be found in “Full Text: Prime Minister Netanyahu’s 2018 UN General Assembly Speech,” *Haaretz*, September 27, 2018.

ment warehouse.⁷ Iran has denied that such a warehouse with nuclear weapons-related equipment ever existed. While we discussed this reported warehouse briefly during our visit, we were not shown specific additional evidence about it beyond that in Netanyahu's speech. IAEA inspectors reportedly visited this second warehouse in 2019, after its contents had largely been removed.⁸

2. Technical Progress: The evidence reveals that Iran's nuclear weapons program made substantially more progress than described in the IAEA's "Final Assessment."

Years of scrutiny by the IAEA and various national intelligence services resulted in a composite portrait of Iran's nuclear activities that suggested that there had been a wide-ranging exploration of many elements of a nuclear weapons program. In November 2011, the IAEA assembled and published a summary of findings, suspicions, and allegations about Iran's nuclear effort, judging that until 2003 there had been a "structured programme" within which "Iran has carried out activities relevant to the development of a nuclear explosive device" and stating that the IAEA "has serious concerns regarding possible military dimensions to Iran's nuclear programme."⁹ The IAEA updated its assessment four years later, as part of the diplomatic process associated with the negotiation of the JCPOA. On December 2, 2015, the IAEA issued its "Final Assessment," reiterating and where possible augmenting its 2011 survey of Iran's "wide" and "coordinated" weapons-related efforts. The IAEA assessment clearly concludes that prior to 2003, Iran had undertaken an organized and systematic effort to move toward the acquisition of nuclear weapons, but judged that "these activities did not advance

7 David Albright, Olli Heinonen, Frank Pabian, and Andrea Stricker, "Revealed: Emptying of the Iranian 'Atomic Warehouse' at Turqz Abad" (Washington, D.C.: Institute for Science and International Security and Foundation for the Defense of Democracies, November 28, 2018).

8 Francois Murphy, "U.N. Nuclear Watchdog Inspects Iran 'Warehouse' Netanyahu Pointed To—Sources," *Reuters*, April 4, 2019.

9 "Implementation of the NPT Safeguards Agreement and Relevant Provisions of Security Council Resolutions in the Islamic Republic of Iran," IAEA, GOV/2011/65, November 8, 2011, p. 10. This document includes a 13-page annex, "Possible Military Dimensions to Iran's Nuclear Programme," that provides an overview of Iran's nuclear activities.

beyond feasibility and scientific studies and the acquisition of certain relevant technical competences and capabilities.”¹⁰

That assessment, unfortunately, was not correct. Instead, the documents, as presented and assessed by Israeli officials, appear to show that at the time of the 2003 halt work order, Iran had completed its nuclear weapons design and was preparing the facilities for manufacturing—though actual production of the needed nuclear material was still in the earliest stages, with hardly any centrifuges operating.

Much that is contained in the nuclear archive is foreshadowed in the material that was already available in the public domain. But the archive fills in the Iranian nuclear puzzle much more completely, and this fuller picture changes our understanding of the program in two ways. First, many past speculations and allegations about Iran’s nuclear activities are transformed by the archive into known facts. For example, there was indeed a large explosion containment chamber at Parchin in which Iran carried out extensive explosive experiments related to the nuclear weapons program. Indeed, there was a second explosive test chamber for measuring tests with flash X-ray photography. The archive includes many photographs and other documentation related to this facility and its experiments.

Second, and much more importantly, the program revealed by the archive was more advanced and substantial than previously known. The Israeli assessment of the archive indicates that Iran had managed to acquire several foreign weapons designs, had refined those designs to develop its own, and had settled on a single frozen design as the basis for its initial weapons production. As discussed below, Iran had also received help from foreign experts. As shown in Appendix A, Iran had made considerable progress on nearly every aspect of developing and manufacturing nuclear weapons, including implosion testing, weapon design, neutron generators, casting and machining (though with surrogate materials, not uranium), and integration of warheads and reentry vehicles. It had excavated an underground tunnel to hold a covert, industrial-scale uranium metallurgy facility to produce weapons components and possessed the equipment necessary to

10 “Final Assessment on Past and Present Outstanding Issues Regarding Iran’s Nuclear Programme,” IAEA, GOV/2015/68, December 2, 2015, p. 15.

do so. Tehran was in the process of selecting sites for a nuclear test. All of this is confirmed by photos, videos, and documentation found in the Iran nuclear archive. As of 2003, other than fissile material, Iran was quite far along in its effort to obtain the bomb.

