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IRANIAN NUCLEAR PROGRAM: A TECHNICAL OVERVIEW

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This document has been translated by a Translation and Interpreting Degree student doing work experience, FERNANDA RAVENTÓS, under the auspices of the Collaboration Agreement between the Universidad Pontificia Comillas, Madrid, and the Spanish Institute of Strategic Studies.

Abstract:

Since several years, the Iranian nuclear program has been under the watchful eye of the International Atomic Energy Agency and, in general, of all intelligence services around the world. According to the available data it seems that behind the legal aspiration to acquire nuclear technology for civilian purposes lays the ulterior motive of being part of the group of countries that have nuclear weapons. This would boost Iran's security and the potential risk to its enemies. However, this is against the Non-Proliferation Treaty and it is a serious challenge to the international community, which has to take decisions in order to prevent a nuclear-proliferating state. The technical understanding of the nuclear activities enables us to comprehend the set of political decisions that have to be taken.

Keywords:

Nuclear proliferation, Iran, Nuclear Weapons, Intercontinental Ballistic Missile, Nuclear Bomb.

INTRODUCTION

On the 11th November 2011, the International Atomic Energy Agency issued a report assuring and confirming with data that there were serious concerns that Iran had been carrying out a nuclear weapons program for years; the IAEA couldn't assure that this program had been entirely cancelled. Moreover, there was information given by different countries and organizations showing that there were still some suspicious activities of developing nuclear weapons. All these activities had been developed at the same time as a nuclear program for civilian purposes allowed by the Non-Proliferation Treaty, if all its requirement points were fulfilled.

The Iranian authorities denied all the accusations and displayed a firm determination to continue all nuclear activities. Everything, despite the fact that the resolutions of the international community are pressuring to stop the Iranian nuclear program until the legal purposes of it are proven and all the doubts regarding the attempt of a nuclear proliferation are cleared away.

The existence of other Iranian weapon programs leads us to think that Iran is very interested in improving their war capability; the ballistic missile program is a very significant fact. This type of weapon system is mostly developed to be capable of using non-conventional weaponry, because the costs and capabilities for the use of conventional explosive warheads are difficult to justify. This fact should be taken into account and it makes us think that the objective is the development of ballistic missiles with the capability to launch nuclear warheads.

The international community has banned the development of nuclear weapons by a large body of legislation led by the Non-Proliferation Treaty, having means for its implementation. However, the nuclear proliferation has been conducted before, for example in India, Pakistan and North Korea[1]. The final result of the Iranian case will be a future example for countries that have enough interest to start a nuclear weapons program; it can happen that, before the firm determination of a state choosing the correct path, it may be demonstrated the lack of an international check to prevent the development of nuclear weapons.

To wholly understand the Iranian nuclear program, we will see first its historic development and then its current situation with the data we have from open sources. The objective of this document is to clarify the technical aspect to understand the terms discussed in the political

[1] The Korean case registers similarities and differences compared with the Iranian one.

negotiations and decisions adopted to manage a crisis in a *hot zone* of the globe like the Middle East.

THE HISTORY OF THE IRAN'S NUCLEAR PROGRAM

The Iranian nuclear program dates back to the fifties and sixties, when Sha Reza Pahlavi started an ambitious project that included the construction of 23 nuclear power plants before the end of the 20th century, and thus meet Iran's energy demand in the early 21th century. As a signatory of the NPT Iran received Western aid since 1968, including from the United States who considered him an ally, due to the fact that it represented a wall to the Soviet influence towards Middle East. Iran began the construction of two nuclear reactors in Bushehr with the support of Germany and a third in Darkhovin with French support. None was finished, because the Islamic Revolution of Iran in 1979 stopped this Western cooperation[2].

The nuclear program for civilian purposes was stopped for several years, even though there are some data indicating that certain investigations never stopped.

