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Background information on a current topic

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Is Iran on the way to acquiring an atomic bomb ?

1. Introduction

It is apparent from various documents published by the International Atomic Energy Agency (IAEA) that in recent years Iran has assembled essential components needed for a comprehensive nuclear infrastructure. Iran has always declared that these components were for use in the development of an entirely peaceful nuclear programme.
Nevertheless, why would a country with its own vast oil and gas reserves, which will last for decades to come, need a comprehensive civil nuclear programme? Does this make economic and political sense? Iran's nuclear programme is so politically sensitive, mainly because it involves manufacturing nuclear fuel; in theory, a country with this technology would also be capable of producing the material necessary for an atomic bomb. Are concerns, voiced particularly by the USA, that Iran is attempting to build an atomic bomb well-founded?
The brief overview below details civil nuclear activities which could potentially be used for military purposes. Subsequently, we present available information from reliable sources on Iranian nuclear activities from a technical and scientific perspective, and place it in the context of the contractual obligations that Iran has accepted.

2. Critical peaceful nuclear activities

What nuclear materials and knowledge are required for a military nuclear programme? Through what peaceful activities can this knowledge be acquired, and what are the possible telltale signs of the existence of a nuclear weapons programme?
Obtaining a sufficient quantity of weapons-grade fissile material is by far the greatest difficulty facing a country which wants an atomic bomb. The illegal acquisition of a few kilograms of such material in the long-term would not be enough to gather a military-relevant (i.e. usable, plausible), albeit modest nuclear arsenal. The prospective nuclear-armed country must be in a position to indigenously manufacture the required fissile material.
The fissile material required is generally highly enriched uranium (HEU) or plutonium. Correspondingly, as the figure below shows, a distinction is commonly made between the "uranium path" and the "plutonium path" (Figure 1).

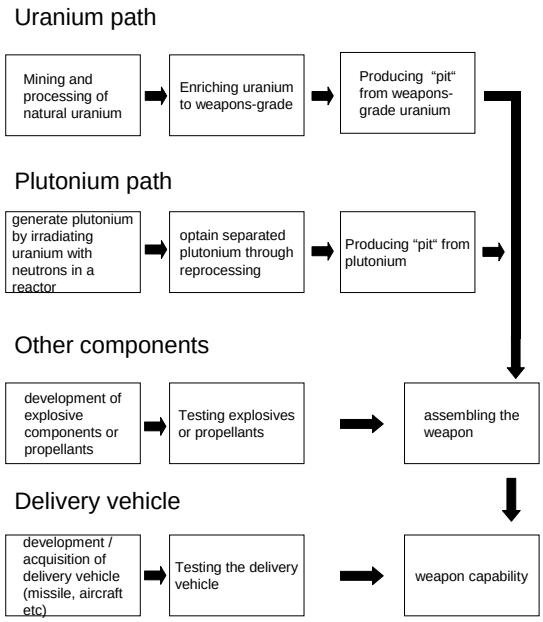

Figure 1 Components of a nuclear weapons programme (the assembly of fissile material in the core of a nuclear weapon is called a "pit").

The uranium path: Natural uranium is a mixture of 3 different isotopes: almost 99.3% ^{238}U, 0.7% ^{235}U, and a negligible quantity of ^{234}U. Isotopes are chemically barely distinguishable atoms of the same element, having the same number of protons in the nucleus of the atom. However, the isotopes differ in the number of neutrons and correspondingly, their mass and nuclear properties. The ^{235}U isotope is essential for nuclear applications. Natural uranium is not directly usable in most nuclear technology applications, as the content of ^{235}U is too low. Normal nuclear power plant reactors use a uranium mixture with 3-5% ^{235}U (LEU - low enriched uranium). In nuclear weapons, the ^{235}U share makes up over 90%. The separation of a uranium mixture into two mixtures with different ^{235}U contents is called uranium separation, or uranium enrichment, because the aim is extract the ^{235}U-rich part. Anyone who can enrich uranium for use in nuclear power plants has the necessary knowledge and technical expertise to manufacture HEU for use in nuclear weapons.

The plutonium path: When uranium fuel rods are "burnt" in a nuclear reactor, they give rise to plutonium and highly radioactive fission products. Using extremely complex chemical procedures plutonium can then be separated from the fission products and the remaining uranium. Anyone who can manufacture fuel rods and separate plutonium from the spent rods, can use this knowledge to manufacture weapons-grade fissile material.