3. Reconstitution Capability: Iran possesses knowledge and capabilities that provide a foundation for reconstituting its nuclear weapons program.

It has always been understood that Iran could at some point choose to resume its nuclear weapons program. Indeed, it is partly the fear or the expectation that Tehran could do so when key enrichment restraints in the JCPOA expire that cause some to doubt the value of that agreement.

What the nuclear archive suggests is that, for several reasons, Iran is in a particularly robust position to reconstitute its program. For one thing, it would be starting from a more advanced base of knowledge and progress than was previously understood. Second, the record of its past efforts was gathered, preserved and curated in the archive itself. Third, as already noted, when Iran's large-scale nuclear weapons program was halted in 2003, some of the scientific and technical explorations potentially related to a weapons program continued in a coordinated fashion. Fourth, Israeli officials report—separately from the information contained in the archive itself—that many of the personnel and the teams that were involved in Iran's weapons effort have remained intact, and some have continued to work on nuclear-related activities. Israeli officials estimate that about 70 percent of the staff who once worked in Project AMAD transferred to SPND, the current defense organization headed by Mohsen Fakrizadeh, who led Iran's nuclear weapons effort. Finally, while Iran's activities involving fissile material are well-known and subject to IAEA scrutiny, the current location of equipment relevant to weaponization remains unknown, and the modest scale required for weaponization efforts means that overall confidence that such activities are not occurring at secret locations is lower. In short, Iran seems likely to be in a strong position to launch a reconstituted weap-

ons program, should it ever choose to do so, and should it have a plausible path to acquiring fissile material without being detected and stopped.

Implications for Nonproliferation

The Iran nuclear archive not only permits a more intimate and authoritative look at Iran's nuclear program and its progress. It also suggests some worrying implications for the nonproliferation regime.

4. Foreign Assistance and Procurement: The archive indicates that Iran benefitted from much more foreign assistance than previously understood—though not help from foreign governments.

Iran was known to have ties to the A.Q. Khan nuclear black-market network. Moreover, it was already known that one expert from the Soviet nuclear weapons program, Vyacheslav Danilenko, had contributed to the effort (though both Iran and Danilenko describe his work as having been focused on explosive production of nanodiamonds, a technology developed from the Soviet weapons program). The archive reveals that Iran managed to recruit many more foreign scientists. According to Israeli officials, over a dozen individuals, from various areas of expertise and from multiple countries, played a role in helping Iran's program move forward.

Preventing a nuclear brain drain that might contribute to the spread of weapons-related expertise has been a focus of nonproliferation policy since the collapse of the Soviet Union raised fears that unemployed or impoverished Soviet nuclear scientists might be available for hire. The Iranian experience suggests that the concern about a nuclear brain drain was warranted and that policies to discourage the phenomenon may have been less successful than hoped. It is disturbing to think that there may exist a small but very damaging network of individuals who are prepared to assist potential proliferators in eluding the constraints of the NPT regime. If Iran was able to recruit so much foreign help, were others able to do the same?

Was such help only available two decades ago, or might it still be available today? Overall, this problem seems more serious in light of the Iran nuclear archive.

The archive confirms that, as was already known, Iran had an extensive effort to procure equipment and materials abroad for its program. Unfortunately, we did not have the opportunity to explore the procurement issues in detail. Israeli officials indicated that procurement operations in times more recent than those covered by the archive tended to be more sophisticated, with more layers of front operations to conceal the real purpose of the items being purchased. Also, given Iran's rapid technical progress and indigenization, it may now be prudent to assume that help such as Iran received from the A. Q. Khan network may no longer be central to Iran's future weapons potential.

One important procurement-related question is how Iran acquired the uranium metal casting and machining equipment it intended to install in the underground tunnel. The answer may exist in the archive, but we did not have a chance to explore this issue in our discussions. Could other states seeking nuclear weapons have acquired similar equipment at that time? Could they still do so today, or have the relevant gaps in controls been fixed since then?

