



Taleghan 2: Pre- and Post Strike Assessment

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Background

On October 25, 2024, Israel launched an attack on Iran that destroyed multiple buildings within the Parchin Military Complex. Three out of four attacked buildings were directly associated with solid rocket motor propellant mixing for ballistic missile production. However, one target stood out—a building used for nuclear weapons development purposes under Iran’s Amad Plan in the early 2000s. Named after the high explosive test chamber the building housed, it was labeled “Taleghan 2” in many documents in the Israeli captured Iran Nuclear Archive. Although available evidence supports that the high explosive chamber and associated flash x-ray were removed from the building during a multi-year Iranian sanitization of the site, which also included the co-located Taleghan 1 building, Israel indicated that Taleghan 2 had in the last few years a nuclear weapons connection. Moreover, after the strike, *Axios* reported that the site was “active” recently and contained nuclear weapons related equipment at the time of the strike. Subsequently, Israel’s Prime Minister Netanyahu stated about the strike: “It’s not a secret - it’s published. There is a certain element of their nuclear program that was damaged in this attack. But still the program itself, its ability to operate here, has not yet been thwarted.”



Figure 1. A before and after satellite image of Taleghan 2, which was destroyed during Israel’s strike on Iran on October 25.

Findings

- High resolution satellite imagery shows that the Taleghan 2 building was thoroughly destroyed in the strikes (see Figure 1).
- According to an Israeli government source, Taleghan 2 was attacked for multiple reasons, and sending a message was one of them.
- The Institute was able to confirm with a Western government that there is evidence that nuclear *weapons* related activities recently took place at Taleghan 2.
- The exact type of nuclear weapons related activities recently taking place at Taleghan 2 requires further clarification.
- Based on *Axios* reporting and the Institute's understanding, it appears likely that Taleghan 2 contained equipment to make high purity PETN plastic explosives. These explosives, which are moldable, were used during the Amad Plan in the channels of the shock wave generators, a type of multipoint initiation system used to detonate the main high explosive charge in a nuclear weapon.
- Whether the reported activities included making such plastic explosives, or one step further, using them to produce multi-point initiation systems, needs further clarification. Both activities have non-nuclear military applications, however, it is the context and intention that need to be taken into account to differentiate between actual non-nuclear military activities versus using a cover story. In the case of Iran, the facts at hand point to the latter, making the activities nuclear-related even if no nuclear material was being used.
- Commercial satellite imagery shows renewed activity at the Taleghan 2 site over the last few years.
- Post-strike imagery analysis does indicate that unidentified equipment was present inside Taleghan 2, and Iran evidently took steps to hide its cleanup activities from both overhead reconnaissance and nearby ground observation.
- Post-strike cleanup efforts conducted by Iran and visible in satellite imagery include rapidly covering the building remnants with a makeshift structure, separating debris piles and erecting visual security screens, all indicative of efforts to hide the removal of remnants of sensitive equipment from the ruins.
- It remains unclear if the strike damaged plastic explosive manufacturing equipment and/or finished explosives. They may in part be difficult to replace for Iran as the production of high purity PETN involves sensitive production and analytical equipment, best made by Western and allied suppliers and typically requiring export authorization for a destination like Iran. PETN, while otherwise easy to make, needs to be of very high purity to be used in a shock wave generator where detonation velocity needs to be controlled at the nanosecond level.
- The Taleghan 2 building also provided intrinsic value — the orientation of the long axis of the building backstopped into the hillside was advantageous for activities involving high explosives or projectile impact/shock physics studies.
- Based on Taleghan 2's use during the Amad Plan, additional equipment, including a high explosive test chamber and a flash x-ray were once inside the building, however, it is

judged as unlikely that this equipment remained inside the building following extensive, multi-year cleanup efforts at Parchin starting in 2011.

- If either of these materials or equipment remained inside the building, the attack would have dealt a serious blow to Iran's ability to peer deeply into a high explosive experiment, necessary for nuclear weapons development, as Iran is assessed to only have had one such flash x-ray and this type of diagnostic equipment is tightly controlled due to its military applications.
- To this day, Iran has not addressed the questions the IAEA raised about the Taleghan sites. With this recent strike, there are now new questions about Iran's ongoing work on nuclear weapons. The number of questions have also likely multiplied with the many new revelations in the nuclear archive concerning Taleghan 1 and 2's former nuclear weapons activities. It is long past time for the IAEA to reopen its discussions with Iran on this particular site.
- At the November 2024 IAEA Board of Governors meeting, the board passed a resolution requesting the IAEA to submit a comprehensive report on the "possible presence or use of undeclared nuclear material in connection with past and present outstanding issues regarding Iran's nuclear programme." The board did not define "comprehensive." Based on considering the sum of knowledge about Iran's undeclared nuclear materials and nuclear weapon-related activities, now including activities at Parchin, a comprehensive report should connect the IAEA's findings from before 2016, before implementation of the Joint Comprehensive Plan of Action, to those from 2018 onwards, after the revelation of the nuclear archive documents beyond the IAEA's findings about additional undeclared nuclear material or undeclared nuclear-related activities at four IAEA specified sites.

Visible Recent Activity at Taleghan 2

Commercial satellite imagery shows renewed activity at the Taleghan 2 site over the last few years. Following the extensive cleanup of Taleghan 1 and 2 in the period from 2011 to 2015 (see Annex, section, IAEA and Parchin) the site appeared abandoned for several years. However, in more recent imagery, there is a white vehicle parked next to the building on the south side or under the entrance cover from time to time (see Figure 2). Further, in recent years, new equipment or materials appeared along the south side of the building. One image taken on October 22, 2021, shows new unidentified equipment or materials stacked along the south side of the building that was not present in an earlier October 2021 image. Some of the equipment or materials newly added over the last few years remained outside of the building and were still visible in imagery taken shortly before the strike (see Figure 3).