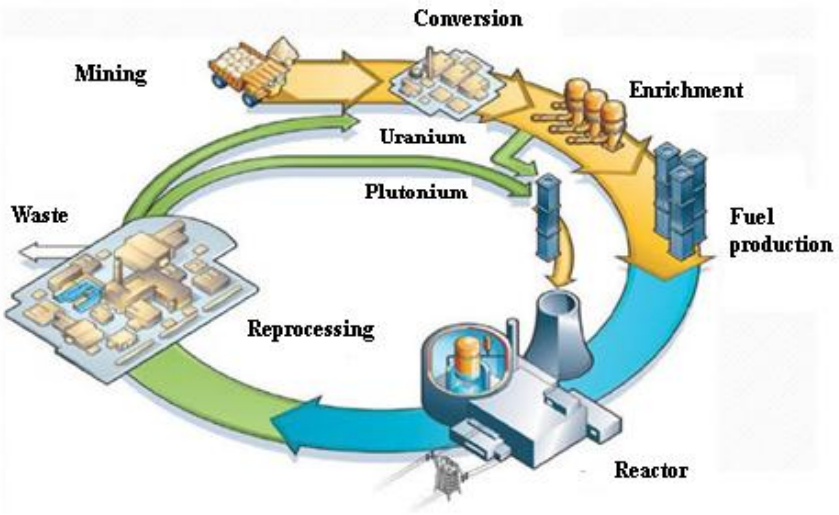
During the war between Iran and Iraq, the nuclear power stations were bombed and, therefore, practically destroyed. Again in the late 1980s, the president Hashemi Rafsanjani pushed forward the nuclear program. He tried to reconstruct the nuclear reactors of Bushehr with the help of Spain and Germany, but as they refused he did it with the support of Russia, and so they build a nuclear pressurized water reactor (PWR).

In the 1990s, still with Russian support, the Iranian authorities reached an agreement with China who gave them technology: they finished the nuclear power station in Bushehr, constructed the pressurized heavy-water reactor of Arak and provided the technology to the laser uranium enrichment.

Around the year 2000 it became clear that Iran wanted to have the complete nuclear cycle, considering that, in 1985, Iran had discovered large quantities of uranium ore and was determined to use it. Iran declared several nuclear facilities, but covered the most sensitive for the nuclear program. In 2002 the facilities in Natanz and Arak were revealed to the public by a group of the opposition, and thus confirming Iran's intentions.

[2] Neither of the countries returned the money they had been given for the construction of the nuclear power plant.

In 2003, the president Kathami acknowledged the existence of Natanz and Arak, and Iran's intention of having its own capacity in all the nuclear cycle. This means that he was



Nuclear fuel cycle. Source:

http://web.ing.puc.cl/~power/alumno09/nuclear/Ciclo_del_combustible.html

interested in developing independently the mining, the separation of natural uranium, its enrichment and use in nuclear reactors and even the reprocessing activities[3]; which is shown in the graphic 1.

[3] Reprocessing activities consist mainly in separating the plutonium and uranium from fission products and other elements of nuclear fuel after having used them in a nuclear reactor.

From this moment on, in Iran take place some strategies, in order to hide part of their nuclear program, and some demands and investigations of the IAEA to determine the nature of it; this is the current situation even though 10 years have passed.

IRANIAN NUCLEAR ACTIVITIES

Studying the chronologic evolution from 2002 to understand the Iranian nuclear program is not the most suitable thing, because the disaggregated data prevent exposing the complete situation of the nuclear program and the reason why it is considered a potential situation of nuclear proliferation. That's why it is better to analyze the technical aspects of the program and comment briefly the importance of each of them without particular dates.

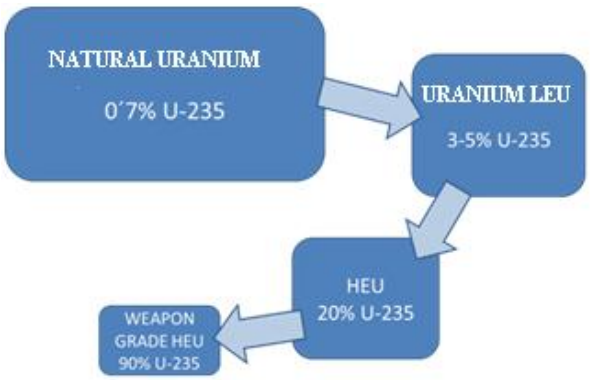
Nearly all the information, especially about possible military activities, come from the IAEA report, issued on November 2011, about the implementation of the Safeguards Agreement between the Islamic Republic of Iran and this body. This is a six-monthly report; however, there had never been data clearly indicating the possible existence of a program with military purposes[4]. The facilities subject to official inspection are the ones declared by Iran; the Safeguards Agreement only allows inspecting these facilities, because Iran did not ratify the Additional Safeguards Agreement and so, they can't enforce the inspections. With this restriction on the inspections, the Agency faces a risk of proliferation, as described below. On February this year, a new report was issued, updating data of quantitative character.