One document from the archive contains an important and surprising revelation: it mentions a specific budget allocated for purchasing HEU abroad. As discussed in Appendix B, as far as we are aware, the portion of the archive the Israelis acquired does not include specifics on how Iran was hoping to do that. The fact that Iran's government was optimistic enough about the prospects to assign a budget for such a purchase highlights the potential proliferation dangers posed by either states or non-state actors willing to sell weapons-usable nuclear material.

5. Detection of Secret Facilities and Activities: The archive confirms that Iran engaged in a protracted covert effort to develop nuclear weapons whose full extent was undetected for an extended period.

By the time Iran's government decided to halt Project AMAD in 2003, it was well down the path to having the expertise, the technology, and the infrastructure (though not the fissile material) to manufacture nuclear weapons. While much was known and suspected of Iran's nuclear ambitions, the full extent of the effort remained hidden from view until discovered in the nuclear archive. The long controversy over Iran's nuclear activities, the various intelligence estimates, and the large pile of IAEA reports on Iran identified a wide range of Iranian nuclear efforts but failed to capture the full extent of Iran's progress.

In particular, Iran dug a large tunnel complex at Parchin for the purpose of casting and machining uranium metal components for nuclear weapons. Israeli officials conclude from the archive that the equipment for the complex had been purchased when the stop work order came but had not yet been installed. Israeli officials indicated that both Israel and the United States were aware of the existence of a tunnel, but had not identified it as nuclear-related. This means that important features of Iran's weapons-related efforts, including a major facility, remained undetected over a period of nearly two decades, despite the extraordinary attention that a number of national intelligence agencies devoted to monitoring Iran's nuclear program.

Similarly, it was previously known that the AMAD Plan was intended to have a separate source of uranium and conversion, with the Gchine mine and the green salt project. But the archive photographs and documents reveal that the AMAD Plan was also working on its own centrifuges (though as noted in Appendix B, these appear visually similar to a known type of Iranian centrifuge, so the degree of separation from other centrifuge programs is somewhat unclear, at least based on the limited information we received). As far as we are aware, it is not known where that centrifuge work took place, where those centrifuges now are, whether they were ever tested with UF₆ (which would be a safeguards violation), how many were

made, or generally how close to being ready for enriching kilogram quantities of fissile material they may have been.

These revelations are particularly surprising given that the U.S. government and some other governments believed they had in-depth intelligence on Iran's programs. The archive confirms that the U.S. understanding of Iran's program was not as complete as had previously been believed.

Much the same can be said of the IAEA's understanding of Iran's efforts. The IAEA's reports make clear that the IAEA was aware of the broad direction of Iran's nuclear interests and quite a number of specifics. Indeed, Tehran has paid a considerable price as a consequence of the wide international belief in its appetite for weapons. But the archive adds substantially to the information that had previously been available to the IAEA. Tehran appears to have been more successful in hiding activities than had been fully recognized.

Indeed, some of the binders in the archive focus specifically on Iran's relationship with the IAEA. These binders include large numbers of official communications between Iran and the agency. But Israeli officials report that they also include evidence that Iran had penetrated the IAEA, and on some occasions knew in advance what questions the agency would ask or what sites they would seek to visit. The archive reconfirms concerted Iranian government efforts to mislead or to conceal information from the Agency.

The fact that Iran succeeded in hiding major activities is problematic, as the nuclear Nonproliferation Treaty (NPT) system is built in part on the assumption that the combination of national intelligence activities and IAEA inspections can provide assurance that parties to the NPT are abiding by their obligations and ensure that the risk of detection will deter those tempted to engage in covert pursuits. When a regime rests heavily on the power of scrutiny, it has to be disturbing that significant elements of a weapons program can remain unnoticed for a protracted period of time, even when the state in question is operating under a cloud of suspicion and scrutiny. At the same time, the combination of national intelligence activities and IAEA efforts had successfully identified that Iran had a program

focused on development of nuclear weapons and had successfully uncovered nearly all of its efforts related to production of fissile material.

6. Next Steps: The material in the archive raises issues and reveals capabilities that will need to be addressed by the parties to the JCPOA and the IAEA and that will need to be considered in any future negotiation with Iran.