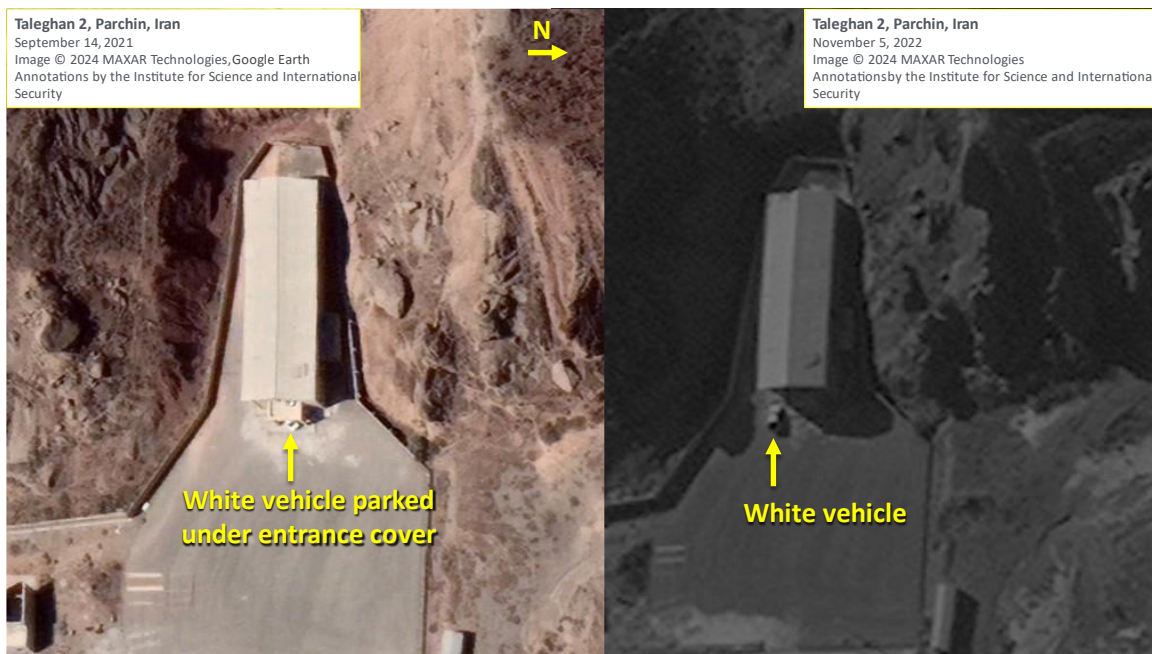


Figure 2. A white vehicle was present at Taleghan 2 from time to time, such as in these images taken September 2021 and November 2022.