The implementation of the activities is sequenced regarding the uranium cycle described before, which would be the one to carry out. The cycle begins with uranium mining conducted in Saghand and Gchine, in central Iran. The IAEA estimates that Iran could produce more than 70 tonnes of natural uranium per year, probably even more thanks to the possible Russian and Chinese assistance, through advanced technical measures, on the production of yellow cake. This is an intermediate product in the making of uranium hexafluoride, which is used in the uranium enrichment activities.

[4] The report doesn't say from where they have obtained the exact information, but points out three different sources: IAEA inspectors, intelligence agency of different countries and directly from the Islamic Republic of Iran. We assume that the IAEA has verified each one of them, and acts as a impartial body. Nonetheless, should the information be wrong, the conclusions of this document would be different.

After studying the satellite imagery[5] they have confirmed that there is activity in both facilities: movement on the ground, building of auxiliary structures, warehouses, pools with liquid waste, etc.

The next step is the uranium conversion[6] and its enrichment. The UN resolutions also ban the uranium enrichment until the trust[7] between the parties is rebuild, therefore all Iranian activities should stop. However, Iran has carried on with the work. Without a deep analysis of technical details, enrichment activities consist in separating the different isotopes of the natural uranium, in order to select the most suitable for both the fission in a nuclear reactor and manufacture of nuclear weapons. The uranium isotope U-235 is the most suitable, because it's a fissile material. In contrast, the 99 % of the natural uranium is U-238[8]. There are several methods to increase the proportion, from 0.7 % in natural uranium to 3-5 % in the fuel used in most nuclear reactors for electric power production, to 20 % used also in research reactors or up to 90 % considered weapon-grade uranium. Every step to a higher enrichment means a lower amount, because it is a separation; and we obtain, as uranium tales and waste, the well-known depleted uranium with higher amounts of U-238.



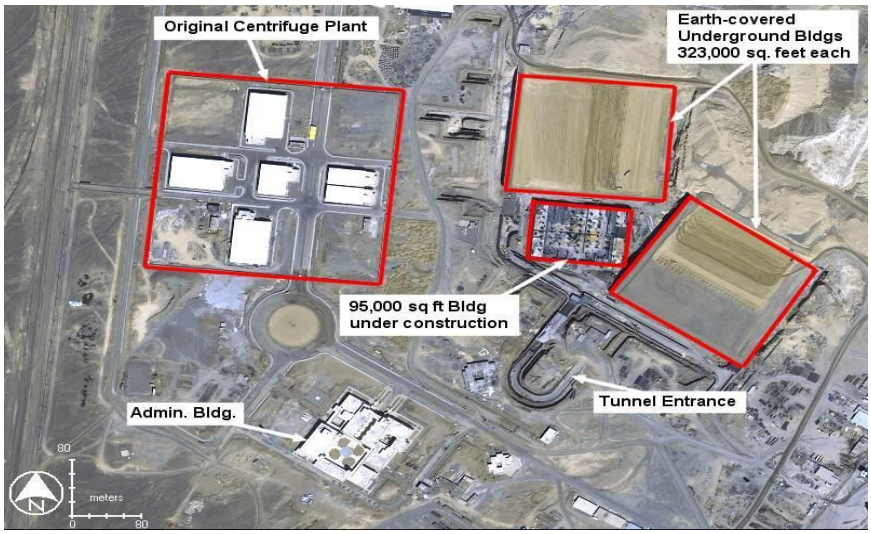
Enrichment. Source: elaboration by the

From all the uranium enrichment techniques, Iran has chosen the Zippe centrifuge technology even though, with the Russian and Chinese support, they have also researched for the use of laser-based methods. The Zippe centrifuge is based on the gaseous uranium high-speed rotation in the form of its hexafluoride. Due to the centrifugal force, light isotopes remain in the center while the U-238, that weights more, rotates on the outside. U-235 and U-238 are extracted through tubes. The repetition of the process by a cascade system allows reaching the uranium enrichment level desired. One of