With the revelations of the Iran nuclear archive, one image of Tehran's nuclear program has been replaced by another, more worrisome specter. While we do not believe that this new picture leads inexorably to any single set of policy conclusions (whether about the utility of the JCPOA or the advisability of the use of force), it does reset the factual basis for further interactions with Iran about its nuclear program. In particular, if Iran has more capability to weaponize fissile material than was previously understood, the importance of maintaining limits on its ability to produce fissile material is even greater than it was before. As discussed in more detail in Appendix B, to the extent the IAEA is able to correlate the archive information with other data to draw independent judgments, it will need to follow up on any discoveries that bear on Iran's compliance with its safeguards agreement and the JCPOA and that have implications for the IAEA's assessment of Iran's nuclear program. In particular, Israeli officials told us—though we were not shown the evidence—that the archive reveals the presence of undeclared uranium in Iran. If so, that would likely be an additional violation of Iran's safeguards agreement.

Similarly, if there are further nuclear negotiations with Iran, they will need to be informed by the revelations of the nuclear archive. The facts the archive reveals about a program whose main lines of effort were closed down fifteen years ago should not be the only, nor necessarily the decisive, factor in nuclear relations with Iran, but they cannot be ignored.

Appendix A: Key Elements of a Nuclear Weaponization Program—What’s New in the Israeli Documents on Iran?

As noted earlier, our group did not have the ability to authenticate the documents in the archive. This table is based on the assumption that the documents and photographs we saw accurately reflect the nuclear weapons effort that was underway in Iran until 2003, parts of which continued after 2003. It is intended only as an overall summary of the key elements of a nuclear weapons program.

Element	What we thought we knew	What our archive briefing suggests
Strategic intent	Unknown; possibly just a nuclear weapons option, for later decision. Activities described as “development of a nuclear explosive device” (1), or “working under government direction to develop nuclear weapons.” (3)	High-level decision to manufacture nuclear weapons and carry out an underground nuclear test—until stop work order in 2003.
Overall progress	“[T]hese activities did not advance beyond feasibility and scientific studies, and the acquisition of certain relevant technical competences and capabilities.” (1)	Substantially greater progress—weapons design completed, preparations to manufacture underway.
Timing	Nuclear weapons program “halted” in fall 2003. (3) Weaponization was “a coordinated effort” prior to “the end of 2003”; some activities thereafter, but not as part of a coordinated effort; no “credible evidence” of activities “relevant to the development of a nuclear explosive device” after 2009. (1)	Confirms major activities stopped in late 2003. But reveals coordinated efforts to fill in technical gaps continued, divided into overt and covert portions. (No information on activities after the mid-2000s.)

Element	What we thought we knew	What our archive briefing suggests
Organization	PHRC, later AMAD Plan, both under Mohsen Fakrizadeh, were the lead organizations. Activities after 2003 were “not part of a coordinated effort.” (1) But note the organization diagram in (2) going more or less to 2011.	Some activities after 2003 were part of a coordinated effort. Current SPND organization headed by Fakrizadeh reportedly includes ~70% of the staff of the AMAD Plan.
Locations/Facilities	There were several particular locations where work took place, including a major explosives test chamber at Parchin.	Archive confirms information on key locations, plus a major underground tunnel at Parchin for uranium weapon component casting and machining (whose equipment was not installed when the stop work order came).
Foreign assistance	Help from the A.Q. Khan network; one expert from former Soviet nuclear weapons program assisted.	Well over a dozen foreign experts assisted. No evidence of state-level foreign support, however.
Procurement	There were many procurements both for fuel cycle and for weaponization activities. On weaponization, “the Agency does not have information regarding any such procurement attempts after 2007.” (1)	Similarly, information on a range of foreign procurement, but no data on later procurement attempts. One document mentions a budget allocation for purchase of HEU abroad.
Technical elements		
• Explosives development	Developed multi-point initiation technology, with simultaneous detonation (less than 1 microsec). Help from a “foreign expert” from the Soviet implosion design program (in Iran 1996-2001) (2)	Iran had completed the explosive design for its proposed nuclear weapon. Iran got much more foreign help than previously understood.
• Explosives testing	“one large-scale experiment in 2003” at a location called “Marivan”; also “small scale experiments” at various locations “in the early 2000s.” (1)	More extensive testing than previously understood.