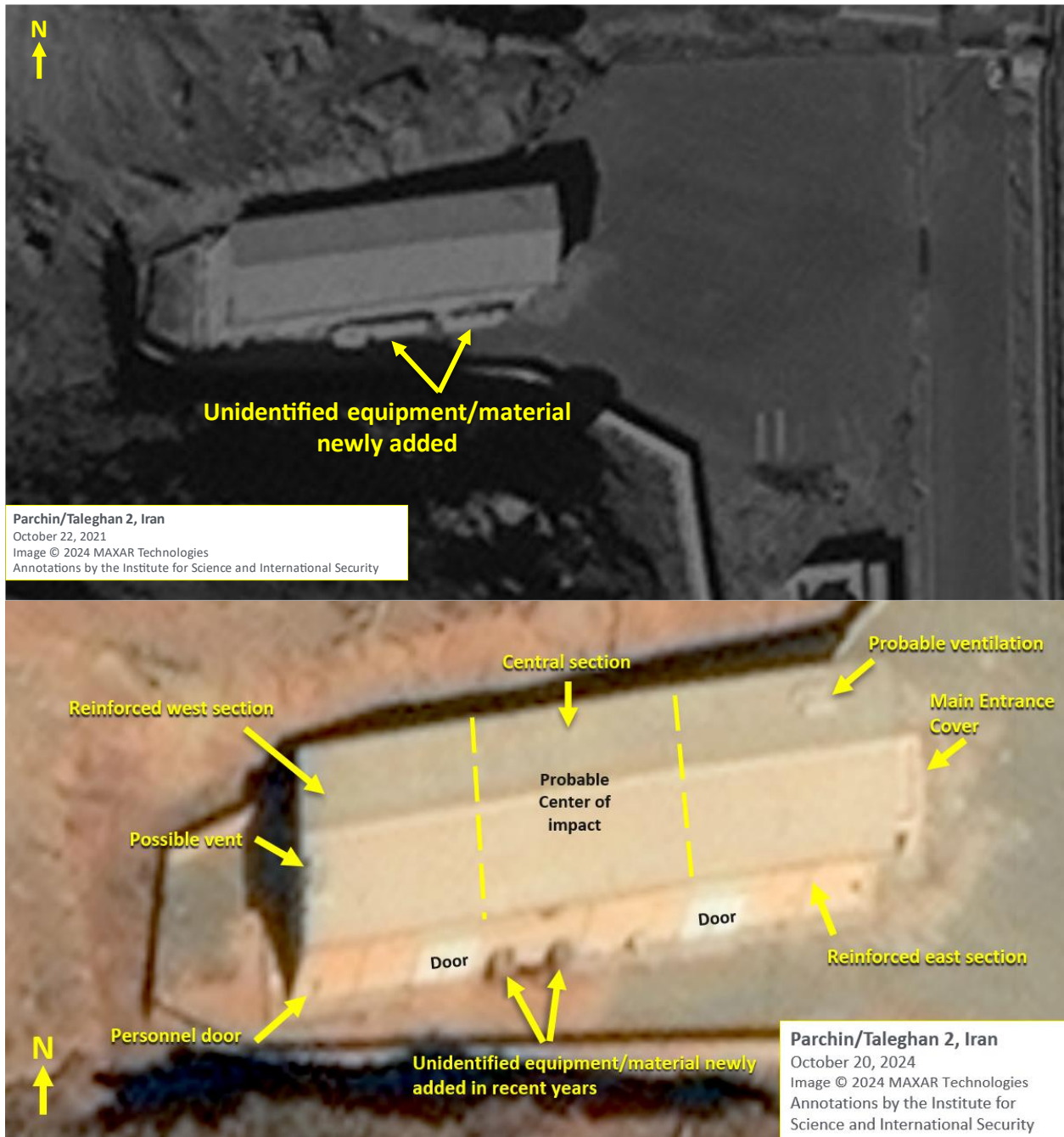


Figure 3. Unidentified equipment and materials appeared along the south side of the building in recent years, most notably in October 2021 (top image). A few days before the strike, unknown equipment or materials added in the past few years were still visibly present at the site (bottom image).

What was going on in Taleghan 2 when it was struck?

Israeli Prime Minister Netanyahu's public statement on the attack on Iran refers to "a certain component of their nuclear program" that was damaged, but does not provide any further details.¹ The Institute was able to confirm in parallel with a Western government that, according to its information, nuclear weapons-related activities recently took place at Taleghan 2.

Axios published two reports making two main points: 1) Research, or more likely development work, related to nuclear weapons development was carried out inside the building², and 2) Taleghan 2 stored equipment to make plastic explosives that had been used in the Amad plan.³

Axios linked the recent change in the U.S. intelligence community assessment about the Iranian nuclear program to activity in Taleghan 2 in the months before the attack.⁴ While not specifically referring to Taleghan 2 or any particular site, the U.S. Director of National Intelligence (DNI) changed the intelligence community's assessment about the Iranian nuclear program, stating that Iran has "undertaken activities that better position it to produce a nuclear device, if it chooses to do so."^{5,6}

Based on *Axios* reporting and the Institute's understanding, it appears likely that Taleghan 2 held equipment for making PETN plastic explosives for the shock wave generator, a multipoint initiator used to set off the main charge of a nuclear weapon. Of note, these explosives do not surround the core as *Axios* stated; the main charge is composed of Octol. Plastic explosives can be molded easily; an ideal choice for insertion into the channels of the shock wave generator.⁷

¹ Israeli Prime Minister's Office, "Prime Minister Netanyahu's remarks in the Knesset plenum as part of the 40 signatures debate" [Google Translation], Full Transcript, November 18, 2024, <https://www.gov.il/he/pages/event-40-181124>.

² Barak Ravid, "Scoop: Israel destroyed active nuclear weapons research facility in Iran, officials say," *Axios*, November 15, 2024, <https://www.axios.com/2024/11/15/iran-israel-destroyed-active-nuclear-weapons-research-facility>.

³ Barak Ravid, "Israel destroyed equipment Iran would need to develop nuclear weapon, officials say," *Axios*, November 15, 2024, <https://www.axios.com/2024/11/15/iran-nuclear-equipment-destroyed-israel>.

⁴ "Scoop: Israel destroyed active nuclear weapons research facility in Iran, officials say."

⁵ Office of the Director of National Intelligence, "Iran's Nuclear Weapons Capability and Terrorism Monitoring Act of 2022," July 23, 2024, <https://www.dni.gov/files/ODNI/documents/assessments/ODNI-Unclassified-Irans-Nuclear-Weapons-Capability-and-Terrorism-Monitoring-Act-of-2022-202407.pdf>.

⁶ The Institute also recently published about renewed activity at two additional former Amad Plan sites, Sanjarian and Golab Dareh, conducted by experts in the Organization of Defensive Innovation and Research (aka SPND or SEPAND) who participated in weaponization work in the Amad Plan. See, David Albright, Spencer Faragasso, and the Good ISIS Team, "Renewed Activity at the Sanjarian and Golab Dareh Amad Sites," *Institute for Science and International Security*, September 12, 2024, <https://isis-online.org/isis-reports/detail/renewed-activity-at-the-sanjarian-and-golab-dareh-amad-sites/>.

⁷ For more on Iran's shock wave generator, see David Albright and Olli Heinonen, "Shock Wave Generator for Iran's Nuclear Weapons Program: More than a Feasibility Study," May 7, 2019, *Institute for Science and International Security*, <https://isis-online.org/isis-reports/detail/shock-wave-generator-for-irans-nuclear-weapons-program-more-than-a-feasibil>; David Albright with Sarah Burkhard and the Good ISIS Team, *Iran's Perilous Pursuit of Nuclear Weapons* (Washington, D.C.: Institute for Science and International Security Press, 2021).

Whether the reported recent activities included the usage of such production equipment and actual production of plastic explosives remains unclear. Going one step further, the activities could have included production of multi-point initiation systems. Either activity could be conceived as non-nuclear military activities, but in these cases, context and intention make the crucial difference between actual non-nuclear military activities or their use as a cover story for nuclear weapons development purposes. In the case of Iran, the facts at hand point to the latter, making the activities nuclear-related even if no nuclear material was being used.