The following activities, which may have a peaceful purpose, can be indications that a country is attempting to manufacture fissile material for military ends through its nuclear industry and expertise.

- Uranium enrichment (uranium path)
- Own production of fuel rods (plutonium path)
- Reprocessing of spent fuel rods (plutonium path)
- Construction of reactors that use heavy water[1] or graphite to slow down neutrons, as well as facilities to produce heavy water (plutonium path). These reactors are particularly problematic because they use natural uranium, and therefore the acquisition of uranium can go unnoticed more easily (particularly in countries with their own uranium deposits) than the low enriched uranium generally used in reactors. Moreover, plutonium from such reactors is more suitable for nuclear weapons purposes than plutonium from other reactor types.

[1] Heavy water is water (H_2O) that contains the rare, heavy hydrogen isotope deuterium rather than the more common hydrogen isotope.

3. How are civil nuclear activities controlled?

The prevention of the proliferation of nuclear weapons is one of the most important tasks and challenges faced by the international community. To this end the Non Proliferation Treaty (**NPT)** was drawn up and entered into force in 1970. It should prevent additional countries acquiring nuclear weapons, while enabling and promoting the use of nuclear energy for peaceful purposes.
There are two types of signatory states: the five "official" nuclear weapons states (USA, UK, Russia, China and France) and those countries which have pledged to forego possession of nuclear weapons. With the exception of Israel, India, Pakistan and latterly North Korea[2], all recognized countries of the world are signatories of the Non Proliferation Treaty, including Switzerland, which joined in 1977.
The **IAEA** (International Atomic Energy Agency) is the organisation in charge of ensuring that no civil nuclear material or civil nuclear facilities are misused for military purposes.
Those signatory states of the Non Proliferation Treaty that are not nuclear weapons states must sign the IAEA Safeguards Agreements. They must pledge to declare all nuclear material and facilities, and allow the IAEA to conduct regular inspections of these sites.

The discovery of secret nuclear weapons programmes in Iraq and North Korea at the beginning of the 1990s showed that the existing safeguards fell short and needed urgent improvement.
To this end, Additional Protocols were introduced. A signatory state to these Additional Protocols accepts inspections of facilities and sites, even undeclared ones, at very short notice. It also agrees to environmental sampling and analyses of the samples with state-of-the-art methods and equipment. These are known as "anywhere-anytime" inspections".

4. Situation in Iran

4.1. Iran's nuclear treaties

Iran is a member of the NPT (signed in 1968, ratified in 1970) and has pledged to renounce any nuclear weapons-related activities. In return Iran, like all NPT members, has the right to participate in the exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy.
In 1973, Iran signed a Comprehensive Safeguards Agreement with the IAEA, and in 1974 the relevant Subsidiary Arrangement. It deals with the technical and administrative details of the Safeguards Agreement.
On 26th February 2003, Iran accepted changes to the Subsidiary Arrangement. Before then, Iran had to inform the IAEA of the existence and features of a facility only 180 days before the planned arrival of nuclear material to that facility. Now, Iran must inform the IAEA as soon as it decides to build a nuclear plant and keep the agency regularly updated.
On 18th December 2003 Iran signed the Additional Protocols to the Non-Proliferation Treaty. In future, the IAEA will therefore be able to carry out "anywhere-anytime" inspections in Iran.

4.2. Iran's development of a nuclear infrastructure

In 1953 Mohammad Reza Pahlavi, known as the Shah, overthrew the elected Prime Minister Mossadeq in a US and British backed coup. American, English, French and Dutch oil companies benefited from the pro-western stance of the Shah and were given permission to operate their oil facilities in Iran.The Iranian nuclear programme began in 1959 with the purchase of a 5-megawatt (thermal[3]) research reactor as well as a number of hot cells[4] from the USA. This "swimming pool" reactor was built at Tehran University and became operational in 1967.

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[2] North Korea declared its withdrawal from the NPT but failed to submit notification to all signatory states, which conformed to the legal requirements of the treaty.

[3] The efficiency of a nuclear power plant, as with all thermal machinery, is moderate. Electrical output represents around one third of thermally generated output. MWe (Megawatts electrical), MWt (Megawatts thermal).

