

Federation of  
American Scientists

FAS Special Report No. 2  
October 2011

# Towards Enhanced Safeguards for Iran's Nuclear Program

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## ACKNOWLEDGMENTS

We express our gratitude to the many people who made this report possible. At the start of this year, the Arms Control Association invited the Federation of American Scientists (FAS) to give a presentation on options for enhanced safeguards on Iran's nuclear program. This presentation led to a feature article by Charles Ferguson for the March issue of *Arms Control Today*.<sup>i</sup> The research and analysis for that article are the launching off point for the enhanced safeguards section of this report. We are thankful for the permission from Daniel Horner, the editor of *Arms Control Today*, to reprint, with some modifications, the table summarizing our assessment of the criteria for enhanced safeguards.

For this report, we have benefited from the feedback of a group of about a dozen diplomats, who provided constructive criticism at an off-the-record roundtable discussion at FAS. Several other colleagues, nonproliferation experts, political analysts, former diplomats and government officials offered useful advice. We are especially appreciative of the excellent research assistance provided by Elizabeth Grace, who interned at FAS during the spring semester of this year and was at that time a student at the Madeira School in McLean, Virginia. We are grateful to Monica Amarelo, Director of Communications at FAS, for editing the text. .

This work was made possible by a generous grant from the Ploughshares Fund. The statements made and views expressed herein are solely our own.

Ali Vaez and Charles D. Ferguson

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## EXECUTIVE SUMMARY

Since the advent of its nuclear crisis, nearly a decade ago, Iran has been at daggers drawn with the West. The main issue at the crux of this predicament has been to determine an Iranian nuclear capability that would be acceptable to the world and defining the rules that should govern it. Failure to solve this dilemma has been in part caused by a lack of concrete diplomatic solutions. As a result, the deadlock has persisted and transformed into one of the most apparently intractable riddles of this era.

This report seeks to address this challenging question by analyzing options for establishing an enhanced safeguards system for the Iranian nuclear program. It is axiomatic that persuading Iran to accept more intrusive inspections is not an easy task. Thus, in parallel to specifying rules that could set boundaries on the Iranian nuclear program to ensure peaceful purposes, this report outlines explicit incentives that could augur in a win-win diplomatic outcome. The report offers a set of recommendations for all the key players to reach a negotiated resolution of the nuclear issue.

In the first section, outstanding issues between Iran and the International Atomic Energy Agency (IAEA) are outlined. Reports from the IAEA provide ammunition for those who aim to either demonize or lionize Iran and its controversial nuclear program. Yet, in reality the problems between Iran and the agency have not changed much over the past few years. These issues fall into three broad categories: past activities, level of cooperation, and access to information. Despite numerous inspections of Iran's extensive nuclear installations, ranking as one of the highest in the IAEA's history, the agency is still unable to "provide credible assurance about the absence of undeclared nuclear material and activities in Iran." Nevertheless the agency affirms that there has been no diversion of nuclear material at declared Iranian nuclear facilities.

The second section of the report explores the main pathways that Iran could exploit to obtain nuclear weapons: operating a clandestine facility, diverting nuclear material, and withdrawing from the Non-Proliferation Treaty (NPT). Past revelations of Iran's covert nuclear installations render the first pathway the most worrisome in the Iranian case. In each scenario, options for enhanced safeguards ranging from applying technical measures to establishing legal obligations are discussed. The implementation of these options is, however, bound by the realities on the ground.

To address these limitations, three criteria are introduced in section three, which evaluates the feasibility of the enhanced safeguards options proposed in the previous section. These decision factors are described as: political acceptability, technical feasibility and effectiveness, and resource constraints. Undoubtedly the most effective measure, which would be politically acceptable to all sides and technically feasible, is the ratification of an Addi-

tional Protocol by Iran. Nonetheless, the report offers additional measures to establish an “Additional Protocol Plus,” in order to further increase confidence in the purely peaceful scope of the Iranian nuclear program.

In the past few years, the United States and its allies have deployed the “dual-track” approach consisting of pressure and diplomacy. As the initial overtures and engagement efforts of the Obama administration came to naught, coercive measures became the only page in the playbook of Iran’s negotiating partners. Yet, punitive measures have not achieved the goal of decelerating Iran’s nuclear drive or eliciting the country’s increased cooperation with the IAEA. The report goes beyond the usual dichotomy of military action and containment to outline options for a negotiated solution of the nuclear issue. Positive sum diplomacy can achieve this goal by increasing “the correlation of fortunes” among key players, breaking free of zero sum games, and creating win-win opportunities.

A clear outline for a package of incentives that could constitute the outcome of a positive sum diplomatic approach is presented in section four. While previous incipient packages, discussed with Iran between 2005 and 2008, contained nebulous inducements ranging from membership in the World Trade Organization to cooperation in the fight against terrorism, this report contains concrete incentives, which are related to the energy sector. Not only could these measures be leveraged in an adroit diplomatic process with Iran, they could establish an adequate precedent for application in cases with other nuclear aspiring countries.

Lastly, section five provides recommendations for the Iranian government, the U.S. administration, the Russian government, the United Nations Security Council, and the International Atomic Energy Organization. These key players were selected as each could play a vital role in resolving the Iranian nuclear issue; and subsequently preserving the integrity of the non-proliferation regime. The recommendations center around a few main subjects: confidence building, respectful engagement, reciprocal compromise, and setting legal guarantees.

Given the short-term ineffectiveness of punitive measures and long-term consequences of military action, diplomacy provides a viable, and arguably best, option for resolving the Iranian nuclear impasse. The measures set out in this report offer a foundation for a diplomatic effort focusing on establishing robust safeguards on Iran’s nuclear program. Based on the available evidence from international nuclear inspectors, it appears that the pace of Iran’s nuclear advancement is much slower than portrayed by the alarmists on both sides of the divide. It is also not clear whether Iranian leaders have decided on building a nuclear weapon or not. Therefore, there is still time for diplomacy to compel them not to take this perilous decision.



## INTRODUCTION

Iran's controversial nuclear program has been front and center on the international stage for more than eight years. Despite negotiations, sanctions and political tug-of-war, the United States and its allies have yet to tame Iran's atomic phoenix. Insisting on their nation's "inalienable right" to enrich uranium and acquiring peaceful nuclear energy, Iranian leaders continue to pursue their "zero compromise" policy.

At the crux of this nuclear standoff is Iran's controversial uranium enrichment program and efforts to obtain full nuclear fuel-cycle capabilities. To alleviate concerns about the intended nature of these activities, the United Nations Security Council (UNSC) has demanded – through six resolutions since 2006 – that Iran suspend enrichment activities as well as construction of a heavy-water research reactor. Characterizing them as "unwarranted," "politically motivated," and thus "not worth a penny," Iran has opted to pay no heed to these resolutions. [1]

The outcome of the two sides diagonally opposed viewpoints has been a zero-sum predicament. Ideally, the United States and its allies would want Iran to cease uranium enrichment because even a relatively small enrichment plant would provide Tehran with a latent capability to make weapons-usable uranium. This technology is dual-use in that an enrichment plant can be used to make low-enriched uranium (LEU) for nuclear fuel or highly enriched uranium (HEU) for nuclear weapons.<sup>1</sup> In contrast, the ideal situation for Iran is to continue its march towards becoming a nuclear threshold state by enhancing its enrichment capacity. Given Tehran's political and capital investment in its enrichment program, halting it appears politically impossible for the foreseeable future.

Despite numerous proposals from different sides, the stalemate persists. A litany of multi-lateral and unilateral sanctions has corralled the Iranian economy. Yet, sanctions have failed to curb Iran's plans to pursue its refinement of uranium.[2] Tehran recently announced plans to triple production of – 20 percent – enriched uranium and to transfer it to a bunkered facility in Fordow, to demonstrate its unabated atomic drive.[3] As a member of the Non-Proliferation Treaty (NPT), Iran has the right to enrich uranium to 20 percent and even higher potency, so long as it uses the uranium solely for peaceful purposes and operates under the supervision of the International Atomic Energy Agency (IAEA).

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<sup>1</sup> The dividing line between LEU and HEU is uranium enriched to 20 percent in the fissile isotope uranium-235. The higher the enrichment of U-235, the more useful the material is for nuclear weapons.