Plastic explosives, i.e. plasticized pentaerythritol tetranitrate (or PETN), are easy to make, and have many civilian and non-nuclear military applications. However, PETN degrades over time and has a limited shelf life; manufacturers commonly cite five years for their products.⁸ Further, for nuclear weapons purposes, the PETN needs to be of high purity in order to control the pressure and detonation velocity achieved at a high level, i.e. nanoseconds. This is complicated by the fact that during the production of PETN in solution, homologs of PETN are created with different molecular weight and structure.⁹ The fraction of homologs can be reduced by using high purity reagents, but those are hard to get. Additionally, during the crystallization process of PETN, two different crystal structures with different densities form, where detonation velocity is directly proportional to density.¹⁰

All in all, to make PETN of high purity for reliable use in a multi-point initiation system, Iran would need very good purification techniques and high precision analytical equipment, including spectrometers and chromatography. This type of equipment is best made by Western and allied suppliers, and would likely require Iran's widely sanctioned military apparatus to employ an elaborate scheme to acquire it illicitly.

After the October 2024 strike, in a November 20th press conference, IAEA Director General Grossi was asked about Taleghan 2. He dodged the question slightly, stating, "we don't have any information that nuclear material was present [...] including in the past."¹¹ However, Netanyahu and *Axios* did not state the site contained nuclear material; rather, nuclear weapons-related work took place. The distinction is important. As such, Grossi's reaction should be interpreted as clarifying that it was not a nuclear site where safeguarded nuclear material or suspected undeclared nuclear material was present.

This fact alone does not exclude the site from being of interest to the IAEA. The likelihood of equipment used in nuclear weapons-related work should attract IAEA attention. Moreover, if such equipment stemmed from the Amad Plan, it would be linked to the IAEA's current

⁸ See for example, "PETN," Austin Powder, https://www.austinpowder.com/wp-content/uploads/2021/08/PIB-C-APA-047-PETN.En_.pdf.

⁹ Jacob Sandoval and W. T. Quinlin, *PETN Homologs*, U.S. Atomic Energy Commission, Albuquerque Operations Office, February 1972, <https://www.osti.gov/servlets/purl/563855>.

¹⁰ "LASL Explosive Property Data," Los Alamos Series on Dynamic Material Properties, <https://sgp.fas.org/othergov/doe/lanl/lib-www/books/epro.pdf>.

¹¹ Press Conference with IAEA Director General Rafael Mariano Grossi, November 20, 2024, <https://www.youtube.com/watch?v=Lu8lpbW-K3M>.

investigation into undeclared nuclear material and related activities from Iran’s Amad nuclear weapons program, such as Lavisan-Shian, and its investigation into the current whereabouts of Amad equipment, which inevitably leads to additional sites.

Complicating matters slightly, Grossi acknowledged activities previously under investigation at the co-located Taleghan 1 building, but omitted that Iran never fully answered the IAEA’s questions about the site and that uranium particles were detected in environmental sampling taken at Taleghan 1 in 2015 (see Annex, IAEA and Parchin).

A positive development is that shortly after the press conference, at the IAEA Board of Governors meeting, the Board passed a resolution requesting the IAEA to produce “a comprehensive and updated assessment on the possible presence or use of undeclared nuclear material in connection with past and present outstanding issues regarding Iran’s nuclear programme, including a full account of Iran’s cooperation with the IAEA on these issues, addressing the Agency’s ability to verify Iran’s implementation of its safeguards obligations including the non-diversion of nuclear material, based on all information available, for consideration by the March 2025 Board of Governors or at the latest by spring 2025.”¹² The IAEA should address this mandate holistically. Its report should connect the IAEA’s findings from before 2016, before implementation of the Joint Comprehensive Plan of Action, to those from 2018 onwards, after the revelation of the nuclear archive documents beyond the IAEA’s findings about additional undeclared nuclear material or undeclared nuclear-related activities at the four IAEA previously specified sites.

Visible Post-Strike Damage

Figure 1 shows a comparison of Taleghan 2 before the strike, in June 2024, and after the strike, on October 27, 2024. The October 27 image shows the building thoroughly destroyed. In the remnants, three separate sections can be discerned, with the center section being the apparent point of detonation (see Figure 4). The building is situated in a carved out hillside, and thus ideal for testing involving high explosives. The westernmost section was where the Taleghan 2 explosive test chamber had originally been located, based on the Amad nuclear archive documentation (see Figure A2 in Annex). It is not possible to discern specific equipment within the visible remnants on the available imagery, but pre-strike imagery shows that unidentified equipment and material, newly added in the past few years, was present (see Figure 3 above).

¹² NPT Safeguards Agreement with the Islamic Republic of Iran, Resolution adopted on 21 November 2024 during the 1746th session, GOV/2024/68, November 21, 2024, <https://www.iaea.org/sites/default/files/24/11/gov2024-68.pdf>.

