VISUAL by Andrea Stricker and FDD's Visual Intelligence Team

WHAT STEPS MUST IRAN TAKE TO CONSTRUCT NUCLEAR WEAPONS?

Based on the original research and status assessments of David Albright, President, Institute for Science and International Security, and Olli Heinonen, Distinguished Fellow, Stimson Center, and former director of safeguards at the International Atomic Energy Agency (IAEA).

The Islamic Republic of Iran may require just six months to produce a crude nuclear explosive device.

Tehran would need only a matter of days to enrich enough weapons-grade uranium (WGU) for a first device.

Iran's remaining challenge is "weaponization" — building a functional bomb.

For years, the U.S. intelligence community asserted in its annual threat assessments that Tehran was not pursuing weaponization.

That assertion disappeared from the intelligence community's July 2024 assessment, coinciding with reports that the U.S. and Israeli intelligence communities observed potential weaponization activities in Iran.

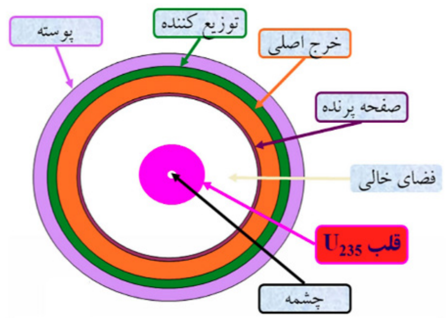
Iran's original nuclear weapons program, spanning the late 1990s to mid-2003, was known as the Amad Plan.

Under growing international scrutiny, Tehran dispersed key weaponization activities to both military and civilian sites, so progress could continue after the Amad Plan ended.

The Israeli Mossad found extensive documentation of Amad Plan weaponization activities, including a nuclear weapon design, among the documents its seized from Tehran's secret nuclear archive in 2018.

By 2002, the regime estimated its weaponization effort, "Project 110," was 40 percent complete.

Iran has likely made additional progress since. For example, it may have produced a more advanced weapon design.

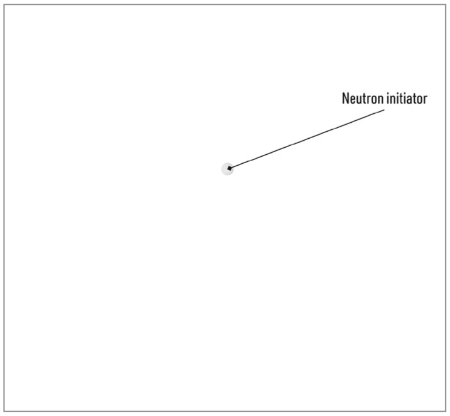


FROM THE BOTTOM, AND PROCEEDING COUNTERCLOCKWISE, THE FARSI TERMS ARE:

- NEUTRON SOURCE
- URANIUM 235 CORE
- AIR GAP
- FLYER PLATE
- MAIN CHARGE
- "DETONATION DISTRIBUTOR" OR SHOCK WAVE GENERATOR, AND
- OUTER CASING

Iran's nuclear explosive device consisted of seven layers, one inside the other, much like an onion.

Let's look more closely at each layer, how close Iran estimated it was to completion in 2002, and how close it may be to completion today.



LAYER 01: NEUTRON INITIATOR

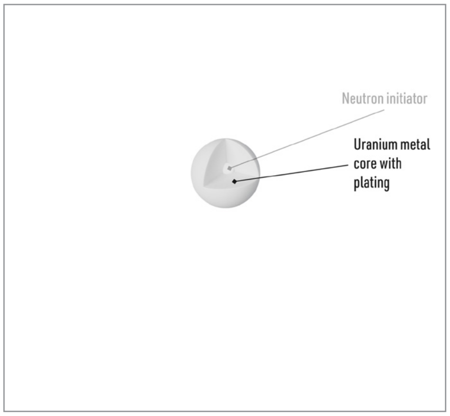
The inner-most layer is the neutron initiator containing a uranium deuteride (UD3) source.

Iran must first produce uranium metal chips from a piece of solid uranium metal and combine the chips with deuterium gas to make UD3.

During detonation of a nuclear weapon, the solid uranium metal core and UD3 source are compressed with high explosives to create a spurt of neutrons that starts a chain reaction.

Early 2002: 33% Completed

Current Status: Likely Ready



LAYER 02: URANIUM METAL CORE

Moving outwards, the next layer is the uranium metal core.