[5] Imagery intelligence: IMINT
[6] It is a process to transform uranium compounds in other composites that are more suitable for the next stage of the nuclear cycle; normally from uranium oxides to uranium hexafluoride.
[7] Paragraph 2; UNSCR 1737 (2006) approved on the 23rd December 2006; subsequently repeated.
[8] U-238 is fissionable but not fissile; so it can be divided due to the collision of high energy neutrons. On the contrary, U-235 can be divided with thermal neutrons (low energy).

the main problems that trouble the international community is that the procedure to obtain enriched uranium for peaceful purposes is similar to the one to obtain nuclear weapons. If a country has such facilities, it can obtain uranium for weapons despite the fact that they are normally used for peaceful purposes.

Iran's Natanz and Fordow nuclear plants in Qom are developing the main enrichment activities. In several satellite images, we can observe the facilities and, by analyzing them, we obtain their evolution[9].



Natanz. Source: DigitalGlobe

There are two nuclear plants in Natanz[10]: the Fuel Enrichment Plant and the Pilot Fuel Enrichment Plant. This facility includes an underground part, which provides bigger protection for the components and means of the program.

The final capacity of the uranium enrichment in this facility will meet the current demands of the nuclear reactor in Bushehr; however, if Iran achieves the 20 nuclear reactors expected, it will need more capacity. In addition, Iran plans to build ten more enrichment plants and has even decided some locations. Nonetheless, there is the problem of the emergence of other facilities that until now were adequately concealed, like the Fordow plant in Qom. The IAEA

[9] We can also obtain them in open sources, for example: Digital Globe. Available at Global Security. www.globalsecurity.org

[10] A full image collection of the Iranian and other countries facilities can be found in Globalsecurity.org

highlights the lack of cooperation of Iran to clarify the real intentions and available capabilities as one of the most important issues.

The Fordow plant, the existence of which has only been known since 2009, is completely underneath a mountain. It seems to be the plant that will produce higher enriched uranium, to a 20 % which is the enrichment level used in Tehran's nuclear reactor. This enrichment level also means a big military advancement, because the enriched uranium storage allows enriching to a 90 % in a short period of time, only needing about 130 kg of HEU to a 20 % per weapon. On February 2012, the IAEA estimated that Iran had succeeded in producing about 95 kg since the beginning of the production on February 2010[11], with a monthly production of 4 kg[12].

Apart from obtaining enriched uranium, it's necessary to transform the uranium hexafluoride in uranium metal, normally uranium dioxide, for the production of fuel elements. This is not an easy process and varies depending on the enrichment level; the more enrichment, the more complex. Mastering this step is essential for the development of a peaceful nuclear program, but also for the development of the nuclear weapon, since this uranium metal must be afterwards machined adequately. According to some data, Iran received help from the clandestine network Abdul Qadeer Khan who gave them documents explaining this process and, possibly, the design of a nuclear weapon[13]. This network is the same as the one that has been supplying information and elements clandestinely for twenty years to nuclear programs such as the ones of Iraq, Libya and North Korea. Abdul Qadeer Khan is the founder of the nuclear program of Pakistan and is considered a national hero. He established a complex network to provide elements and knowledge for nuclear programs; he also designed centrifuges and substitutional elements of sensitive materials, the export of which is controlled[14]. He may have assisted the enrichment program in Iran, modifying the centrifuges P1 to IR-1 centrifuges, or even to the IR-2 or IR-4[15]. For example, these sensitive

[11] IAEA. GOV/2012/9. *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran.* 24th February 2012.
[12] David Albright and others. *ISIS Analysis of IAEA Iran Safeguards Report: Part 1.* Washington DC: Institute for Science and International Security. November, 2011.
[13] Uranium metal document.
[14] David Albright.*Peddling Perill*. Free Press. New York, 2010. Pages. 13-28.
[15] David Albright and Corey Hinderstein. The centrifugue connection. Bulletin of the Atomic Scientist. March-

elements are turbines with high performance for high speeds that can be substituted by pumps used in the oil construction, as well as other elements: high strength stainless tubes, special steels… The exportation of these elements is controlled and they can be referred to nuclear programs through illegal traffic networks, as it may be happening in Iran, not without certain difficulties that could be delaying the program.