Element	What we thought we knew	What our archive briefing suggests
<ul style="list-style-type: none"> • U metallurgy 	<p>Undeclared production of 126.4 kg U metal; 3kg metal recovered from waste; 50 kg U metal received from abroad (4)</p>	<p>Most major casting and machining experiments carried out with surrogate materials such as tungsten, for fear of creating detectable uranium contamination. Facility for production-scale uranium casting and machining under construction when the order to stop work came.</p>
<ul style="list-style-type: none"> • Uranium weapons component design, fabrication 	<p>Iran conducted “preparatory work, not involving the fabrication of nuclear material, for the fabrication of uranium components for a nuclear explosive device”; no evidence of activities directly tied to U metal document (1)</p> <p>Iran “manufactured simulated components for a nuclear explosive device from high density materials” (1)</p>	<p>Confirms these activities using surrogates such as tungsten. Design of uranium components completed. Facility for production-scale component production under construction when the order to stop work came.</p>
<ul style="list-style-type: none"> • High-speed detonators 	<p>Iran developed “exploding bridgewire detonators” in 2002-2003 (1); Iran claims these were for conventional weapon safety and oil + gas.</p>	<p>[Not addressed in our discussions.]</p>
<ul style="list-style-type: none"> • Neutron initiators 	<p>Produced Po-210 at the Tehran Research Reactor in 1989-1992 (4); some member state information indicates work on shock-driven neutron initiators, but no clear IAEA conclusion (1)</p>	<p>More extensive work and testing than previously known, including explosive tests of shock-driven uranium deuteride initiators.</p>
<ul style="list-style-type: none"> • Design of an actual device 	<p>Computer modeling of various implosion arrangements (before 2004, and in 2005-2009); manufactured simulated components for testing (1)</p>	<p>Had finalized and frozen design, building on designs acquired from abroad.</p>

Element	What we thought we knew	What our archive briefing suggests
• Fuzing, arming	The “alleged studies” documents indicate “development of a prototype firing system” that would enable the payload for Shahab-3 to be airburst or groundburst (1). Iran “considered” a “number of technical options” (1)	[Not addressed in our discussions.]
• Integration with the delivery system	The “alleged studies” documents describe “detailed project work” in 2002-2003 on “how to integrate a new spherical payload into” the Shahab-3 reentry vehicle. “Mock-up model parts” were made in “a number of workshops.” (1)	A separate project for integrating the explosive with the reentry vehicle.
• Cold or hydrodynamic testing	Alleged large cylinder for testing with up to 70 kg of explosives at Parchin, matching publications of the foreign expert (1,2)	Large cylinder for testing at Parchin confirmed in detail (many photographs); may have been used more for neutron detonator experiments than for cold tests of the full system; an additional chamber for explosive experiments monitored with flash X-rays.
• Nuclear testing	In 2002-2003, Iran “may have planned and undertaken preparatory experimentation relevant to testing a nuclear explosive device”—including “practical tests” to see if the exploding bridge wires would work with a long distance between the firing point and a test device deep in a shaft.	Iran was in process of choosing locations for a nuclear test and making technical preparations (though it did not yet have the fissile material needed to build a test device).

1. International Atomic Energy Agency, *Final Assessment on Past and Present Outstanding Issues Regarding Iran’s Nuclear Programme*, GOV/2015/68 (Vienna: IAEA, December 2, 2015).

2. International Atomic Energy Agency, *Implementation of the NPT Safeguards Agreement and Relevant Provisions of Security Council Resolutions*

in the Islamic Republic of Iran, GOV/2011/65, Annex C (Vienna: IAEA, November 8, 2011).

3. Office of the Director of National Intelligence, *National Intelligence Estimate: Iran: Nuclear Intentions and Capabilities* (Washington, D.C.: ODNI, November 2007)

4. International Atomic Energy Agency, *Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran*, GOV/2004/60 (Vienna: IAEA, September 1, 2004).

Appendix B: Mysteries of the Iran Nuclear Weaponization Archive

The archive of nuclear weapons-related documents Israel acquired from Iran reveals important new information about Iran's past nuclear weapons efforts. But it also leaves a number of mysteries unresolved. Here are a few of the open questions that struck our group as particularly important.