This solid WGU metal alloy sphere, comprised of two hemispheres, surrounds the neutron initiator, containing a hole at the center for the latter.

While Iran previously lacked the means to make WGU during the Amad Plan, due to delays in building a secret enrichment plant (now known as Fordow), it currently has enough enriched uranium to make WGU for up to 16 nuclear weapons within five months.

Iran's design required less than 25 kilograms of WGU, uranium enriched to more than 90 percent purity.

The WGU is produced in an enrichment plant in the form of hexafluoride (WGUF6).

It must be converted into the powder WGU tetrafluoride (UF4), and then converted into WGU metal alloy.

Tehran must melt the WGU in a furnace and pour it into a mold. Afterwards, it must machine and finish the two WGU metal hemispheres. It also must prepare other uranium metal components.

The resulting uranium metal core is plated to prevent oxidation.

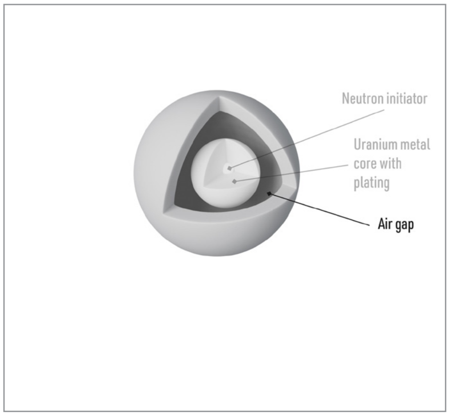
During the Amad Plan, Iran obtained key information about alloying uranium metal from a foreign source. In 2003, the IAEA found Tehran had produced some 200 kilograms of uranium metal.

It has also indicated its ability to make both natural uranium metal and near-20 percent enriched uranium metal at IAEA-safeguarded uranium metal production lines at the Esfahan nuclear center, producing small quantities during several months in 2021.

Photos from Iran's nuclear archive also show the regime practicing production of uranium metal using surrogate material. At the end of the Amad Plan, Iran was preparing to start working with uranium metal at its secret Amad sites as the last major step in preparing for later making nuclear cores of WGU.

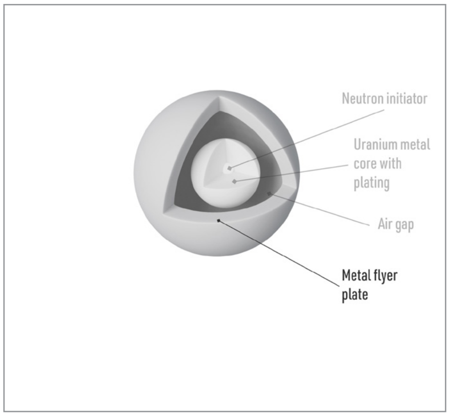
Early 2002: 51% Completed

Current Status: Can likely be done in weeks



LAYER 03: AIR GAP

The third layer is an air gap, which separates the core from an outer shell of high explosives. When initiated, the outer explosives create additional compression on the core to increase the weapon's explosive yield.

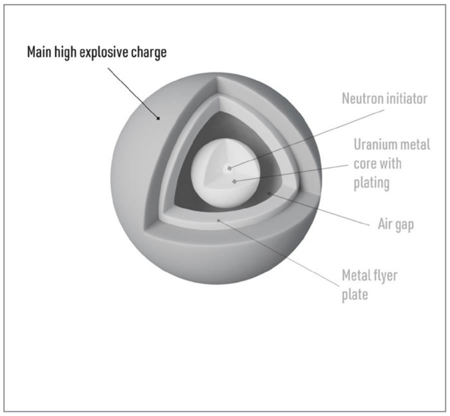


LAYER 04: METAL FLYER PLATE

Surrounding the air gap, core, and initiator is the fourth layer, a metal flyer plate composed of two symmetrical metal hemispheres, which also act to increase compression on the core.

The nuclear archive contained simulations and photos of Iran's model device showing these steps, with the outer metal flyer plate seen and likely a mock core on the inside.