The next stage of the nuclear fuel cycle is being conducted in the nuclear power plant of Bushehr, a reactor build with Russian assistance and that started working on the electric power production with 3.5 % enriched uranium. There is no information indicating that the activity in Bushehr is not completely legal.

Moreover, Iran also has another reactor in Tehran for the research and production of radioactive isotopes, build by the United States in 1967, which uses 20 % enriched uranium. Nowadays it's fuelled with some rods brought from Argentina in 1992 and it is estimated that they'll be consumed this year or during 2013. That's why Iran needs to produce 20 % uranium enriched rods, but they think they will not obtain them until next year, due to its complexity. This reactor may be the key to start a confidence-rebuilding process. Iran should stop all enrichment activities higher than 5 % and, in turn, receive 20 % nuclear fuel (similar proposal to the agreement reached between Brazil and Turkey, that didn't come into effect)[16].

In this nuclear reactor of Tehran has been declared that Iran conducts research activities of radioisotopes for scientific and medical purposes. 85 000 people are treated every year with the radio-pharmaceuticals produced. There are also certain activities like polonium production that can entail nuclear weapon production, but no illegal activities regarding the research reactor have been detected.

The heavy-water reactor in Arak is a completely different story[17]. Currently, the design given by Iran and the intentions declared aren't consistent, and the IAEA inspectors believe that there are a lot of things to explain. It is important because this type of reactors is the one

April 2004. (vol 60, num. 02). Pages 61-66.

[16] http://www.elmundo.es/elmundo/2010/05/17/internacional/1274075874.html

[17] The main design difference is that the reactors listed above use as moderator conventional water; in contrast, this uses heavy-water in which the hydrogens of the water molecule are mainly from the isotope deuterium.

used for weapons-grade plutonium production, which is another way to obtain nuclear weapons. Fuel rods are made of natural uranium and last year the Islamic Republic of Iran declared that it had finished the indigenous construction of the first one. Therefore, this way Iran may obtain enough plutonium for the nuclear weapons production in a relatively short period of time (3-5 years), if it has the adequately knowledge of the reprocessing process and the uranium, which is a complex issue. Therefore, obtaining plutonium is not enough, it also has to be separated from other products and treated accordingly. For that, reprocessing facilities are needed and Iran has been banned from operating these facilities, although he has them. In the report, the IAEA claims that it's not possible to confirm if Iran is conducting activities in this area or not. This part of the nuclear program is very complex and needs a high know-how. Even though it's inconclusive, certain data seems to indicate that Iran is working with non-radioactive materials, in order to learn these procedures. The IAEA points out that Iran needs to clarify this part of the program and extend the data, but Iran hasn't responded to these demands.

POTENTIAL MILITARY DIMENSION OF THE NUCLEAR PROGRAM

Until now, all nuclear activities mentioned have a civil application as can be checked in the uranium cycle, and they can also be integrated in a nuclear program for civilian purposes. However, Iran needs to conduct multiple activities to get the materials for the completion of a real nuclear weapons program. This program wouldn't need to have the magnitude of the first nuclear program in the history, the "Manhattan Project"[18], but it requires the use of both multiple human and material resources. In addition, these resources will be bigger if they don't have direct knowledge gained from staff involved in successful nuclear programs, in order to obtain the appropriate data for the weapon's design.

The International Atomic Energy Agency has also obtained data from other activities that have almost exclusively a military application. Over years, these activities were developed under a program officially recognized by Iran until 2003. From that moment on, the Iranian

[18] We must keep in mind that they didn´t even know the fission cross-section of nuclear materials when the Project begun.

authorities assured that they had completely deactivated the program; however, the IAEA notes that certain data suggest that this is not true.

The main specific activities in a military program are developing efficient high explosives; high quality micro-delayed detonators, the execution of hydrodynamic experiments to study the compression of nuclear material, the need for having a scientific and calculation model for them and for the neutronic flux. Finally adjusting them to the vector of the nuclear warhead and transforming it into a weapon with a fuze, an insurance mechanism…of a suitable size and weight.