During its 32 years of existence, the Iranian theocracy has demonstrated a strong adhesion to the instruments of power, which it considers vital to its security and survival.[4] Resistance to Western pressure has always been depicted as the regime's *raison d'être*. The metamorphosis of the nuclear issue into an instrument of power and a symbol of resistance has emboldened this ethos of defiance. The leaders in Tehran have long considered the international pressure on the nuclear program a disguised instrument for changing the clerical regime. Concomitantly, the Iranian government has persuaded its citizenry that its pursuance of nuclear technology is a noble and necessary endeavor for life after oil and turned the nuclear program into a highly nationalistic issue. According to a recent survey, 87 percent of Iranians strongly favored their country's development of nuclear energy for civilian use.[5]

An Iranian nuclear weapon is neither imminent, nor inevitable. Thus, there is still time to achieve a peaceful resolution of the crisis through diplomacy. Ali-Akbar Salehi, Iran's foreign minister and former head of the Atomic Energy Organization of Iran (AEOI), stated recently, "No conflict is eternal. Therefore, one day, Iran's nuclear issue will be solved... We desire a win-win solution. Now, if the Westerners believe in this solution, they should show up at the negotiating table. We are ready. If they don't believe in it, they should continue their path, since the pressure has hardened us." [6] Hence, the time is ripe for a creative initiative to put the genie of Iran's nuclear crisis back in the bottle. A Russian proposal is now on the table. The so-called "step-by-step" proposal is a phased approach in resolving the stalemate, whereby Iran would address questions raised by the IAEA about its nuclear activities in a staged schedule and in return economic sanctions imposed on Iran would be lifted in a staged manner over time.[7] Still the details of this plan are not clear.

This report proposes a multipronged approach in resolving the stalemate. Enhanced safeguards, as the most important pillar of this proposal, allows for a rigorous and diligent monitoring of Iran's nuclear activities, while offering a face-saving solution to all stakeholders. Iran, however, should have enough incentives to agree to a more stringent supervision of its activities. Positive-sum diplomacy, thus, constitutes the second pillar of our approach. By increasing "the correlation of fortunes" among key players, positive-sum diplomacy increases the chances of breaking free of zero-sum games and creating win-win opportunities.[8] To facilitate such an approach, this report recommends a set of incentives that could be used not only in the case of Iran, but also applied to other aspiring nuclear states and would-be nuclear proliferators. This report concludes with a set of recommendations for all key players in the Iranian nuclear issue.

## OUTSTANDING ISSUES

Since 2003, the IAEA has inspected, about every three months, Iran's 16 nuclear facilities and nine hospitals where nuclear materials are used.[9] Although all the declared Iranian nuclear activities are under the IAEA's supervision, Tehran continues to disregard the resolutions of the agency's Board of Governors and the UNSC demanding suspension of enrichment, heavy water, and reprocessing activities. Moreover, the IAEA has called on Iran repeatedly to answer outstanding questions about past, present, and planned nuclear activities and possible military dimensions of its nuclear program. After more than eight years, the issues that remain unresolved between Iran and the agency fall into three broad categories:

### *Past activities*

The possible military dimensions of Iran's nuclear program, including work with high explosives, detonators and advanced neutron initiators, constitute the most critically unresolved issues between Iran and the IAEA.[10] The agency's May 2011 report indicated that, contrary to the 2007 U.S. National Intelligence Estimate, some of these activities might have continued after 2004.[11] The discovery of several clandestine enrichment plants has further raised concerns that Iran may have a covert nuclear weapons program. In some cases, including nuclear installations at Natanz, Kalaye Electric, and Lavizan, Iran only declared the formerly secret sites after they were unveiled by other nations and groups.

Most recently, in September 2009, the leaders of France, Germany, and the United States revealed that their governments had evidence that Iran was building such a plant near the city of Qom. Upon this exposure, Iran was compelled to inform the IAEA about the Fordow Enrichment Plant. At that time, Iran stated that the Fordow plant was designed for the production of five percent enriched uranium and would contain 16 cascades, corresponding to about 3,000 centrifuges. Almost exactly a year later, however, Iran told the IAEA that it had revised its plans so that the Fordow facility would include research and development on advanced centrifuges in parallel to pro-

duction of five percent enriched uranium with the older-generation centrifuges. Recently, Iran announced that the facility would be exclusively used for producing 20 percent enriched uranium. The IAEA has asked Iran to clarify its intentions and provide a detailed design for this facility. Iran has objected to the legal basis for the IAEA's request for access to design development information and to the companies that are designing the Fordow plant. Thus, the chronology and the purpose of the Fordow plant have turned into the newest mooted question of the Iranian nuclear dilemma.

### *Level of cooperation*

The diplomatic impasse has soured relations between Iran and the IAEA and consequently reduced Iranian cooperation with the agency. Except for sporadic sightseeing tours of the heavy-water reactor and production plant, Iran has not provided full access to its heavy water production and storages to the international nuclear inspectors.[9] The UNSC has called on Iran to suspend work at this facility. However, according to the IAEA's September 2011 report, this work is ongoing.[9] The IAEA also has used satellite imagery to monitor uranium-mining and –milling activities in Iran. Under the 1974 safeguards agreement, Iran would not have to give the IAEA access to the uranium mines and mills. Moreover, Iran has not responded to the Agency's requests to provide more information about its laser enrichment technology and refuses to apprise the agency about its additional enrichment plants.

### *Access to information*

Another contentious issue is the IAEA's access to information in a timely manner. For example, the IAEA has no detailed design information on Production Hall B at the fuel enrichment plant near Natanz. Qualifying these requests as illegal and beyond its safeguards agreements, Iran has refused to provide this information to the IAEA. Nonetheless, Tehran previously had indicated willingness to be more forthcoming. On February 9, 2003, the IAEA obtained Iran's agreement to provide early notification of design information upon decision to construct a nuclear facility. This provision is part of the modified Code 3.1 for the subsidiary arrangement to Iran's 1974 comprehensive safeguards agreement. Under this agreement, the IAEA has the obligation to ensure that a state's declaration of its nuclear material and peaceful nuclear activities is correct

and complete. In 2007, after the IAEA referred Iran's case to the UNSC, Iran unilaterally decided to suspend implementation of the modified Code 3.1. Since then, Iran has adhered to the less rigorous interpretation of the 1974 safeguards agreement. Concomitantly, the IAEA's knowledge regarding Iran's enrichment activities is continuously shrinking.

Iran has announced plans to construct ten additional enrichment facilities, but it has not given the IAEA details about the proposed sites and design information on these facilities.[12] Such information would help the IAEA in determining where best to place monitoring equipment in safeguarded facilities before they are built. Once a facility is constructed, obtaining access to areas that are considered proprietary becomes extremely difficult. Facility operators are exceedingly wary of revealing industrial secrets to competitors. By agreeing on where to place monitoring devices ahead of actual construction, the IAEA and the operators have greater opportunity to find a balance between optimizing safeguards and minimizing the likelihood of revealing sensitive information.

## OPTIONS FOR ENHANCED SAFEGUARDS

A non-nuclear-weapon state could try to exploit three different proliferation pathways:

- Operation of a clandestine nuclear weapons program, which would as much as possible be parallel to and separate from a declared, safeguarded nuclear program.
- Diversion of weapons-usable material and technologies, such as centrifuges, from a declared, safeguarded program into a weapons program.
- Withdrawal from the nuclear NPT and the IAEA safeguards system and then use of the acquired nuclear technologies to make fissile material for nuclear weapons.