Current Status: Ready



LAYER 05: EXPLOSIVE CHARGE

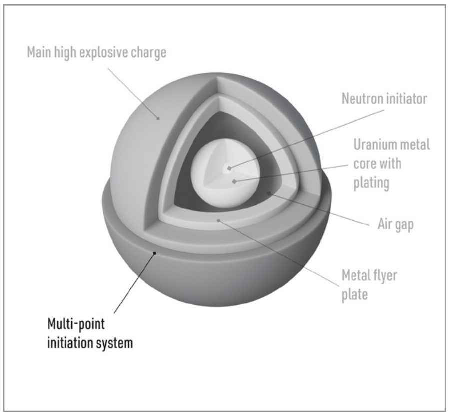
Layer five is the main high explosive charge, machined into hemispheric shells.

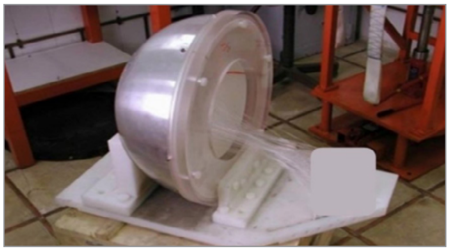
Iran's design required a high-quality explosive, machined into hemispherical shells around the flyer plate, air gap, core, and neutron initiator.

Tehran previously sought an explosive called Octol, composed of HMX and TNT, for its nuclear weapon design.

A photo from the nuclear archive shows an Iranian technician next to a high explosive casting mold.

Current Status: Ready





LAYER 06: MULTI-POINT INITIATION SYSTEM

Layer six is the multipoint initiation system (MPI), also known as a shock wave generator. This component causes an initial explosion that uniformly detonates the main high explosive charge in layer five. This, in turn, initiates nuclear fission in the uranium metal core.

Iran's MPI required two metallic hemispheric shells containing a network of explosive-filled channels, which lay right outside the main high explosive charge. Iran dubbed this sophisticated MPI a shock wave generator, a type of device that others have called a detonation distributor. The design and testing of the shock wave generator depended on a former Soviet nuclear weapons expert.

An advantage of this design is that it is detonated at only two points — one per hemisphere — by a trigger or detonator, called an exploding bridgewire (EBW). After firing the EBWs, the shock wave generator uniformly initiates pentaerythritol tetranitrate (PETN) high explosives in a network of channels.

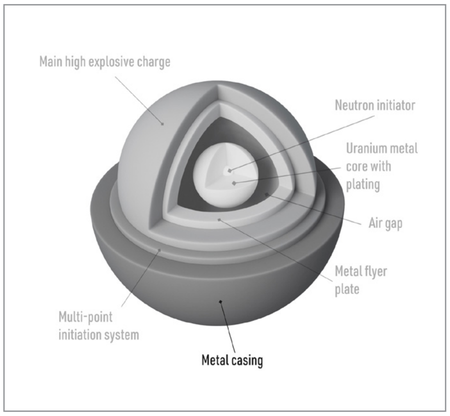
This uniformly detonates the inner main high explosive charge and creates a shock wave that compresses the core to achieve supercriticality, or fission at an increasing rate.

The IAEA found out that Iran had done several hundred tests with detonators. In some meetings with foreign counterparts, Iranian scientists did not use their real military-related affiliations. The IAEA determined that this work continued after 2003.

Tehran's nuclear archive contains a photo of an Iranian hemispheric model of a shock wave generator with high explosives and a sophisticated diagnostic system using fiber optic cables.

Early 2002: 45% Completed

Current Status: Likely Ready



LAYER 07: METAL CASING

The final layer of the warhead is a metal casing for the inner layers.

Fashioning this casing entails no current technical challenge for Iran.

Current Status: Ready

If capable of constructing all these layers, Iran would likely seek to conduct a "cold test," or test of a nuclear explosive with a surrogate nuclear core.

It would then likely seek to conduct a nuclear test, probably underground, to demonstrate its nuclear deterrent.

By 2003, the regime already selected five candidate test sites under a separate Amad Plan project called Project Midan.

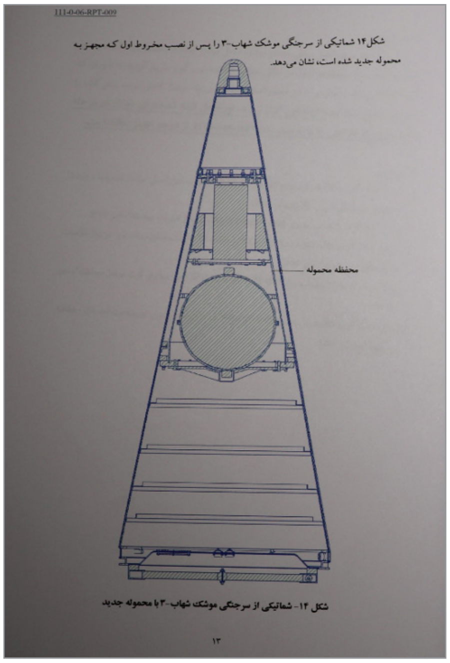
Alternatively, it could use a horizontal tunnel inside a mountain to detonate a nuclear explosive, as North Korea does.