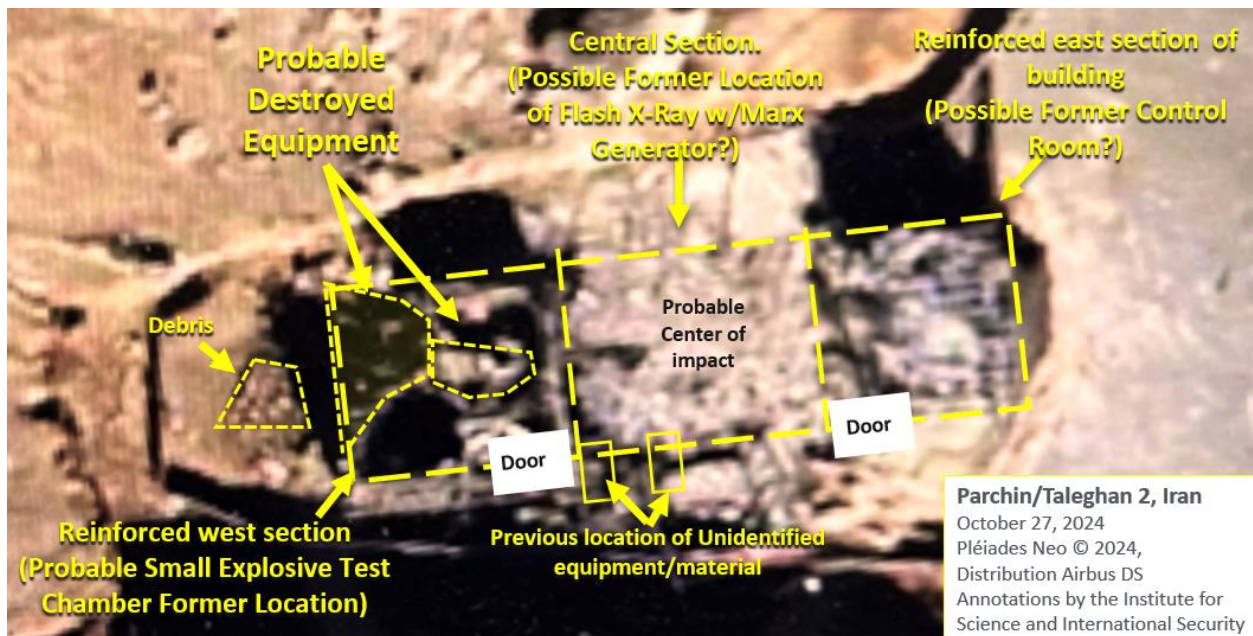


Figure 4. A high resolution Airbus image appears to show some destroyed equipment (as yet unidentified) within the remnants.

Visible Post-Strike Cleanup Activity

Satellite imagery taken days after the attack shows a rapid cleanup operation underway at Taleghan 2. Within ten days after the attack, Iran covered the demolished building with a makeshift structure and erected visual security screens to shield the immediate area from outside ground observation (see Figure 5). These efforts are consistent with an Iranian effort to remove sensitive equipment remnants without being observed by outsiders, be it via overhead imagery or ground observations.

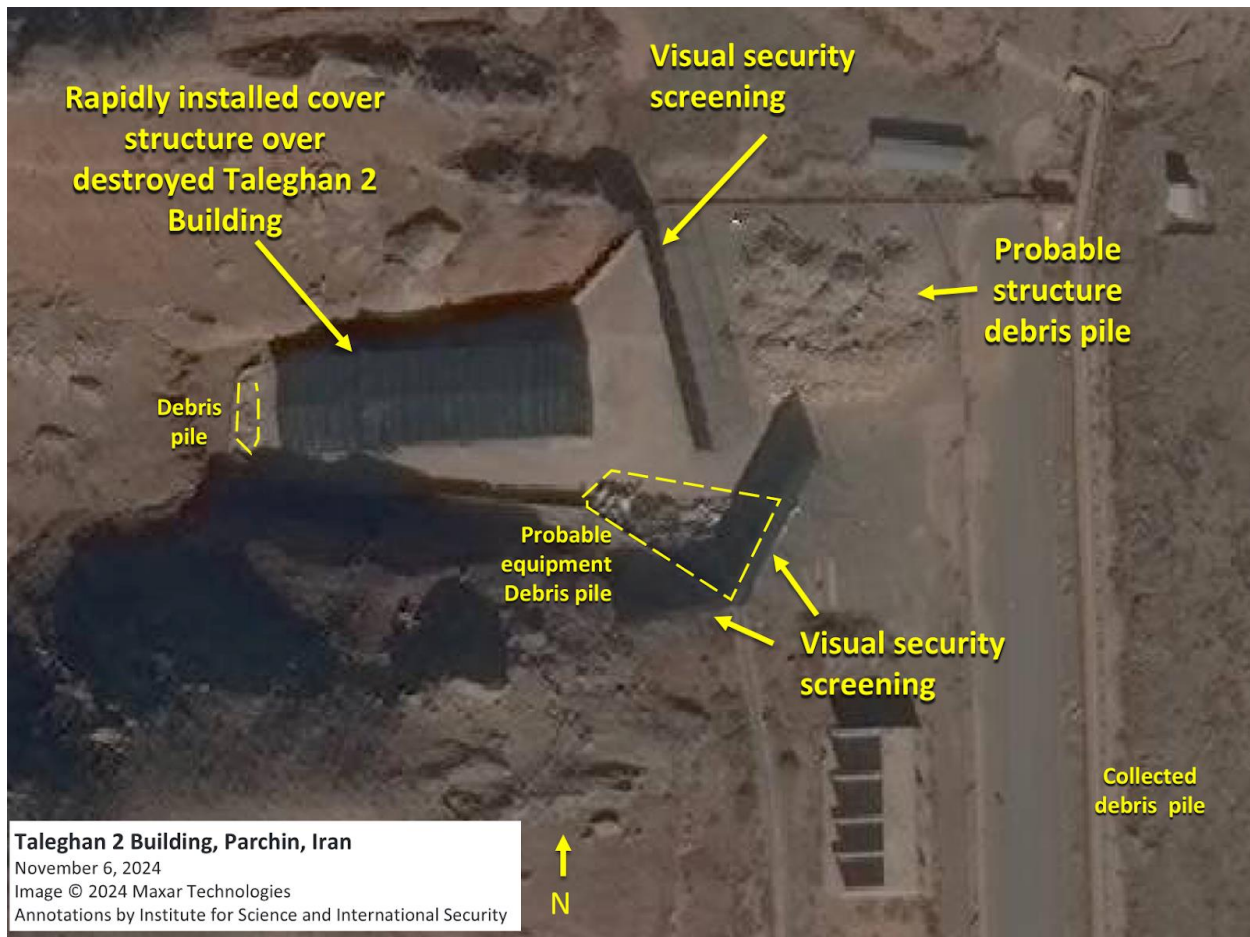


Figure 5. Clean up activities at Taleghan 2 involve a cover structure over the demolished building, debris separation, and visual security screening.