Why did Iran decide to manufacture nuclear weapons when it did?

The documents in the archive focus on Iran's technical program, not on the initial decision to carry it out. The decision appears to have occurred in the late 1990s, though if the archive contains the specific date, that was not shown to our group. This was a major and surprising decision—a decision to clearly violate Iran's NPT commitments, in a situation in which doing so might bring a harsh international response. Was the decision mainly a response to the perceived threat from Iraq? Iran's bitter war with Iraq had ended a decade before this decision, but the potential for another attack from Saddam Hussein's Iraq had not disappeared, and in the late 1990s inspections in Iraq were seen by some to be breaking down and the United States was loudly saying that Iraq was still pursuing nuclear, chemical,

and biological weapons. Or was the decision influenced mainly by fears of threats from the United States and Israel? Some years before, in 1991, the United States had shown that it could rapidly defeat the Iraqi military, which Iran had been unable to do over eight years of bitter war. Was the decision influenced by a belief that they could use a nuclear deterrent to free up their options for aggressive behavior in the region, as appears to have been Saddam Hussein's idea for his own program? Was it some of all of these? Or were other factors driving the decision?

The timing of the decision is also technically puzzling. Most states make a firm acquisition decision when they are “ready”—when the technical experts have developed the weapons technology and fissile material is either in hand or soon to be produced. Iran made a decision when the path to the bomb was still quite murky, as Iran did not have any operating centrifuges to produce nuclear material or any substantial progress in developing its understanding of weapons design and manufacturing. Why make a decision of this kind before the wherewithal was available to implement it? Why not wait and make the formal acquisition decision once the R&D effort had progressed further? One possibility has to do with foreign help. This decision occurred soon after Iran had received the second tranche of assistance from the A.Q. Khan network, which included more centrifuge help and the famous document with instructions on casting uranium metal weapons components.¹¹ That tranche may also have included the bomb design from the network found in the archive documents. Did this—and perhaps other indications of available assistance—give Iranian leaders confidence they could build the bomb that they would not otherwise have had?

What was Iran thinking about its ability to keep the effort secret?

Iran's government was clearly concerned about the possibility that this nuclear weapons program would be detected. This concern is evidenced by Iran's effort to establish a fully separate, unsafeguarded fuel cycle, outside the efforts of the Atomic Energy Organization of Iran, for the nuclear

¹¹ For an official discussion of this second tranche of assistance from the Khan network, confirmed by Iran, see International Atomic Energy Agency, “Implementation of the NPT Safeguards Agreement in the Islamic Republic of Iran,” GOV/2004/83 (Vienna: IAEA, November 15, 2004), par. 23.

weapons effort, and even more by Iran's decision to use tungsten rather than uranium for its extensive testing of casting and machining of potential weapons components, which was apparently intended to avoid having potentially detectable uranium contamination of facilities.

Yet at the same time, Iran's government seems to have believed that it could carry out a large-scale nuclear weapons development and production program without being found and stopped before it could be completed. What was their thinking about the risks of the program being detected? Did they think they were running a serious risk of suffering military strikes, or did they believe such strikes would not occur? And how did their thinking on this change as some aspects of the program were discovered in 2002 and subsequent years, and they realized that foreign intelligence services had penetrated their program?

What were the specific reasons for the partial stop work order in late 2003?

The archive documents reconfirm that Iran's government ordered that the large-scale elements of the program be stopped in late 2003, when the effort was preparing for manufacturing. Why was this stop work order given? Coming after the U.S.-led invasion of Iraq, with hundreds of thousands of U.S. troops next door, was the decision driven by fear that Iran would be in the U.S. crosshairs next if the program was discovered? If that was the fear, how did they choose between stopping the program and accelerating it to get a nuclear deterrent to such an attack as fast as possible? Did the lack of a rapid path to the production of nuclear material play a role in that choice? With the beginning of IAEA inspections of the previously secret facilities at Natanz and elsewhere in 2003, was Iran's leadership afraid the program would be discovered before it was completed if it was not stopped? The stop work order appears to have come at about the same time as the opening of talks about Iran's nuclear program with Britain, France, and Germany; was the decision influenced by a desire not to risk blocking the potential opening to the West via the Europeans? The decision also seems to have come at about the time that it became clear that participants in the A.Q. Khan network were giving secrets to the Americans—presum-

ably including some secrets about Iran's program. How much influence did that concern have? How did those wanting to put the brakes on the effort manage to reverse a nuclear weapons acquisition decision already made? What role did Ayatollah Khamenei himself play in this decision to stop the large-scale elements of the program?