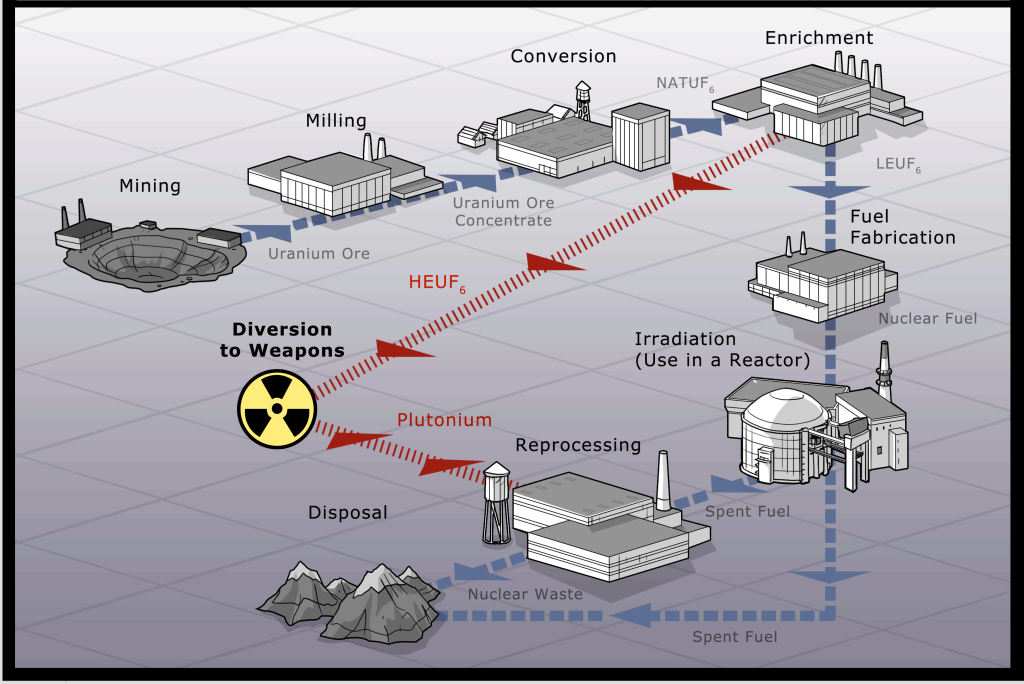
### *Clandestine Nuclear Program*

The first pathway is the most likely Iranian route to a nuclear weapon, as the genesis of Iran's nuclear crisis was associated with the revelation of its covert facilities, of which the most recent was discovered in 2009. Operating covert facilities is the most worrisome weaponization scenario, as under the current safeguards approach, the IAEA's access is solely limited to declared facilities and thus is constrained in its ability to discover undeclared facilities, materials, or activities. The Model Additional Protocol, however, expands safeguards to cover all activities in the nuclear fuel cycle depicted in Figure 1. In comparison, Iran's comprehensive safeguards agreement includes enrichment, fuel fabrication, reactors, spent fuel storage, reprocessing, and the output of a uranium-conversion facility, but does not include mining, milling, waste disposal, and the input to a conversion facility. Thus, there is a possibility that uranium ore or its concentrates be used as feedstock in a clandestine facility. Although the IAEA carried out complementary access of Iran's mines and mills in 2004, the Additional Protocol would allow for a regular and accurate material accountancy.[13] Yet, from a technical point of view, detailed material accountancy is expensive and laborious.

The Model Additional Protocol offers complementary access to sites and facilities where inspectors need to resolve unanswered questions and concerns. This access does

**Figure 1: The Nuclear Fuel Cycle**

In this schematic diagram of the nuclear fuel cycle, dashed lines show possible routes for diversion of nuclear material to production of nuclear weapons.



not mean that the inspectors can barge into a site or facility immediately. Under the managed-access provision, they can request access within two hours to a facility at a site that they are presently inspecting and within 24 hours to a site at which they are not presently conducting inspections. Inspections under the Model Additional Protocol are more resource intensive and burdensome to the state than inspections under a comprehensive safeguards agreement. Therefore, the IAEA offers integrated safeguards for those states in which, after the implementation of the additional protocol, the agency has resolved outstanding concerns and has determined that there are no undeclared nuclear materials and facilities. The integrated safeguards system reduces the overall

frequency of inspections and instead provides assurances through unannounced random inspections and complementary access. In sum, the revised safeguards system under the Model Additional Protocol expands the emphasis from verifying nuclear materials at individual facilities to evaluating the state as a whole.

Methods to uncover these materials and facilities include satellite monitoring, wide-area environmental sampling (WAES), and human intelligence. In recent years, the IAEA has established a satellite-imagery laboratory to detect physical indicators of clandestine facilities. The agency has acquired high-resolution commercial images obtained by 16 satellites operated by 11 imagery providers in eight states.[14] In the past few years, the IAEA has purchased and analyzed several hundred images. Satellite imagery, however, can be hampered by clouds and satellites' fixed orbits.[15]

WAES monitors the air, water, and sediments to search for the presence of radioactive materials that could indicate clandestine nuclear activities, such as hidden enrichment and reprocessing plants.[16] WAES is permitted under the Model Additional Protocol as long as the Board of Governors has approved its use, which depends on a demonstration of its effectiveness and consultations between the IAEA and the state. Because there is no precedent for applying WAES under a state's additional protocol, this measure would effectively be considered a supplement to additional protocols that states have already implemented.

To detect secret enrichment plants, WAES would need to discriminate between enriched uranium and natural uranium, by measuring the ratio of U-235 and U-238. Any ratio greater than 0.72 divided by 99.28 (the percentages respectively of naturally occurring U-235 and U-238) could indicate clandestine enrichment activity. The WAES monitoring station would also search for fluorine, which is chemically combined with uranium.<sup>2</sup> Uranium hexafluoride (UF<sub>6</sub>) would point towards the presence of uranium-conversion and -enrichment plants. The evidence would not necessarily be a smoking gun. In a state in possession of a declared enrichment plant, the inspectors have to discern the source of UF<sub>6</sub>. Moreover, UF<sub>6</sub> leakage in modern enrichment plants is usually negligible.

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<sup>2</sup> The gas is "enriched" by separating U-235 hexafluoride from U-238 hexafluoride and thus increasing the U-235 concentration.



Hence, to significantly increase the likelihood of detecting enriched uranium in a relatively large country, such as Iran, at least a few tens of thousands of WAES monitoring stations would be required with a detection radius of about 10 kilometers for each station. A much more modestly scaled network with 400 stations for a detection range of about 100 kilometers would have an estimated annual cost of just less than \$17 million.[17] Nevertheless, the low likelihood of detection and invasive nature of this technique raise substantial barriers to its use in Iran. In contrast to enrichment plants, molecular uranyl fluoride ( $\text{UO}_2\text{F}_2$ ) produced in conversion facilities and the relatively large and distinctive releases of krypton-85, a rare radioactive gas, at the reprocessing plants make them better targets for WAES. Nevertheless, a state could try to hide these emissions by installing filtering systems.

Arguably, the most effective means for finding evidence on clandestine facilities is by using human intelligence. Although this craft often has the connotation of spying, the sense here is to provide IAEA inspectors with access to scientists and engineers, who have worked on the peaceful nuclear program. The inspectors then would have permission to ask questions of these personnel. During such investigations, some of these scientists and technicians may provide evidence of a clandestine program advertently or inadvertently. The interviews should be recorded and take place inside the inquired country. Whistleblowers likely would need protection against retribution. Based on Iran's rebuffs of several IAEA requests in recent years to question personnel, Tehran most likely would resist providing this extra measure.

### *Diversion of Nuclear Material*

For the second pathway, diverting material and technologies from a safeguarded program into a weapons program, enhanced safeguards would provide better means to detect or substantially raise the likelihood of detecting the diversion of nuclear materials and technologies from declared facilities. Using the authority provided by Iran's 1974 comprehensive safeguards agreement, the IAEA has done an effective job of verifying that Iran has not diverted declared material. The safeguards methods briefly outlined here would go beyond Iran's interpretation of its current safeguards agreement or even an additional protocol. Conceivable methods include applying physical contain-

ment and material accountancy at uranium mines and mills, measuring the mass of uranium ore concentrate entering conversion plants versus the amount of  $UF_6$  leaving these plants, improving measurements of nuclear material at enrichment plants, and verifying the production of centrifuges.

Physical containment at mines and mills would involve placing fences around these facilities. The fencing would employ detectors that would sound alarms, if someone breached the fence or used unauthorized access points. Portal monitors would check on traffic to and from the facilities. This method would be considered highly invasive, and there is no precedent for it under the Model Additional Protocol, which requires a state to submit estimated annual information on its uranium mining and milling. Yet, neither the Model Additional Protocol nor states' additional protocols have required the more burdensome step of providing detailed material accountancy at these facilities.

After uranium is milled, it is in the form of uranium ore concentrate. Measuring the amounts of this material entering a uranium-conversion facility could enhance safeguards. By measuring the amount of uranium in the ore entering the plant and the amount of uranium in  $UF_6$  leaving the plant, the uranium mass balance measurement is taken. Any discrepancy in the uranium mass balance close to or certainly larger than the amount of uranium needed for a nuclear weapon—25 kilograms of U-235, according to the IAEA—would be cause for concern.