Interestingly, the solid visual security screening supported by wire frames shields the demolished building and the possibly sensitive equipment debris pile from being viewed by anyone passing by, or involved in cleanup activities outside the immediate area (overhead observation excluded, but that is limited to the top layer of the pile and the available public imagery is not of sufficient resolution to pick out details).

The November 6 image is the only high resolution image with the visual security screens present. The schematics in Figure 6 show more clearly what is difficult to see from the overhead perspective, but which can be derived from faintly visible shadows.

More recent Maxar satellite imagery dated November 24, 2024, shows the visual security screening removed. The makeshift structure over the demolished building and the debris piles remain (see Figure 7).

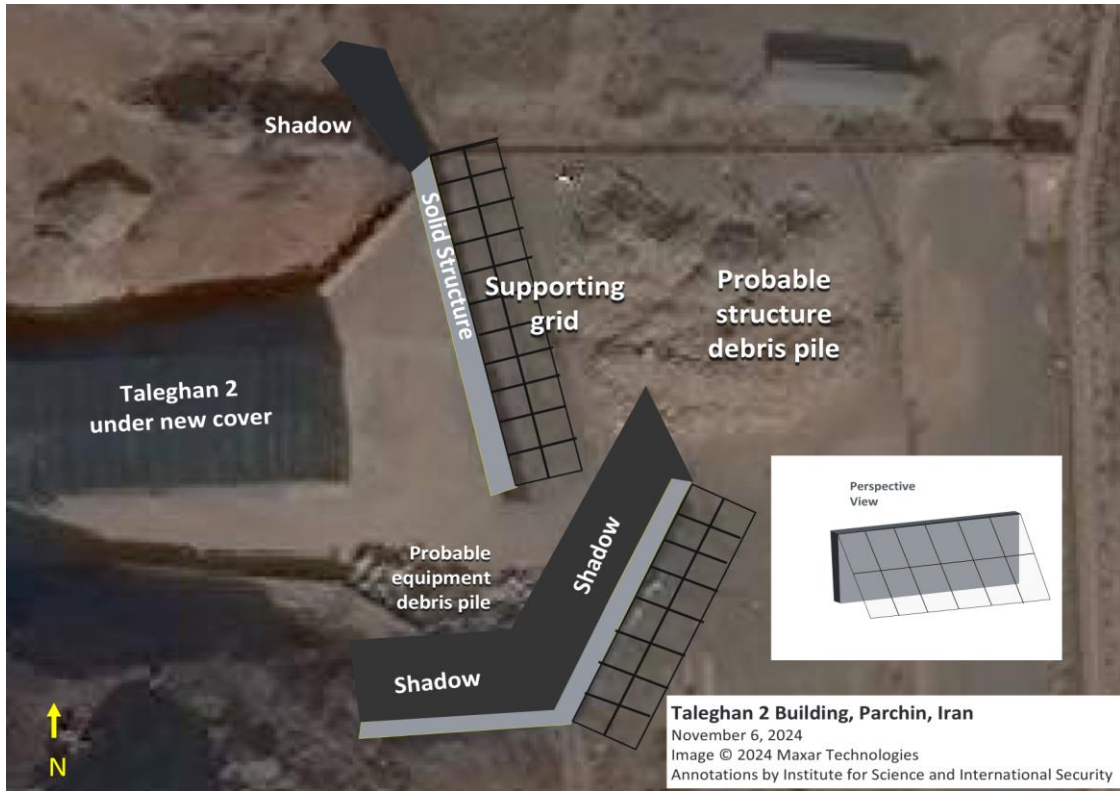


Figure 6. A clear labeling and schematic of the visual security screening to show it blocks outside views.



Figure 7. Later in November, the demolished building remains covered, but the visual security screening is removed.

Last Word

It is not possible to answer definitively what exactly was going on inside Taleghan 2 or how extensively Iran's current nuclear weapons capabilities were damaged.

To this day, Iran has not addressed the questions the IAEA raised about the Taleghan sites. With this recent strike, there are now new questions about Iran's ongoing work on nuclear weapons. The number of questions have also likely multiplied with the many new revelations in the nuclear archive concerning Taleghan 1 and 2's former nuclear weapons activities. It is long past time for the IAEA to reopen its discussions with Iran on this particular site.

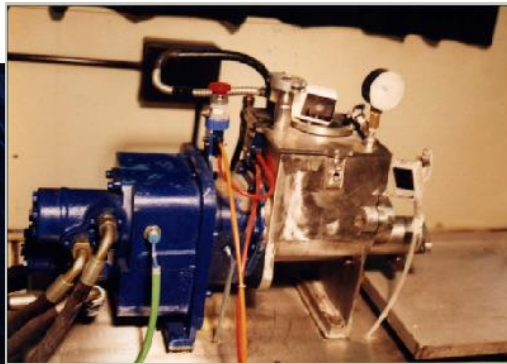
Annex

Plastic Explosive Manufacturing under the Amad Plan¹³

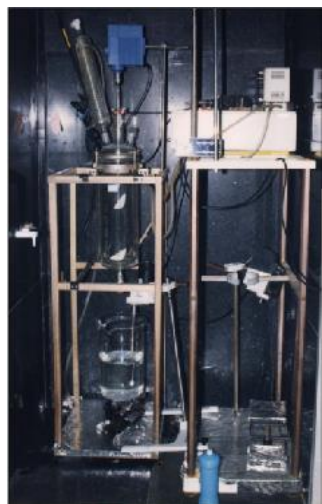
In the Amad Plan, plasticized pentaerythritol tetranitrate (or PETN) for use in the shock wave generator channels was not made at Taleghan 2, but at the Sanjarian site. Figure A1 includes six pictures from the nuclear archive, showing some of the equipment and plasticized products that were at Sanjarian and thus may have been in Taleghan 2 when it was destroyed.