How did Iran's strategic intent change over 2003-2019?

The archive makes clear that prior to the 2003 order, the Iranian government's strategic intent was to manufacture nuclear weapons and carry out an underground nuclear test. But what was their intent after that 2003 order, now almost 16 years ago? The documents in the archive say little on that subject and largely end after 2006. Beyond the 2003 order, was there still a unified government decision that Iran would eventually manufacture nuclear weapons? Or were there some who wanted to do that, others who preferred to keep a future option to do so while staying within the NPT for the time being, and no formal decision made on the topic? As discussed earlier, in 2003, there was a decision, worked out in a series of meetings confirmed in the archive documents, to continue some work to fill in technical gaps—some of it open, with civilian cover stories, and some of it covert. Was that decision made solely by technical experts or was it approved at the highest levels? What about the decision, at the time of the Joint Comprehensive Plan of Action, to collect and carefully compile and index the documents in the archive? The archive documents simply do not tell us what the Iranian government's strategic intent with respect to nuclear weapons has been for the last decade and more.

Why did they pick the numbers five nuclear weapons of 10 kilotons each as goals?

Some of the questions the archive leaves open are less strategic and more technical. Why these particular numbers, for example? Given the sophistication of their effort, these both seem quite modest in their ambition. With access to foreign nuclear weapon designs and well-thought-out

innovation from them (in the Israeli view), Iran should have been able to achieve much more than 10 kilotons if they chose (though those foreign designs and Iran's innovations came after the initial decision, so the initial decision may have been conservative). And once Iran was producing material and fabricating weapons, they could have made many more than five—particularly given the scale of the uranium casting and machining facility and enrichment facilities they were building. One possibility is that these goals were set because Iranian technical experts were confident that they could meet them, even if they ultimately had higher ambitions. Put another way, they might have been the minimum expectation for Project AMAD.

Why did the extensive penetration of Iran's program not reveal this information before?

The evidence strongly suggests that Iran's program was deeply penetrated by foreign intelligence agencies. The U.S. government and several other governments felt they had deep knowledge of Iran's program, from multiple sources. In that circumstance, why were the new elements revealed by the archive—the strategic decision to manufacture nuclear weapons, the greater technical progress in several areas than previously understood, the construction of a major underground facility for casting and machining uranium weapon components, the availability of more foreign help and foreign weapon designs than were previously understood—missed in previous assessments? Israeli officials indicated to us that neither Israel nor the United States had identified the tunnel built for casting and machining uranium as a nuclear-related facility. While that may be understandable given that the relevant equipment had not yet been installed, as noted earlier, it raises troubling questions about the international community's ability to have confidence in the absence of secret facilities elsewhere.

Where is Iran's uranium casting work?

As far as can be seen from the archive, Iran carried out extensive tests of casting and machining with tungsten as a surrogate for uranium, and then began building a substantial production-scale underground facility

for casting and machining uranium weapons components—but never did serious work with real casting and machining of uranium. It seems odd to move to building a large production facility without having done at least pilot-scale work with real uranium before that. Is there perhaps uranium casting work we still do not know about? Or did Iran believe that foreign expertise was sufficient to address any gaps it might have on uranium metallurgy?

How were they going to try to buy HEU?

Israeli officials report that the archive includes a document assigning a budget for the purchase of HEU abroad. How did Iranian experts envision trying to do that? Did they think they could buy HEU from a state? Did they think they could buy HEU from non-state actors with stolen material? One could imagine that Khan, having received HEU from China, might have suggested the idea of buying HEU abroad to Iran—or that Iran might have thought they could purchase HEU from Pakistan or from Khan and his cronies. Given the foreign help they were receiving not only from the Khan network but from nuclear weapons experts from elsewhere, might those people have offered potential pathways for getting stolen nuclear materials? Does the idea of purchasing HEU abroad help explain taking the decision to make nuclear weapons at a time when no immediate path to producing nuclear material was likely to be available? One element of the 2007 U.S. National Intelligence Estimate that was little-noticed at the time was a “low confidence” assessment that “Iran probably has imported at least some weapons-usable fissile material,” coupled with a “moderate-to-high confidence” judgment that Iran had “not obtained enough for a nuclear weapon.” Did Iran actually succeed in importing any HEU from abroad?