Additional safeguards on enrichment plants can involve a number of different activities and techniques, but the most important concept is to provide timely warning of diversion of nuclear material enough to make a weapon. For enrichment plants, the IAEA typically has had a goal of 12 months to detect a diversion of this quantity of fissile material. The agency has been visiting the Iranian enrichment facility at Natanz on a much more frequent basis; however, it has performed the physical inventory verification (PIV) annually.

To reduce the uncertainty in the measurement error further, the IAEA could increase the use of destructive analysis (DA), which is a set of scientific techniques that destroy or alter a sample in order to determine the characteristics of the larger amount of material. Although DA is very accurate, it is expensive and can significantly increase the cost of inspections. Additionally, the IAEA could make independent measurements on all items of nuclear material. Despite having the legal right to do this, the IAEA usually performs verification procedures on a randomly selected subset of items to reduce the cost.

Verifying production of centrifuges could enhance safeguards significantly. A major concern is that Iran could be manufacturing excess centrifuges at declared production facilities or making them at undeclared facilities. Either way, greater access to production facilities would increase the likelihood of deterring diversion of centrifuges. The IAEA is not permitted to have access to these facilities under comprehensive safeguards agreements, but the Model Additional Protocol does require a state to give the IAEA a “description of the scale of operations for each location” involved with fuel cycle activities, including production of centrifuges.[18] However, providing detailed information on manufacturing centrifuges would require a special agreement between Iran and the IAEA, as the Model Additional Protocol does not authorize the agency to inspect the production of centrifuge components. Ideally, the IAEA should have the ability to tag and count centrifuges, ensuring that they are installed only in declared facilities.

### *NPT Withdrawal*

The third pathway, withdrawal from the NPT, is the least likely as long as Iran derives benefits from staying within the treaty. Of course, once Iran signals its intention to leave the NPT, there will be little or no doubt that the country’s leadership intends to embark on nuclear weapons production. Article X of the NPT allows a state to cite its supreme national interests and depart the treaty on three months’ notice. Because comprehensive safeguards agreements under IAEA Information Circular 153 are linked to the NPT, a withdrawal from the NPT would stop application of these safeguards.

To ensure continued safeguards, one approach would be to require states that are withdrawing from the NPT and are in noncompliance with their comprehensive safeguards agreements to adhere to facility-specific safeguards, which are defined in IAEA Information Circular 66. Because this type of safeguards does not depend on adherence to the NPT, such safeguards would remain in perpetuity. The UNSC would have to pass a resolution to require application of continued facility-specific safeguards. It also could pass a generic resolution, not tied to a particular case, requiring a special inspection to investigate the possible misuse of nuclear materials and technologies that a state in noncompliance acquired when it was an NPT member.<sup>[19]</sup> Because UNSC member states would likely prefer to address safeguards noncompliance on a case-by-case basis, it would be difficult to obtain passage of such a resolution. Similarly, the IAEA's Board of Governors has been reluctant to exercise its authority under its own statute to call for special inspections in any state.

## DECISION FACTORS

Several enhanced safeguards options are conceivable, but few additional measures are likely acceptable to all states.[20; 21] The decision factors are political acceptability, technical feasibility/effectiveness, and resource constraints.

### *Political Acceptability*

Justice is a fundamental principle in the Iranian psyche. From the time of the pro-Western Shah of Iran to the Islamic Republic's firebrand president Mahmoud Ahmadinejad, Iran has resisted adopting safeguards measures beyond what other states have applied. Furthermore, Iranian leaders believe that compromise only invites more pressure. They maintain that mastery of uranium enrichment was attained not with the détente policy of the reformist president Mohammad Khatami, but under the conservative administration of Mahmoud Ahmadinejad and his uncompromising nuclear stance.

The United States faces political constraints as well. The Obama administration would not want to appear weak, especially in the lead-up to the 2012 presidential election. The U.S. House and Senate have introduced bills (H.R.1905, S.1097) to expand sanctions against Iran and restrict the president's prerogative to waive them.[22] There is also tremendous pressure on the Obama administration to impose sanctions against the central bank of Iran, an unprecedented measure that could be considered an act of war.[23]

Finally, the IAEA has its own political challenges as its leadership has to remain politically neutral while balancing the demands from developing and more technologically advanced states. The developing states usually seek more technical assistance from the IAEA for their peaceful nuclear programs, and they want less-intrusive monitoring of their activities. In comparison, states with greater political power and monetary resources typically do not need much, if any, technical assistance from the IAEA. Several

of these states, such as the United States, however, favor greater efforts to ensure that peaceful nuclear programs remain such.

### *Technical Feasibility and Effectiveness*

Physical constraints impede the capability to detect clandestine enrichment plants. Enrichment plants that use the centrifuge technique emit few, if any, strong signs, such as uranium leakage, heat emissions, and electronic signals, to indicate uranium refining.  $UF_6$  emission from modern centrifuge enrichment plants is negligible.[24] Detection of leakage from the previous stage of the nuclear fuel cycle — the uranium-conversion plant that makes  $UF_6$  and  $UO_2F_2$ — might be possible, although high-efficiency particulate filters could significantly reduce this leakage.

The energy consumption of a centrifuge enrichment plant is small. Thus, the heat emissions, as shown by infrared radiation, are not easily distinguishable from non-nuclear industrial facilities. Electronic signals might be more detectable.[25] The electrical systems in a centrifuge plant would affect the electrical signals carried by the power lines coming into a plant. In particular, the operation of the spinning centrifuges would impose voltage and frequency distortions — a sort of electronic “fingerprint” — on the power lines. To detect these signals, however, the inspectors would need access to these lines, and appropriate electronic filters could reduce or eliminate them. Moreover, satellite images and over-flights might reveal buildings that house enrichment facilities, but without human intelligence, confirmation cannot be definitive. In sum, off-site detection of centrifuge enrichment is extremely challenging.

### *Resource Constraints*

Because of the physical challenges of remote detection, on-site access remains one of the most essential requirements for effective safeguards. Yet, the IAEA faces substantial resource constraints. Its limited budget and human resources are insufficient to implement all conceivable safeguards options. The disparity between the amount of nuclear material and facilities under safeguards and the money budgeted to the IAEA Department of Safeguards has been growing. During the past three decades, the quantity of

**Table 1: Feasibility of Enhanced Safeguards Options**

The table below lists various options for enhanced safeguards in Iran and evaluates their feasibility on the basis of certain key criteria.

Options	Political acceptability	Technical effectiveness	Feasible given IAEA's resource constraints
<b>Additional Protocol</b>	Yes	Would provide significantly improved capability	Yes
<b>Satellite monitoring</b>	Iran cannot stop its use	Would provide improved capability as long as supplemented with additional information	Yes, but currently limited up to a few hundred images annually
<b>Wide area environmental sampling</b>	Not likely because of its intrusive nature	Would likely not provide substantially more capability given Iran's landmass	Would require significantly more resources
<b>Interviews with Iranian nuclear personnel</b>	Unlikely, especially after assassination of Iranian nuclear scientists	Would likely provide significantly improved capability	Yes
<b>Physical containment of mines and mills</b>	Unlikely	Would likely not provide significantly improved capability	Would require some more resources
<b>Material accountancy at mines and mills</b>	Unlikely	Would likely not provide significantly improved capability	Would require some more resources
<b>Measuring the mass balance at uranium conversion plants to compare the mass of uranium going into and out of the plants</b>	Likely to obtain especially if Iran would agree to an additional protocol because this measure would not go significantly beyond such a protocol	Would likely provide significantly more capability	Would require some more resources
<b>Improved measurements at enrichment plants</b>	Likely to obtain if it can go not too far beyond an additional protocol and as long as proprietary information is protected	Would likely provide significantly more capability	Would require some more resources
<b>Verifying production of centrifuges</b>	Unlikely to obtain because of likely Iranian perception of intrusiveness on its proprietary information	Would provide significantly more capability	Would require some more resources
<b>Facility-specific safeguards</b>	Very unlikely to obtain agreement	Would likely provide significantly more capability	Yes
<b>Special inspections</b>	Only conducted twice: in Romania (voluntarily) in 1992 and North Korea (involuntarily) in 1993. Can be called by the Secretariat, but needs Board of Governors agreement if the state refuses and UNSC if the state withdraws	Would provide significantly more capability	Would require more resources

material has expanded about six fold, and the number of facilities has roughly tripled, while the budget has approximately doubled.[26] Unless IAEA member states provide more financial and human resources, the agency will remain substantially constrained in its ability to apply more rigorous safeguards in more states.