[4] Small, heavily insulated rooms with remote controlled arms used to handle radioactive material.

In the following years, hundreds of Iranian students trained as nuclear physicists and engineers first in Britain and the USA, and later in Germany and France.

The Shah had had extremely ambitious plans to develop a nuclear power infrastructure. According to a declaration made in 1974, Iran would build nuclear power plants with a total output of 23,000 MWe[5] within twenty years. Negotiations began with the USA, France and Germany on the construction of reactors. In 1975, Iran signed a contract with France on the construction of a nuclear research centre in Isfahan. In 1976, Iran signed a contract with the German "Kraftwerk Union" on the construction of two 1,300 MWe reactors in Bushehr. In 1977, Iran signed a contract with France on the construction of two reactors outside Ahvaz. Iran also voiced an interest in uranium enrichment, as well as in the reprocessing of spent fuel rods.

The Islamic Revolution of 1979 forced the ruling Shah to flee abroad and Iran became an Islamic Republic. Conservative religious forces did away with western influences and put a stop, for the time being, to the development of a nuclear infrastructure.

During the war with Iraq from 1980 to 1988, the half-finished Bushehr reactors came under attack several times and were destroyed. From the mid-1980s, nuclear activities came back into favour. China took over the completion of the nuclear research centre in Isfahan from France. At the end of the 1980s, Iran tried to tempt western companies to rebuild the Bushehr reactor. All attempts failed, mainly due to pressure exerted by the USA. Then, in 1995, Iran succeeded in concluding a contract with Russia to build a 1,000 MWe reactor there.

Over the next 20 years, Iran plans to build nuclear power plants with a total power capacity of around 7,000 MWe.

4.3. Nuclear constructions and facilities in Iran

Iran has large nuclear facilities in various locations throughout the country (Figure 2).

Figure 2 Map of Iran – sites of the most important nuclear facilities.

Natanz: After a visit to the site in February 2003, the IAEA Director, Mohamed El Baradei, reported that a pilot uranium enrichment facility containing approximately 1,000 gas centrifuges is under development. Around 160 centrifuges are almost operational and the parts for the rest of the centrifuges are ready and on site. According to information from Iran, this pilot plant should be up and running by 2003. This type of plant could produce around 10-12 kg of weapons-grade uranium per year.

The introduction of centrifuges in a commercial, much larger enrichment plant (approx. 50,000 centrifuges) is planned to start in 2005. The necessary buildings are almost complete.

[5] For comparative purposes, this is the equivalent to around 23 nuclear power plants, the same size as the Gösgen nuclear power plant in Switzerland.

Figure 3 Satellite picture of the Natanz uranium enrichment facility.

Source: http://www.isis-online.org/publications/iran/natanz03_02.html

Arak: A heavy water production plant is under construction. Iran informed the IAEA on 5th May 2003 that it was to begin the construction of a heavy water research reactor with an output of 40 MWt. This type of reactor would be capable of producing around 8 to 10 kg of plutonium per year.

Isfahan: A facility to convert uranium oxide to uranium hexafluoride (UF_6) and metallic uranium is near completion. The manufacture of the UF_6 compound is necessary for uranium enrichment. There is also a nuclear technology centre with the following 4 small research reactors:

1 reactor to produce neutrons, 27 thermal kW,
1 heavy water reactor 0 kW,
1 subcritical light water reactor and
1 subcritical graphite reactor (not in operation).

These research reactors are only capable of producing insignificant quantities of plutonium, but they provide important material data and experience in running different types of reactors.
The construction of a plant to manufacture fuel rods is scheduled to start this year. The rods will be used in the future heavy water reactor in Arak.

Bushehr: According to Iranian information, the Soviet-designed VVER-1000, a 1,000 MWe light water reactor will probably be operational in 2005, not June 2004 as originally planned.
Iran wanted to process spent fuel rods itself (with Russian support). Following US pressure, Russia will only deliver fuel rods on condition that Iran returned them once they are spent. Furthermore, it is possible that Russia delayed delivery in a bid to get Iran to sign the Additional Protocols.

Figure 4 Construction of the Bushehr reactor.