Where were the other centrifuges developed and tested, and how much progress did that effort make?

The archive documents describe the nuclear weapons effort having its own centrifuge effort, apparently separate from those under the control of the Atomic Energy Organization of Iran (AEOI). The archive includes a video of these AMAD Plan centrifuges. Visually, these centrifuges appear similar to the IR-2 centrifuges that Iran worked on (not the IR-2M).¹² This raises the question of how different these centrifuges were. If they were a completely separate design, was this an indigenous Iranian design, a foreign design, or a mixture of both? Where were these centrifuges being tested? Was it some previously unknown facility, or one that has already been inspected? Were they ever tested with UF₆? Were they ever joined together in cascades? (If they were tested with uranium at a previously undeclared location, that would be another safeguards violation.)

Why did they not declare one particular set of nuclear material?

Israeli officials reported to us that the documents indicate that there is undeclared nuclear material in Iran, though we were not shown the evidence. That would be a huge risk for Iran to take, since it would be a clear violation of their safeguards agreement and the JCPOA. Yet the Israelis did not seem to think it was especially important nuclear material, other than its legal implications (e.g., not weapons-usable material in any notable quantity). If it really is unimportant nuclear material, why run the risk of not declaring it? What is special about this nuclear material?

Israel has provided the IAEA with a complete copy of the material Israel acquired, after working out special arrangements to ensure that only personnel with appropriate clearances from states with nuclear weapons would have access to the portions of the archive containing nuclear weapons design information. Working out those arrangements took some time;

¹² For an image of the IR-2 centrifuges, see Project Alpha, "Iran's Centrifuges: A Field Guide" (London: King's College London, January 12, 2015).

it is our understanding that the IAEA did not have the full set of documents until months after they had received their first briefings from Israeli officials.

It is our understanding that the IAEA is in the process of reviewing the information carefully, including assessing what points can be corroborated from other sources. The IAEA needs to draw independent judgments, and cannot be seen to be simply a tool of Israeli (or U.S.) intelligence. U.S. government officials have indicated to us that they believe the IAEA is pursuing this information seriously and will not hesitate to take action wherever the information leads. As recently as February 2019, the IAEA reported that it had conducted complementary access measures under the Additional Protocol to “all of the sites and locations which it needed to visit.”¹³ As noted earlier, in April 2019, press reports indicated that the IAEA had visited the warehouse Israeli Prime Minister Netanyahu identified as having held equipment and material from Iran’s nuclear program, though after the building appears to have been largely emptied.¹⁴

While much of the archive involves activities not involving nuclear material subject to safeguards, the IAEA needs to understand Iran’s activities in these areas to fulfill its obligation to verify that all nuclear material in Iran is in peaceful use and subject to safeguards. Nevertheless, it is our understanding that some member states are arguing that the IAEA should not pursue investigations in these areas, arguing that the 2015 “final assessment” report closed the issue of the possible military dimensions of Iran’s program. A close reading of that report and the subsequent Board of Governors decision makes clear that this is not the case—that if new information becomes available that could raise questions about whether all nuclear material is under safeguards, the IAEA continues to have a right and an obligation to pursue it.

The IAEA has a variety of reasons for not wanting the full scope of its verification activities and plans to be public. Nevertheless, given the criticisms the IAEA has been receiving, it would help in building public confidence if

13 International Atomic Energy Agency, *Verification and Monitoring in the Islamic Republic of Iran in Light of United Nations Security Council Resolution 2231 (2015)*, GOV/2019/10 (Vienna: IAEA, February 22, 2019), par. 23.

14 Murphy, “U.N. Nuclear Watchdog Inspects.”

the IAEA released more information on how it is using the information in the archive, and whether that information, combined with other information, has yet led to visits or requests to Iran for clarification. In the public domain, mysteries remain. What pressures is the IAEA under? What strategies are they thinking of pursuing?



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