Of the roughly dozen options considered here, very few meet the criteria of political acceptability, technical effectiveness, and feasibility given scarcity of IAEA resources. Political acceptability depends on Iran's willingness to agree to an additional safeguards measure and on the ability of the international community to reach consensus among the members of the UNSC and the Board of Governors. Technical effectiveness, as the analysis above indicates, hinges on whether the option provides significant enhanced capability to the safeguards system. Resource constraints affect the IAEA's choices in what additional measures it can afford to apply to Iran or any other state under safeguards. Table 1 shows these options and an assessment based on the criteria.

As Table 1 illustrates, few good options receive high marks under the three criteria. Therefore, the best course of action is, first, to reach agreement to apply an additional protocol in Iran. This step has the precedent of dozens of other states having ratified an additional protocol to their safeguards agreements and of Iran's previous willingness to implement it voluntarily. It also significantly enhances the capabilities of the safeguards system and fits within IAEA resource constraints.

In their discussions with Iran, policymakers and negotiators should give priority to obtaining agreement on application of measurements of the mass balance of uranium entering and exiting conversion plants and on improvements in tracking flows and measuring the mass balance of uranium at enrichment plants. These two options have the advantage of likely obtaining political acceptance, providing significant technical effectiveness, and requiring only somewhat more resources for the IAEA. If the international community can reach agreement with Iran on application of more safeguards options, they should focus on those, such as verifying production of centrifuges, which would provide significantly improved effectiveness.



## MAKING A DEAL

Pressure without an open door is an exercise in futility. Sanctions as a tool of influence would be effective only when coupled with diplomacy. Aware of this principle, American officials frequently assert that, “sanctions and pressure are not an end in themselves; they are a complement, not a substitute, for the diplomatic solution to which we and our partners are still firmly committed.”[27] In practice, when early efforts of the Obama administration to engage Iran through diplomacy failed, punitive measures became the only page in the P5+1’s playbook. The effectiveness of sanctions is a subject of conjecture. Undoubtedly, the punitive measures have severely impaired critical sectors of Iran’s economy such as its financial system, insurance companies, transportation, shipping, and most importantly the oil and gas sector. At least \$60 billion foreign investment in the energy sector has been scuttled and nearly half of the companies that previously worked in the Iranian energy sector have stemmed their commercial work in the country.[28; 29]

Yet, since its inception, the Islamic Republic has been subject to a steady stream of sanctions. After more than three-decades, the Iranian regime has come to master the art of skirting sanctions and has even learned to thrive in isolation. The recent round of sanctions augured in deep economic reforms to remove the subsidies from energy products and basic staples, which cost about \$70 billion, equating to nearly 20 percent of Iran’s GDP. The implementation of the long-due economic overhaul, profusely hailed by the International Monetary Fund, can be considered an indirect consequence of the international sanctions.[30] It can be anticipated that as sanctions over the past three-decades failed to preclude development of long-range missiles and advanced chemical/biological capabilities in Iran, they could come short of damping Iran’s nuclear drive.

In the most optimistic scenario, the international pressure has only achieved a temporary deceleration of Iran’s march towards becoming a virtual nuclear weapon state. The number of centrifuges has increased almost eight fold since the UNSC imposed sanctions on Iran. Tehran has unveiled new generations of its more sophisticated IR-2m and IR-4 centrifuges, which are reportedly three times more efficient than the antiquated

IR-1 machines. Iran is now enriching at 20 percent in Natanz and is equipping the Fordow facility, hardened against air strikes, with IR-1 cascades to exclusively produce 20 percent enriched uranium.

By now, many American and Israeli officials have come to realize that there is no military solution to the crisis.[31; 32] Scholars also contend, based on historical evidence, that military force might not even yield the modest outcome of temporarily delaying Iran's nuclear program.[33] Studies show that attacks on Iraqi nuclear installations only whetted Iraqi leader Saddam Hussein's appetite for nuclear weapons. Iran's nuclear facilities are dispersed and near population centers, making the international political costs of a strike for Israel and the war-weary United States potentially enormous. Therefore, diplomatic efforts should be revived by providing the Iranian government with concrete, realistic, and attractive alternative avenues to the current punitive treatment it receives on the world stage.

This is not an easy task as Iran has come to regard western-led diplomatic efforts as means towards the end of curtailing the country's right in having nuclear power. In 2004 after negotiation with the United Kingdom, France, and Germany ("the EU-3"), Iran voluntarily suspended all its enrichment activities and implemented an additional protocol. Despite these important confidence-building measures, the negotiations lingered and eventually failed. The main reason was the failure of the EU-3 to obtain the United States' approbation in offering an apt package of incentives to Iran. Consequently, Iran restarted uranium enrichment and even accelerated the pace of its program.

Cajoling Iran to change its current course requires, in addition to restoration of trust, a consensus among all stakeholders on what should be offered to Iran. Contrary to previous proposals by the international community, the incentives proposed to Iran should not be case-specific. Allowing Iran to become a member of the World Trade Organization (WTO) or providing other economic or security-related incentives would set a precedent that could entice other nuclear-aspiring countries to achieve their goals through pursuit of dual-use technologies. Instead, as Iran argues that its peaceful nu-

clear program is for energy production, the incentives should solely target Iran's energy sector, which is facing monumental challenges ranging from lack of investment, poor management, growing demand, and declining production.

Natural gas accounts for 53 percent of Iran's total domestic energy consumption with the remaining 44 percent coming predominately from oil.[34] Ranking third in the world, Iran's proven oil reserves are estimated at 138 billion barrels. Before the Islamic Revolution of 1979, Iran's oil production hovered around six million barrels a day (mb/d), of which five mb/d were exported. Since then the population has doubled in size, the domestic consumption has skyrocketed and oil wells have considerably aged. Today, only 2.5 mb/d of Iranian oil reaches the world market. As much as 400,000 b/d of new capacity is needed every year just to maintain current production levels.[35]

The Iranian gas sector faces similar predicaments. Despite having the second largest natural gas reserves in the world, Iran ranks only 26<sup>th</sup> among natural gas exporters. Over two-thirds of Iranian natural gas reserves are located in non-associated fields, and remain untapped.[34] Iran is also incurring significant losses for falling behind in developing its part of South Pars, the world's largest gas field shared between Iran and Qatar. Approximately 16 percent of Iran's gas production is re-injected into the wells for enhanced oil recovery. Shrinkage, loss, and flaring accounted for about 14 percent.[34] If Iran were to reduce its waste of natural gas at the wellhead, it could generate electrical power at a small fraction of the cost of nuclear energy. Natural gas plants have low capital cost, are rapidly built, offer high reliability, and present the most attractive carbon balance among fossil fuel options. Capturing and using the flared gas in excess of the Middle East or North America average flaring rates would support electrical generation projects equivalent of two to four nuclear reactors with 1000 MWe capacity per reactor.[36]

In addition to domestic energy production, incentives to maximize Iran's export of natural gas should be appealing to the leaders in Tehran. A pipeline from Iran would provide needed alternative gas supplies to Turkey. Moreover, Iran could be invited to join the Nabucco pipeline that would stretch some 2,000 miles from Turkey through

Bulgaria, Romania, Hungary and Austria.[37] While Nabucco would diminish European dependence on Russian gas, the rising European demand will guarantee continued Russian supplies and thus will deflect Russia's objection. Such an arrangement would provide leverage for Iran over Turkey and other European states, if they were included in any nuclear deal with Iran. Mutual interest, i.e. European energy security in return for investment in Iranian energy sector, pipelines and even nuclear industry, crystallizes the concept of correlation of fortunes.<sup>3</sup>

None of the above-mentioned deals, however, could be realized without restoration of trust and recognition of potential risks. For years the mantra of the IAEA has been to "Trust, but verify." It will take considerable effort from all sides to bridge the trust gap and compromise on an Iranian nuclear program thoroughly verified by the IAEA. The following recommendations could help to pave the way towards this goal.

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<sup>3</sup> Potential energy-related projects for cooperation between Iran and the international community are the subject of an upcoming FAS special report.