They show PETN powder, manufacturing equipment, and the final sheets of plasticized PETN in storage. The sheets are then cut and inserted into the channels of the shock wave generator. The explosive selected by Iran was PETN because, once mixed with a plasticizer, in this case polyisobutylene or PIB, it is easy to mold.

¹³ See: "Shock Wave Generator for Iran's Nuclear Weapons Program: More than a Feasibility Study."



PETN powder image from the archive (left). Mixer image from the archive (right).



Recrystallization reactor image from the archive (left). Extruder image from the archive (right).



Hydraulic roller image from the archive (left). Plasticized PETN sheet storage, image from the archive (right).

Figure A1. Nuclear archive pictures of plastic explosive manufacturing and product storage during the AMAD plan at Sanjarian. The equipment and/or finished explosives may have been moved to Taleghan 2.

Taleghan 2 During the AMAD Plan

During the Amad Plan, Taleghan 2 was used for nuclear weapons development purposes. It originally contained a specially built high explosive chamber and a flash x-ray able to peer deeply into a high explosive experiment (see Figure A2). Iran reportedly conducted an important nuclear weapons test in Taleghan 2 in 2003 involving a scaled-down version of the multipoint initiation system that Iran called the shock wave generator. It was designed to fit in the outer volume of the nuclear weapon and uniformly set off the main high explosive charge. In photos from the nuclear archive, a sphere about eight centimeters in diameter, with the channels of shock wave generator visible on its outer surface can be seen next to the chamber and flash x-ray. The shock wave generator is one of the most important nuclear weapons components in Iran's nuclear weapon design and the Iran Nuclear Archive contains much discussion of its production and testing.

The shock wave generator is designed so that a detonation front initiated at one point via an exploding bridgewire is made to arrive simultaneously at a multitude of points on the surface of the main high explosive charge of the nuclear weapon. The assembled Iranian system consists of two hemispherical shells and requires only two detonation points.

Tests of the full, albeit miniaturized, shock wave generator would have allowed for the evaluation of its performance and the compression of the core. This experiment would have been conducted toward the end of the program to build nuclear weapons. Its results would be very useful to Iran today if it builds nuclear weapons.¹⁴

Figure A3 shows Taleghan 2 in 2004. It is next to Taleghan 1, a building containing another, larger high explosive test chamber, used for hydrodynamic experiments involving high explosives and in the development of a neutron initiator, according to nuclear archive documents.

¹⁴ See also, *Iran's Perilous Pursuit of Nuclear Weapons*.

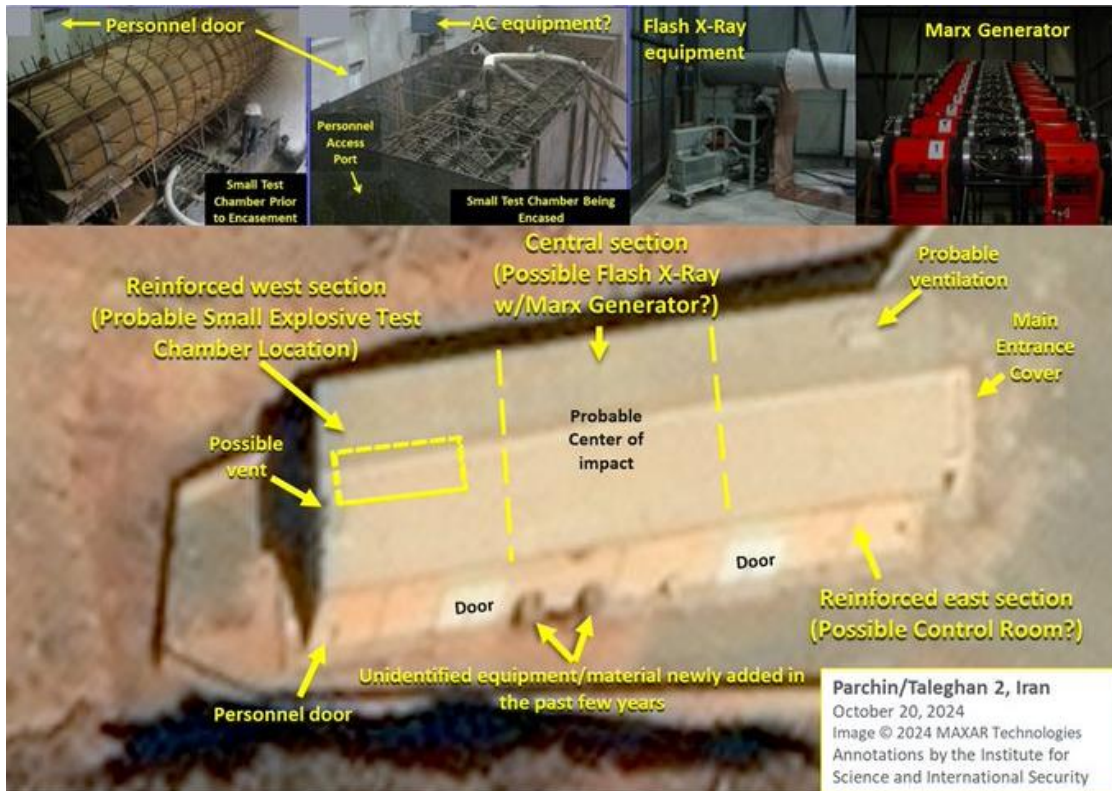


Figure A2. Equipment once present at Taleghan 2. Nuclear archive pictures at the top, annotations by the Institute.