Iran may also opt to reveal that it has nuclear weapons via ambiguous but credible statements or via photos. Iran may have confidence that a nuclear device would work without a test.

If it did conduct a demonstration test, Iran could probably lower a container carrying a weapon into a deep shaft. This is how Iran prepared to conduct a test prior to 2003. Such a shaft may already exist.

A photograph from the nuclear archive shows a container for a nuclear weapon and a carrying device to lower it into a shaft.

Early 2002: No test site selected, although candidates were identified
Current Status: Can likely build a test site within months



Next, Iran would seek to build a missile delivery capability by outfitting the warhead into the re-entry vehicle of a medium-to-long-range missile.

Mating the warhead to the missile is challenging and may still require months of work, yet the warhead itself provides an initial nuclear deterrent.

Iran could initially employ an aircraft or even a truck to deliver a nuclear weapon, but the preferred means of a delivery is a ballistic missile, of which Iranian has an extensive arsenal.

Iran made substantial progress on missile-integration efforts under another Amad Plan project, Project 111 or "Integrating Missile Re-entry Vehicle," and under Project 110's Warhead Project.

A schematic from the archive shows the Shahab-3 missile's warhead outfitted with a nuclear weapon. Today, Iran would opt to use a different, more advanced medium-range missile.

Early 2002: 45% Completed
Current Status: Likely Ready

KEY ACTIVITIES IRAN MAY STILL NEED TO ACCOMPLISH

Make Uranium Metal Cores and Other Nuclear Weapons Components

Iran may have shortened the time needed to produce these items by accomplishing some steps via computerized work and by manufacturing key components in advance.

Theoretical work

Theoretical work is required for most steps in fashioning a nuclear device. Tehran already developed computer codes to simulate a nuclear weapons explosion. It continued its theoretical nuclear weapons work after the end of the Amad Plan, as documented by the IAEA.

Build a Prototype Nuclear Weapon

The planning for post-Amad work included building a prototype nuclear weapon. It is not known if this happened.

Conduct a Cold Test

It is unclear if Tehran has conducted a cold test of a nuclear explosive. At the end of the Amad Plan in 2003, Iran was preparing to conduct a cold test of a nuclear explosive with a surrogate nuclear core at the Marivan site.

Construct a Nuclear Weapon Assembly Plant

The IAEA never determined whether Iran constructed a plant to serially assemble nuclear weapons. Iran requires only small, non-descript facilities to carry out initial assembly work.

In a breakout — that is, a rapid sprint to build a nuclear weapon — Iran would likely rely on its IAEA-safeguarded stocks of enriched uranium to fuel its weapons. The need to move those stocks would trigger IAEA detection.

Once the regime moves the enriched uranium to deeply buried underground sites, however, Iran may be able to complete weaponization unimpeded, unless the United States and its allies have sufficiently precise and reliable intelligence to facilitate covert action or military strikes.

Moreover, Iran may move WGU late in a potential weaponization effort — perhaps only two months prior to finalizing construction of nuclear devices — leaving the international community little time to intervene.

If it chose to do so, Iran could re-activate the full suite of Amad Plan activities and sites to serially produce missile-deliverable nuclear weapons within two years.

Yet, as described, it could produce working nuclear devices and have a credible deterrent within six months.

A nuclear-armed Iran would be freer to pursue its aggressive and expansionist aims in the Middle East, threaten Israel with attacks and nuclear annihilation, and limit the actions of the United States and its allies, which would hesitate to act lest they trigger escalation to nuclear exchange.

Thus, the United States, Israel, and their allies must deter, detect, penalize, and stop Iran's efforts now.

Key Sources

Iran's nuclear weapons archive information, processes, and photos are from: David Albright, Sarah Burkhard, et. al., *Iran's Perilous Pursuit of Nuclear Weapons* (Washington, D.C.: Institute for Science and International Security Press, 2021) and Institute reports on Iran's nuclear archive.

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