## RECOMMENDATIONS

### *Iran*

- One of the first major steps that Iran can and should take is to ratify an additional protocol to its comprehensive safeguards agreement and commit to fully implement the new IAEA Code 3.1. In December 2003, Iran agreed to voluntarily implement an additional protocol, but it reversed its decision in February 2006, just two days after the IAEA Board of Governors referred Iran's nuclear file to the UNSC. Such a protocol, if fully implemented, would allow IAEA inspectors to make a determination of whether Iran has any undeclared nuclear materials or facilities. Measures to supplement the Model Additional Protocol would provide needed confidence that Iran is committed to a peaceful nuclear program. Iran could apply such an "Additional Protocol-Plus" system of safeguards until outstanding concerns are addressed and confidence that its nuclear program is entirely peaceful has been restored. If these concerns are fully resolved, Iran could then apply an additional protocol and eventually an integrated safeguards system to reduce the burdens of safeguards. The only way that Iran could provide assurances about the peaceful intentions of its nuclear program is through cooperation with the IAEA. Therefore, opening the gates of its nuclear facilities, providing access to its scientists and putting its nuclear program under enhanced safeguards, would be in Iran's enlightened self-interest.
- Iran's current stance regarding the outstanding questions on its past nuclear activities and the potential military dimension of its program is not constructive. Iran should recognize that from the vantage point of the IAEA, the 2007 modality plan has not resolved all issues of contention. Therefore, Iran should be prepared to answer these questions as part of a new work plan.
- By employing a maximalist "zero-compromise" position, Iran will not be able to gain international recognition of its right to peaceful nuclear power. From a purely legal point of view, Iran requires another UNSC resolution, authorizing the continuation of its nuclear program under specific conditions. As the cur-

rent resolutions require suspension, not termination, of all enrichment-related and reprocessing activities, Iran should be prepared for a *pro forma* or a symbolic suspension of one day or one week to meet the objective of the resolutions once an agreement has been secured.

- To restore the international community's confidence in the exclusively peaceful nature of its nuclear program, Iran should ratify the Comprehensive Nuclear-Test-Ban Treaty (CTBT). As Iran's Supreme Leader has already issued a fatwa in 1995 against weapons of mass destruction, there should be no hurdle in ratifying the treaty.<sup>4</sup>
- In order to demonstrate its irreversible commitment to peaceful nuclear activities and to provide a guarantee that it will never withdraw from the NPT, Iran should consider renouncing article X of the treaty or perpetuating its safeguards agreement.[38]
- Iran should pass a whistleblower protection act to assure the international community that those scientists and technicians, who are involved in the country's nuclear program, are allowed to raise the alarm bells in the case of any diversion from peaceful nuclear activities.
- Iran should not conflate its current dispute with the IAEA, with ratification of nuclear safety and security conventions. With the official launch of the Middle East's first commercial nuclear reactor in Bushehr in September 2011, Iran became the only nuclear power country that is not a signatory to the convention on nuclear safety. This has increased the angst of Iran's Arab neighbors as Bushehr is closer in geographical proximity to Dubai, Kuwait City, Manama, Doha, and Saudi Arabia's oil rich eastern province than it is to Tehran.[39]

### *United States*

- There is growing recognition and grudging acceptance among the majority of the permanent UNSC members of the fact that Iran will never relinquish its nuclear program.[40] The Non-Aligned Movement countries also consider

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<sup>4</sup> Since then Ayatollah Khamenei has explicitly stated several times that the use of nuclear weapons is prohibited in Islam.

nuclear discrimination against Iran a threat to their own rights to peaceful nuclear energy. Thus, the United States should pragmatically come to terms with Iran's right to obtain a complete fuel cycle. Ditching Iran's enrichment activities after the hefty price that the country has paid to acquire the requisite knowledge of refining uranium is simply not realistic at this time. Evidence points to the fact that, despite strong opposition from the legislative branch of the U.S. government, the Obama administration is gradually acclimatizing to this reality.[41] Washington should, however, propose adequate restrictions that would offer all sides a face-saving solution. The options for a framework that would couple acceptance of Iran's uranium enrichment with rigorous international monitoring are discussed in the IAEA recommendations section. Nearly 15 years ago, American policy experts reached the conclusion that the only solution in dealing with Iran's nuclear aspiration is to reach an agreement to limit the nuclear program, so as it is "enough to give outsiders reasonable confidence that further military progress is not being made." [42] The time to adopt this policy has finally arrived.

- The Bushehr Nuclear Power Plant could serve as a role model on reaching a compromise for the centrifuges at the enrichment centers. Although the United States, initially opposed Iran's possession of a nuclear power plant (evidenced in the 1998 Iran Nuclear Proliferation Prevention Act), once Iran agreed to repatriate the reactor's spent fuel to Russia and thus significantly reduced the risk of nuclear proliferation, Washington agreed to exempt the Bushehr plant from sanctions.
- After more than three decades of enmity, Iran and the United States will not be able to come to a grand bargain in which all their strategic and historic grievances are addressed. Nonetheless, if the current nuclear crisis is dissipated, the ground will be paved for further engagement of the two countries on issues of mutual interest, such as the future of Iraq, security in Afghanistan, the Middle-East peace process and energy security.
- Absent a fruitful diplomatic process, the United States has no reason to unravel the consensus that it has created, with significant political and diplomatic capital, around international sanctions. Nevertheless, as a goodwill gesture and to diminish mistrust, the United States should adopt practical measures that

are not related to Iran's nuclear activities. One such humanitarian measure could be lifting unilateral sanctions on civilian aircraft parts and repairs, which has caused at least fifteen Iranian plane crashes in the past decade.

- If negotiations are successful, the United States should be prepared to alter its three-decade old foreign policy discourse on Iran. Any incentive proposed to Tehran in a diplomatic process will not be realistically achievable without the approval of the United States. In return for Iran's acceptance of stringent inspections of its nuclear facilities, the United States should terminate its unilateral sanctions banning more than \$20 billion investment in the Iranian oil and gas industry and allow Western firms to restart their work in Iran's energy sector. Recent attempts by American legislators to restrict the president's authority to waive U.S. sanctions against Iran will backfire and heighten Iran's distrust.[22] At least \$200 billion investment is needed by 2015 to upgrade and expand the oil and gas industry in Iran.[43] Such a narrative of partnership will provide concrete opportunities for a win-win solution to emerge.
- The United States should work with its allies and encourage them to become clients of Iran's uranium enrichment program. Countries like India, Brazil, Turkey and eventually the United States could buy Iran's nuclear products at a competitive price in exchange for Tehran's acceptance of more-rigorous safeguards on its nuclear program.[44]
- The United States should tread carefully in skewing the balance of power in the Middle East. Strengthening the conventional forces of Iran's neighbors will only exacerbate Iran's sense of encirclement and vulnerability, further pushing the country towards the ultimate weapon.
- By ratifying and enforcing the CTBT and by encouraging Israel to follow suit and even join the NPT, the United States would demonstrate its commitment to non-proliferation and strengthen its credentials in demanding Iran and other countries to ratify and abide by the treaty.[45]
- The United States could take an extra step by placing enhanced safeguards on its enrichment plants including those owned by foreign companies. To address the economic concerns of companies operating these plants, the United States should pay for the application of these safeguards. By doing so, Washington



could become a standard-bearer for all countries in possession of enrichment plants, whether nuclear-weapon states or non-nuclear-weapon states.

- A special attention to the safety and security aspects of Iran's nuclear program, especially in the aftermath of Japan's nuclear disaster at Fukushima Daiichi, will enable the United States to adopt a less antagonizing tone towards the Iranian nuclear program and counter Tehran's "denial of rights" narrative. Such an approach creates opportunities for public diplomacy with the Iranian people, which could result in placating the nationalistic sentiments about the nuclear program inside Iran, shift the political balance back to nuclear accommodation, and expand the political space for Iranian moderates.