Figure A3. Taleghan 1 and 2 in 2004.

The IAEA and Parchin

Substantial cleanup efforts occurred at Taleghan 1 and 2 starting in 2011, when the International Atomic Energy Agency indicated interest in visiting the site, specifically in the context of investigating Iran's use of high explosive test chambers and high speed diagnostic equipment, including neutron detectors and flash x-rays, for nuclear weapons development purposes. It is thus judged as unlikely that the high explosive chamber and the flash x-ray, remained at Taleghan 2 following Iran's sanitization efforts (see Figures A4 and A5)

The IAEA ultimately conducted a limited visit at the site in 2015, visiting Taleghan 1 and finding it empty. Still, the IAEA detected some uranium particles in samples taken (where the sampling was actually conducted by Iranian technicians outside of normal IAEA environmental sampling protocols). The IAEA stated: "The results identified two particles that appear to be chemically man-modified particles of natural uranium. This small number of particles with such elemental composition and morphology is not sufficient to indicate a connection with the use of nuclear material."¹⁵

This report did not mention any requests to revisit Taleghan 1 or to take more samples. In fact, the IAEA has not discussed Taleghan 1 in a public report since December 2015. Nonetheless, the IAEA concluded that Iran's explanation of the purpose of Taleghan 1 was inadequate and its "extensive activities undertaken since February 2012 at the particular location of interest to the Agency seriously undermined the Agency's ability to conduct effective verification."¹⁶

¹⁵ Director General, *Final Assessment on Past and Present Outstanding Issues regarding Iran's Nuclear Programme*, International Atomic Energy Agency, GOV/2015/68, December 2, 2015, <https://www.iaea.org/sites/default/files/documents/gov-2015-68.pdf>.

¹⁶ *Final Assessment on Past and Present Outstanding Issues regarding Iran's Nuclear Programme*, International Atomic Energy Agency, GOV/2015/68.

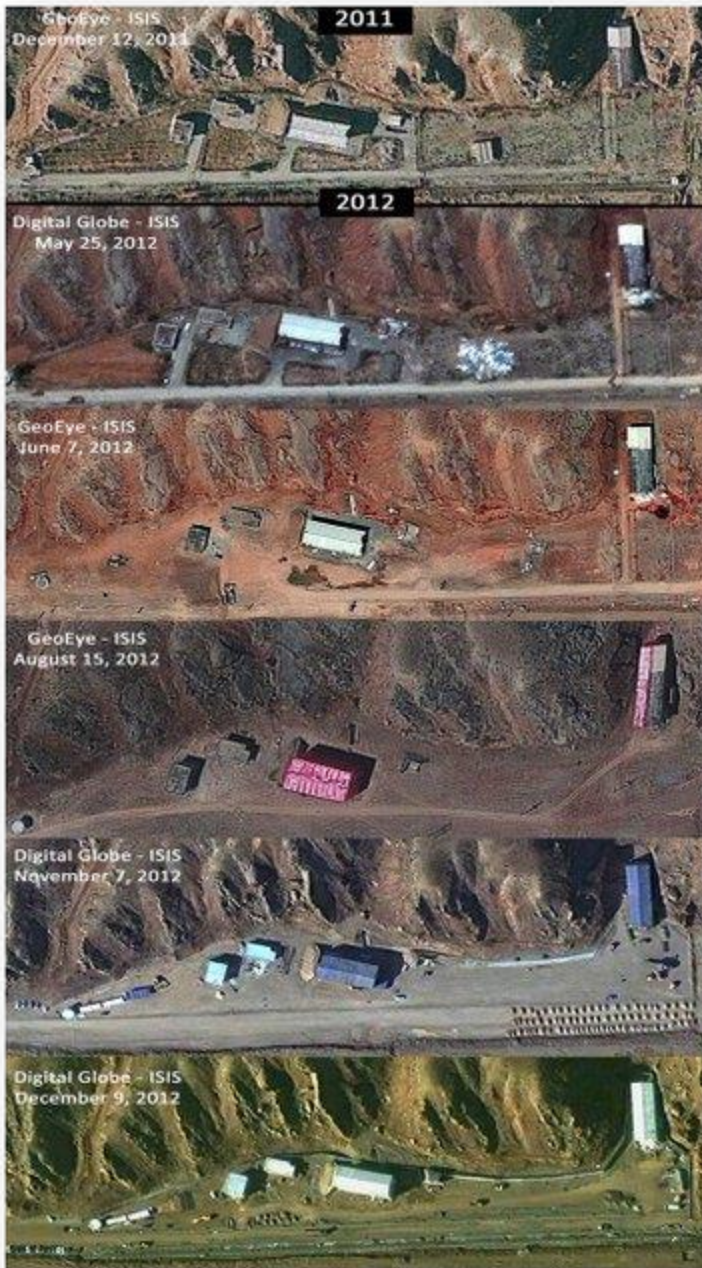


Figure A4. GeoEye/Digital Globe high resolution satellite imagery showing changes at Taleghan 1 and 2 at the Parchin military complex between December 2011 and December 2012.



Figure A5. Digital Globe high resolution satellite imagery showing changes at Taleghan 1 and 2 between January 2013 and November 2013.