In order to have a nuclear weapon, it's necessary to implement all of them and to have nuclear fuel material. In the report, the IAEA shows that Iran has conducted all these activities over the last years, especially in 2002 and 2003, but specific data show that it has also conducted in 2008 and 2009; Iran has refused to give explanations to the Agency.

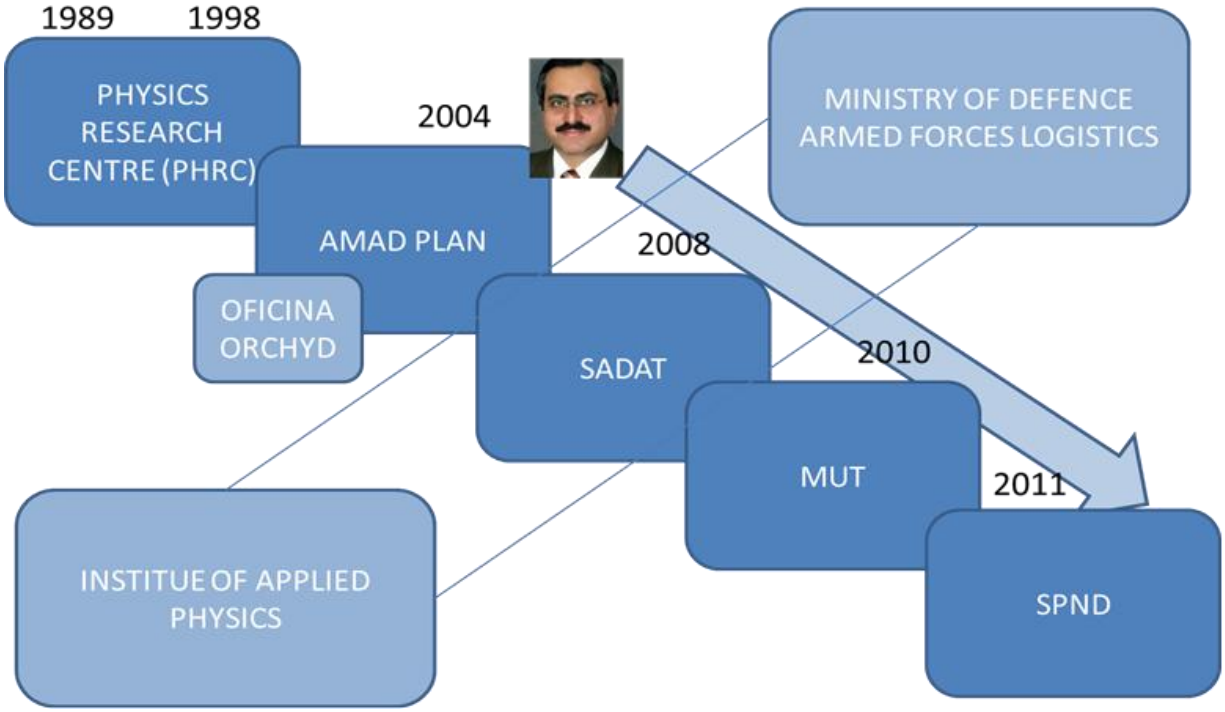
With the available data, Iran may have taken steps for the production of a nuclear weapon of enriched uranium with an implosion design; nevertheless, if Iran gains in the future enough plutonium, it may also produce a plutonium weapon with an implosion design.

In the implosion design, the nuclear material is machined in an empty sphere that is compressed with conventional explosive and designed to reach criticality conditions so the nuclear explosion may take place. The gun-type design is also very common; it's simpler and it would probably work best. This design fires with conventional explosive a sub-critical uranium amount on top of another, reaching suitable criticality conditions and causing the fission chain reaction necessary for a nuclear explosion.

However, the main advantage of the implosion design is that it can be smaller and needs less fissile material to reach the critical mass, and thus facilitating the warhead "vectoring".