### *Russia*

- Russia is in a special position for bridging the gap between the United States and Iran. While Russia endorses Iran's entitlement to a civilian nuclear energy program and has been Iran's nuclear partner since 1995, it opposes a nuclear-armed Iran as much as the United States and has consistently consented to all six UNSC resolutions condemning Iran's nuclear activities. Past experience has proved that there is no "freeze-for-freeze" solution to the current crisis. Therefore, a "step-by-step" approach offers a logical path to gradually step towards a compromise. The so-called "Lavrov plan," offers such a solution. The plan invites Iran to answer the IAEA's questions, starting with easier ones that can be quickly answered and moving to more complicated questions that require more time for response. In return for genuine responses, the Russian plan suggests rewarding Iran at each step by removing international sanctions. Russia should ensure the mutuality and reciprocity of each step. Failure of this process could be detrimental as each time after failed negotiations, Iran creates new facts and realities by advancing its nuclear programs.
- Russia should devise its step-by-step proposal in a way that the final outcome be clear for all sides, lest the negotiations fall into the same trap as the six-party talks among Russia, South Korea, North Korea, China, Japan, the United States on Pyongyang's nuclear program. According to the 2005 pact among the six-parties, North Korea would rejoin the NPT, allow IAEA inspectors to

monitor its activities, and will eventually denuclearize in exchange for aid and diplomatic concessions. Yet, diplomatic standoffs between six-party member states and nebulous proposal milestones resulted in the failure of the talks after six rounds. The most important outcome of any negotiation for Iran is recognition of its legal right to enrich uranium and removal of sanctions. For the United States and its allies, the best outcome would be establishment of stringent IAEA supervision on the Iranian nuclear program. If Iran cooperates with the IAEA, the Russian proposal could offer easing and eventual removal of unilateral sanctions followed by lifting the international sanctions. It is also important to provide guarantees for Iran, that if it unveils its undeclared nuclear facilities and admits to past wrongdoings, it will not be penalized.

- Russia already has a special deal with Iran to provide nuclear fuel for the first 10 years to the Bushehr power plant. Moscow has a continued interest in supplying nuclear fuel to Iran in order to burnish its non-proliferation credentials and to undermine Tehran's stated rationale for significantly expanding its enrichment capacity. A guaranteed supply of fuel for the entire life (at least 40 years) of the plant would further lower the perceived need for Iran to make nuclear fuel.
- Past experience proves that these negotiations would be long and frustrating. Russia should not await the outcome of the 2012 U.S. and 2013 Iranian presidential elections to start preparing the stage for a deal. Moreover, Russia should invite all sides to restrain from escalating the tension during the negotiation period by engaging in saber rattling, cyber attacks, assassinations, provocative statements and any other bellicose policy.

### *United Nations Security Council*

- By inviting Brazil and Turkey to join "P5+1" countries, the UNSC would create a new "P5+3" framework for negotiations with Iran. The current diplomatic construct requires Iran to place disproportionate trust in the Western powers. Expanding the negotiating party states will restore the Iranian confidence in balanced and objective approach of the international community and

acceptability of any compromise to all sides. Turkey and Brazil are rising global powers and in 2010 initiated a potential diplomatic breakthrough with Iran.

- Enhanced safeguards are designed to provide “timely warnings” of any attempt to evade them. It is critical to recognize, however, that no system of safeguards can be entirely effective, and even with full IAEA supervision Iran could still succeed in manufacturing a nuclear weapon. Therefore, the UNSC should preemptively draft a resolution that clearly determines the consequences of such eventuality.[19] The swiftness and strength of international response should be clear, as to set an effective deterrent for Iran and any other prospective nuclear proliferators.

### *International Atomic Energy Agency*

- The IAEA should work with Russia, the United States, and Iran to design a framework in which Iran’s right to peaceful nuclear energy is underscored and concerns of the international community about Iran’s stockpiling of enriched uranium is addressed. Uranium enrichment can be capped in several ways: by number of centrifuges, by volume of enriched material, and by percentage of enrichment. Although in 2005, Iran showed willingness to accept a temporary upper limit on the number of its centrifuges, the new realities have rendered this option irrelevant. Yet, the latter two options are still viable. Iran could agree to limit enrichment activities to its actual fuel needs. Otherwise, as part of a deal with Iran, any amount more than this could be sold to buyers with which Iran has mutual economic interest. As past attempts to make a fuel swap deal came to naught, this option is no longer tenable.[46] Iran should also be persuaded that if it halts its 20 percent uranium enrichment activities, it would be provided with the LEU required for its research reactors and medical isotopes. The IAEA could facilitate the transfer of 20 percent enriched uranium from the United States to Iran as a humanitarian gesture to provide nuclear medicine for 850,000 cancer patients in Iran. [47]
- To achieve greater accuracy in detecting diversion, the IAEA should increase the frequency of measuring nuclear material to quarterly or monthly.

- The IAEA should work with the United States and its allies to provide centrifuge components for Iran, in return for the agency's access to centrifuge production centers and permission to tag the manufactured centrifuges. Such a measure will allow the IAEA to ensure that no centrifuges are produced for a covert facility. Once Iran masters the indigenous capability to produce essential centrifuge parts and material such as maraging steel and carbon fiber, which appears to be the case for the latter, this option could no longer be leveraged in negotiations.[48]
- The IAEA Board of Governors and the Nuclear Suppliers Group should redouble efforts to make the Model Additional Protocol the universal standard for nuclear commerce. Brazil, in particular, would have to be convinced to implement an additional protocol, lest Iran attempts to use their example to evade implementing it. The "Additional Protocol Plus" should become the standard for all states operating uranium enrichment and reprocessing of spent fuel facilities.
- The IAEA should urge Iran to join the Convention on the Physical Protection of Nuclear Material (CPPNM), the Convention for the Suppression of Acts of Nuclear Terrorism, the Convention on Nuclear Safety (CNS), and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. In return for Iran's ratification of these conventions, the IAEA should ask the international community to lift the restrictions that deprive Iranian scientists and technicians to attend the IAEA and other scientific workshops and increase their cooperation with Iran in the related fields.
- In cooperation with the International Energy Agency (IEA), the IAEA should devise an energy plan for Iran and encourage the P5+3 countries to invest in Iran's oil and gas sector and collaborate with Iran on developing its renewable energy resources.
- Overall, the IAEA has had a positive record as many more countries have given up nuclear weapon programs than have begun them.[49] The agency is, however, constrained by inadequate resources. Its budget is not commensurate to its growing responsibilities. As recommended by the Commission of Eminent Persons, the agency's budget should be doubled by 2020 to allow coping

with the rising use of nuclear energy around the globe.[26][49] The agency should be provided with the technology, resources and professional personnel, which it deems necessary for fulfilling its tasks. Nevertheless, implementing the proposals as discussed in this report have negligible budgetary consequences, as the verification burden of Iran's limited enrichment program pales in comparison to a large fuel cycle facility elsewhere in the world.