Source: www2.ijs.si/~icjt/plants/ picl/pic1086.html

Tehran: Tehran University has a 5 MWt research reactor, which can produce up to 600g of plutonium per year; it also has laboratory-scale "hot cells" and "reprocessing facilities". The centrifugal technology was probably developed at the **Sharif University** of Technology in Tehran and the centrifugal components manufactured by the **Kalaye Electric Company**.

Saghand near **Yazd:** In February 2003, the Iranian President Khatami announced that Iran had begun to process uranium near Yazd.

In light of this overview, it is clear that Iran's development of a nuclear infrastructure involves activities which would also be of central importance for a military nuclear programme.

4.4. Why the need for a nuclear programme?

According to official information from Iran, the sole aim of its nuclear programme is to build new nuclear power plants in order to reduce its consumption of oil for electricity generation. On one side nuclear power should be less damaging to the environment, and it would also allow Iran to sell off its oil reserves on the world market at a profit.
It is very difficult to say whether this programme makes economic sense, since it depends heavily on the further evolution of the dollar exchange rate and oil prices.
Economic considerations hardly justify the construction of uranium enrichment or reprocessing facilities in Iran. There is excess capacity worldwide in both areas.
Iran counter-argues that the construction of a closed fuel cycle is necessary due to the lack of support (which it should receive in accordance with the NPT) and obstacles put in its way. An example of such an obstacle was given by the Iranian Vice President Aghazadeh: since the first Bushehr reactor plant was built, Germany has continued to store 100 t of low enriched uranium which belongs to Iran but was never delivered.

4.5. Has Iran breached the IAEA treaties?

Media reports in August 2002, stating that Iran was building an underground uranium enrichment plant and a heavy water production plant, were confirmed by Iran. An IAEA delegation was shown the enrichment plants in February 2003. According to the Safeguards Agreements then in force between the IAEA and Iran, the IAEA could only inspect notified plants and materials. According to the IAEA treaty at that time, Iran was legally obliged to declare new plants only 180 days prior to the delivery of nuclear material to those plants, and not when the decision was made to launch such projects or to begin construction. The construction of existing and known plants by Iran did not therefore infringe any treaty.
The construction of such a large and technically complex uranium enrichment plant usually requires prior comprehensive testing of the necessary centrifuges using UF_6. However, Iran declared that this type of test had not been carried out anywhere in the country.
In February 2003 Iran admitted that it had received large quantities of uranium compounds (1,000 kg UF_6, 400 kg UF_4 and 400 kg UO_2) from China in 1991. The uranium in question is reported to be natural uranium. According to the Treaties in force, Iran would have been legally obliged to declare this delivery to the IAEA in advance. Iran, however, did not respect this contractual obligation.
According to an IAEA report from 26th August 2003, environmental tests in Natanz found traces of enriched uranium. This discovery increased IAEA suspicions that Iran had carried out centrifuge tests against its own claims and thus breached the Safeguards Agreements. As a result, Iran was given an ultimatum in an IAEA resolution passed on 12th September 2003. It was told to fully answer outstanding questions concerning all imported material related to uranium enrichment and any experiments involving uranium by the end of October 2003. In addition, Iran had to grant the IAEA unlimited access to all its facilities. Should Iran be unable or unwilling to meet these demands, the IAEA would go to the UN Security Council to seek economic sanctions. Basically, Iran had three choices: meet these demands, reject them and withdraw from the NPT, or wait and do nothing.
On 21st October 2003, following a meeting with the British, French and German foreign ministers, the Iranian government declared that it would sign the Additional Protocols and stop all uranium enrichment activities. Two days later, Iran's ambassador in Vienna, Ali Akbar Salehi, handed over comprehensive documentation on his country's nuclear programme to the Director General of the IAEA, Mohamed ElBaradei; Iran admitted that it had tested its centrifuges using the UF_6 it obtained from China in 1991, and had irradiated 7kg UO_2 from which it had extracted a small quantity of plutonium.
On 26th November 2003, after heated debates, the IAEA Board of Governors decided not to call on the UN Security Council in spite of Iran's failures to meet its obligations under its Safeguards Agreements. The IAEA will now try to verify whether the information Iran gave is correct and complete.