These activities may be coordinated or integrated in a program that has had various stages over the years. Every single one could be considered an adjustment to prevent the regulatory body and other intelligence agencies' surveillance and detection. We can observe that over the last ten years there has been a succession of an organization type or scientific centers that have a direct relation with the Ministry of Defence. As mentioned, Iran cancelled all the activities in 2003, closing the "Orchid Office" that conducted the AMAD

Plan; it controlled the activities that were more sensible or were closely related to the development of a nuclear weapon. The head of the project, Mohsen Fakhrizadeh, carried on his activities in positions of great responsibility in the following bodies: Section for Advanced Development Applications and Technologies (SADAT), Malek Ashtar University of Technology (MUT) in Tehran, and the Organization of Defensive Innovation and Research.



Sequence of Bodies. Source: elaboration by the author

Therefore it seems that Iran intends at least to gain scientific knowledge regarding these proliferation activities. An additional indication that increases the suspicions is that, despite the demands, Iran hasn't let the IAEA inspectors have a meeting to question him. Moreover, it is suspected that in the military complex of Parchin there are indications of activities such as high explosive tests in a test chamber[19]. Despite the repeated demands to investigate, Iran denied the access for the IAEA to these facilities.

[19] ALBRIGHT David and BRANNAN Paul, *Early Satellite Image shows foundation for high explosive test chamber at Parchin Site in Iran: What was the chamber for?* Washington DC: ISIS- Institute for Science and International Security, 2010.

The ballistic missiles' Project that Iran is conducting constitutes another of the most sensitive issues regarding the nuclear program. The ballistic missiles' range has increased and will continue doing so over the next years, representing a risk for all Europe.

CONCLUSION

Observing and considering as valid all the information presented by the IAEA, we can briefly draw some conclusions. As the whole document, these conclusions aren't an intelligence analysis of the intentions and capabilities of the Islamic Republic of Iran, but a summary of the technical aspects' analysis of the nuclear program:

- There isn't any "smoky weapon" that may unmistakably prove that Iran is currently conducting a nuclear program for military purposes; however, in case of proliferation, it's difficult to obtain this "smoky weapon".
- The IAEA's doubts indicate that Iran is probably carrying on this type of activities, or that at least it intends to acquire the knowledge for a future development.
- Moreover, there are indicators, like the ballistic missiles program, that leads us to think that Iran may be conducting this program; theses suspicious are based on the fact that the ballistic missile program is the aim of a highly destructive warhead, due to the high cost of the vector. We could even say that there's no point in conducting a ballistic missiles program in order to carry conventional explosive.
- Iran's current situation represents an important risk to the non-proliferation regime, and it will be an example for the future. If we don't stop Iran's supposed aspirations of a nuclear proliferation and Iran gains nuclear weapons, this will prove that the current design of the Non-Proliferation Regime doesn't work.

The political and strategic intentions that would derive from this program are not analyzed in this document. However, the situation raises a major dilemma for the international community and it's currently managed through a containment and deterrence strategy.

In addition, there are more ways to prevent the development of a nuclear weapon, for example, covert operations against the program and the military attack. As in any crisis situation, all options have its advantages and disadvantages. It may seem like the option of covert operations is being carried out, but it's not certain. Therefore, both the murder of

Iranian scientists linked to the nuclear program and the spread of the malware SUXNET, DUQU or even FLAME could be framed in this strategy.

A military attack may open Pandora 's Box and, it seems that neither the United States nor Europe want to be responsible of doing it. It's difficult to predict what will be Israel's course of action. The United States may be trying to delay, at least a bit, this option to see if the freezing economic measures and others that have been adopted force Iran to redirect the situation. A possible outcome is a trust reestablishment if Iran accepts an additional Protocol regarding safeguards and give up the nuclear bomb. Later, Iran would be allowed to continue a program with civilian purposes. This renunciation would be framed in a tacit acknowledgment of a total strategic control by Iran, from Syria to Afghanistan and without any American influence.

Furthermore, analysts of Stratfor think that the doubt about the nuclear program's existence brings benefits to Iran by itself. This way, one of the objectives may not be to gain a nuclear weapon in a short period of time, but to use the supposed nuclear program as a deterrent. Moreover, Syria's current situation will surely influence Iran and the international community's decisions, bringing an additional factor of instability to the situation.

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