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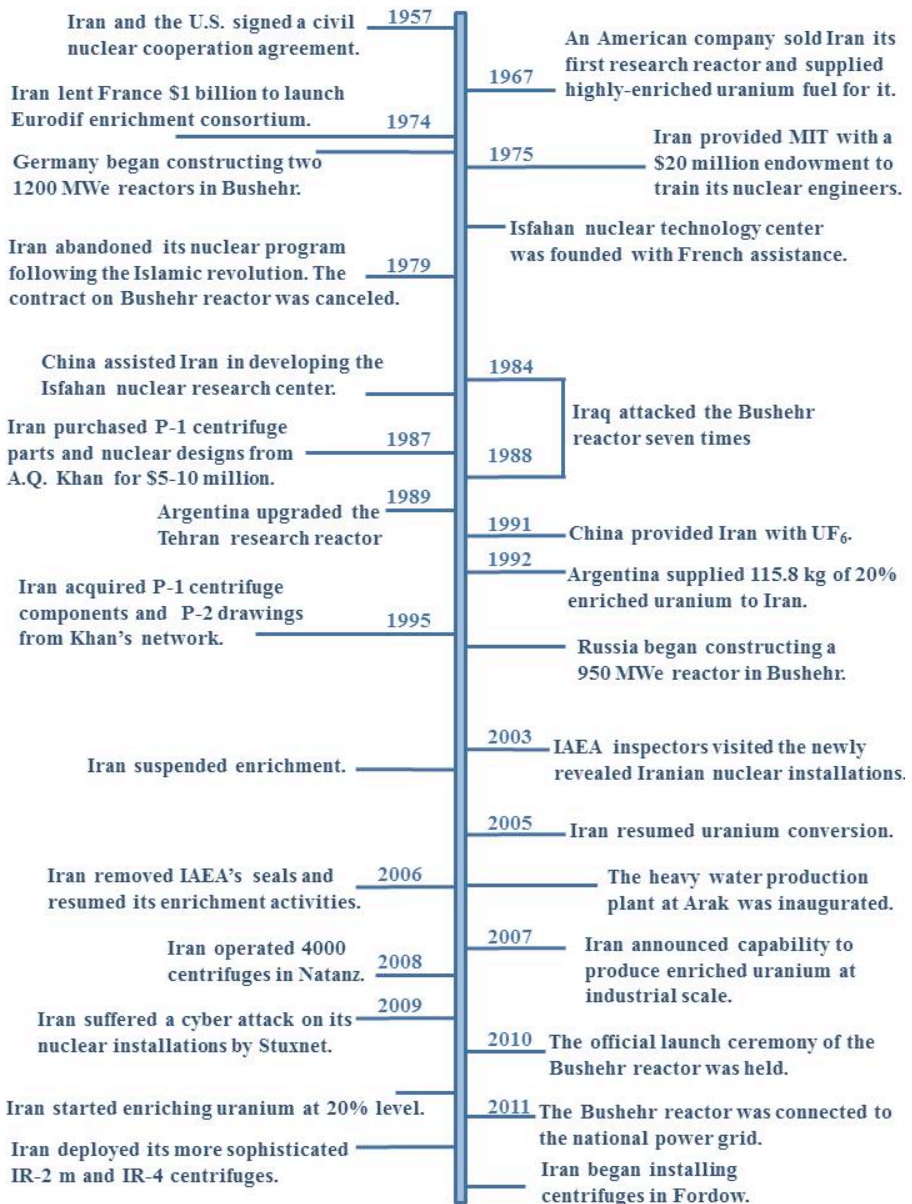
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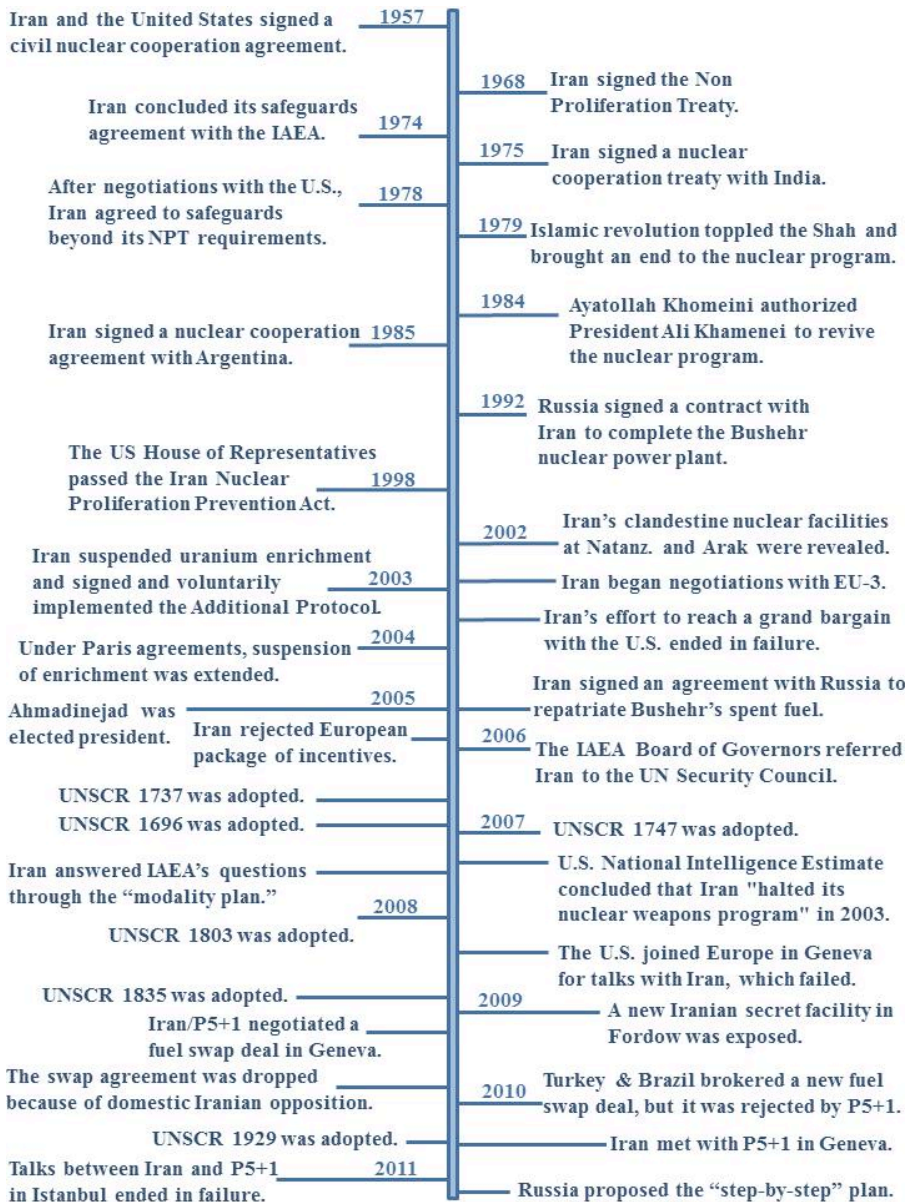
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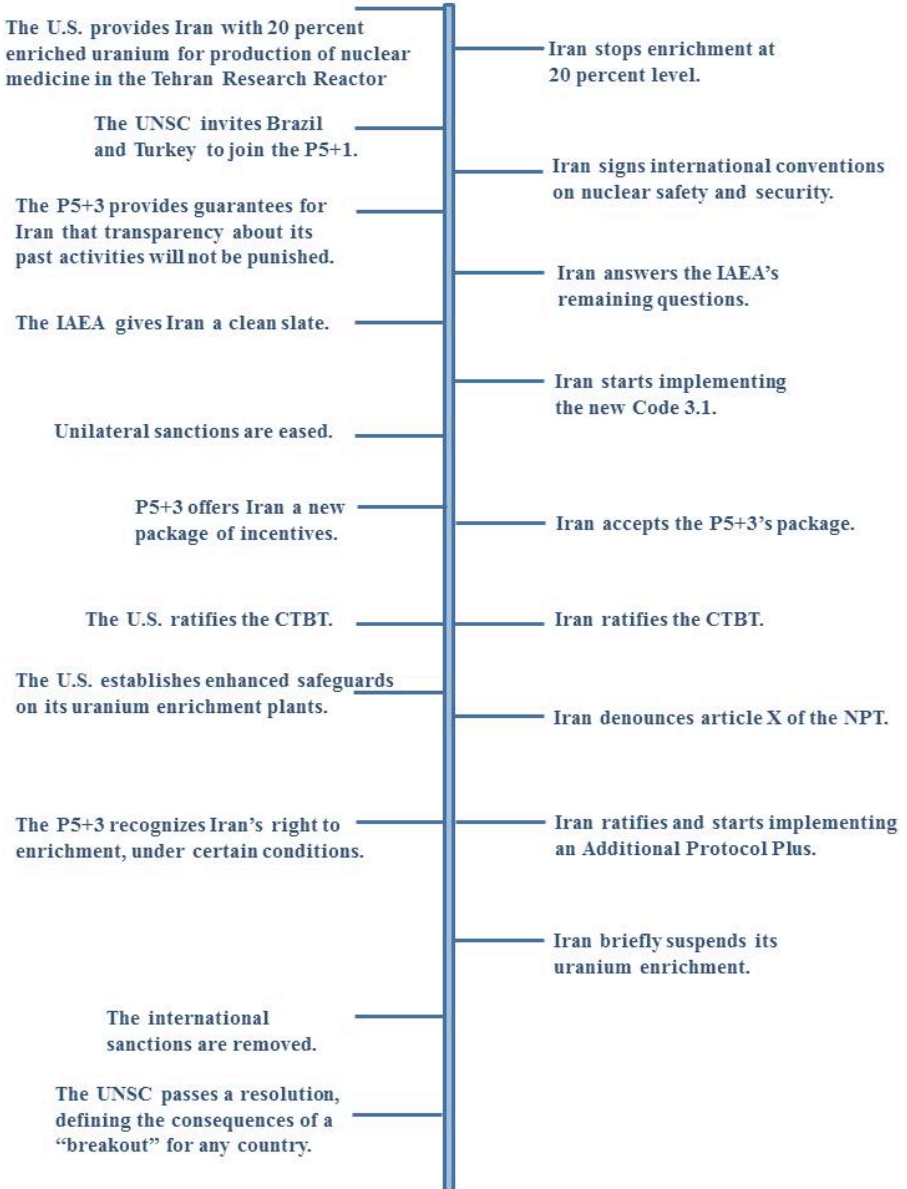
## APPENDIX I: Iran’s Nuclear Program - Technical Timeline



## APPENDIX II: Iran’s Nuclear Program - Diplomatic Timeline



### APPENDIX III: A Diplomatic Proposal



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