4.6. Iran's missile programme

The Iranian ballistic missile Shahab-3, which reportedly can carry a 700-1,000 kg warhead over a distance of around 1,300km, was tested on various occasions. Iran is also working on the larger Shahab-4, which is expected to have a longer range and greater load capacity than its predecessor.
It is known that eight states possess nuclear weapons. Of these five are the “official” nuclear weapons states: USA, UK, Russia, China and France. According to the Non Proliferation Treaty, they have the right to own nuclear weapons. The additional three “unofficial” nuclear weapon states are India, Israel and Pakistan, who are not members of the NPT. All eight states, as well as Iran and North Korea, are also the only countries which have produced or tested rockets with a range in excess of 1,000 km.
It is obvious therefore that there is a strong link between missile programmes and military nuclear programmes. A serious missile programme is an important indicator of a military nuclear programme.

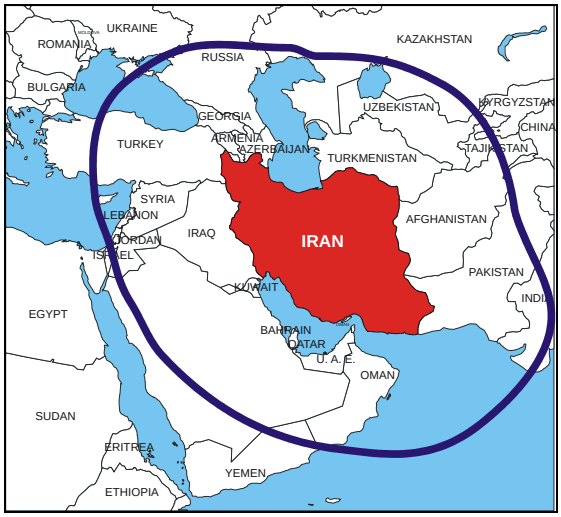

Figure 5 The blue circle shows the area, which could be affected by an Iranian missile with a 1,000 km range.

4.7. Is there a motivation for an Iranian nuclear weapons programme?

With Pakistan, India, Israel, Russia and China, Iran is surrounded by states with nuclear weapons. In addition, Iran’s neighbour Iraq had a military nuclear programme until the first Gulf War.
Existential threats, insecurity and fear are the driving forces behind nuclear proliferation.

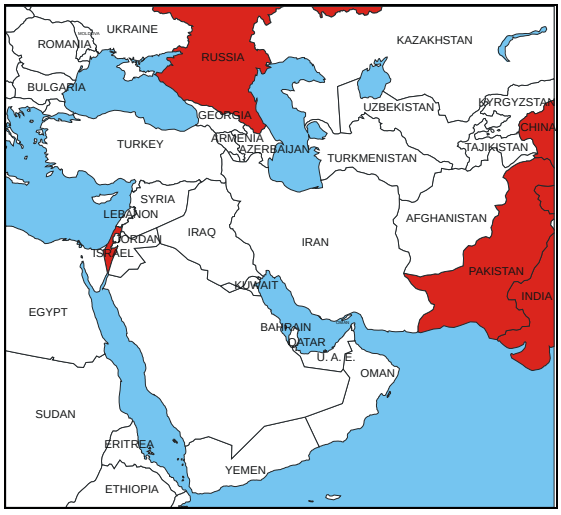

Figure 6: Countries with nuclear weapons in red.

As a result of the two Gulf Wars, Iraq no longer poses a threat to Iran. However, the large presence of US troops in Iran’s two neighbouring countries – Iraq and Afghanistan – and the strong influence of the US in the young central Asian states presents Iran’s security policy with new challenges. The volatile security situation of that world region constitutes the background for Iran’s possible nuclear military ambitions respectively for the global apprehension about such a programme.

5. Nuclear energy or nuclear weapons programme?

There is no evidence that Iran has pursued or is pursuing a nuclear weapons programme under the cover of a civil nuclear programme. The following facts, however, cause true concern and must be thoroughly checked:

- Iran is pursuing a comprehensive nuclear programme which it has declared as peaceful, although the economic advantages are questionable.
- By producing a small quantity of plutonium and enriching uranium, Iran has failed to meet its obligations under the existing Safeguards Agreements.
- Iran is pursuing a programme to develop missiles with a range in excess of 1,000 km.

By signing, and hopefully in the near future ratifying, the Additional Protocols, which will allow the IAEA to carry out comprehensive controls and tests, Iran may assuage the fears of the international community and prove that its nuclear ambitions are entirely peaceful.

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