Steps Toward a Deal on Enhanced Safeguards for Iran’s Nuclear Program

Charles D. Ferguson

- Table 1: Feasibility of Enhanced Safeguards Options

During more than eight years of a political tug-of-war over Iran’s nuclear program, the United States and its allies have yet to reach agreement with Tehran. Iranian leaders repeatedly have demanded recognition of their country’s “right” to enrich uranium and pursue peaceful nuclear energy.

The United States has insisted that Iran suspend enrichment activities as well as construction of a heavy-water research reactor until Iran addresses concerns about the intended nature of these activities and gives the international community confidence that Tehran will not make nuclear weapons.

Numerous proposals from each side have failed to break this impasse. Recently, however, the increasing effects of multilateral sanctions on Iran’s economy and nuclear program have given rise to some hope from the United States for a negotiated settlement.

The route to a negotiated agreement is highly uncertain because the two sides have ideal outcomes that appear diametrically opposed. Ideally, the United States 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 bombs. (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.) If there were no enrichment plants in Iran, the United States would have an easier verification task than if it had to monitor a permitted, known enrichment capacity to ensure that it was not being used as cover for clandestine enrichment plants. In contrast, Tehran’s ideal situation is to continue improving its enrichment capacity so that it conceivably could make several bombs’ worth of HEU annually if its leaders chose to do so.

Reaching agreement for Iran to stop enriching uranium, however, appears politically impossible for the foreseeable future. Despite the increasing pressure of sanctions, Iranian leaders have demonstrated during the theocracy’s 32 years of existence that they will cling tightly to instruments of power that they believe are vital to their state’s security.[1] A top instrument of power is the nuclear program. Concomitantly, this program has become a highly nationalistic issue. Thus, the Iranian leadership most likely would do everything in its power to maintain this program. Faced with this political reality, the United States, its partners, and Iran need to be prepared to understand the options for enhanced safeguards that would provide the necessary international confidence for continued uranium enrichment in Iran.

**Decision Factors**

Several enhanced safeguards options are conceivable, but few additional measures are likely acceptable to all states.[2] The decision factors are political acceptability, technical feasibility and effectiveness, and resource
constraints.

**Political acceptability.** Iranian leaders have been acutely sensitive about fairness. They have resisted adopting safeguards measures beyond what other states have applied. 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.

Moreover, the International Atomic Energy Agency (IAEA) faces political constraints in that its leadership has to remain politically neutral while balancing the demands from developing and more technologically advanced states. The developing states usually want more technical assistance from the IAEA for their peaceful nuclear programs, and they want less-intrusive monitoring of these programs. 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 that enrichment is occurring. Modern centrifuge enrichment plants emit very little uranium hexafluoride, the gas used in the enrichment process. (The gas is “enriched” by separating U-235 hexafluoride from U-238 hexafluoride and thus increasing the U-235 concentration.) Detection of leakage from the previous stage of the nuclear fuel cycle—the uranium-conversion plant that makes uranium hexafluoride—may 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. 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 see this fingerprint, however, the inspectors would need access to these lines, and appropriate electronic filters could reduce or eliminate these signals. Satellite images 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. It does not have the money or human resources to apply 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 material has expanded about sixfold, and the number of facilities has roughly tripled while the budget has approximately doubled. 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.

Before examining options for additional safeguards in Iran, it is worthwhile reviewing the major contentious issues that remain.

**Disputes With the IAEA**

Since 2003, the IAEA has inspected Iran’s declared nuclear materials and facilities about every three months. Also, the IAEA has called repeatedly for Iran to answer outstanding questions about past, present, and planned nuclear activities and possible military dimensions of its nuclear program. One of the major points of contention is the issue of giving the IAEA access to information in a timely manner. For example, the IAEA has not obtained access to detailed design information on Production Hall B at the fuel enrichment plant near Natanz.

Nonetheless, Tehran previously had indicated a willingness to being more forthcoming. On February 9, 2003, the IAEA obtained Iran’s agreement to provide early notification of design information once Iran decides 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 a comprehensive safeguards 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 December 2003, Iran also had agreed to implement voluntarily an additional protocol to its comprehensive safeguards agreement. Such a protocol, if fully implemented, would allow IAEA inspectors to make a determination of whether Iran has any undeclared nuclear materials or facilities. On February 6, 2006, however, two days after the IAEA Board of Governors referred Iran’s nuclear file to the UN Security Council, Iran suspended implementation of its additional protocol. In 2007 it 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.

The revelation of a clandestine enrichment plant has raised further concern that Iran may have a nuclear weapons program. 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 Qom. That revelation forced Iran to inform the IAEA that month about the Fordow Enrichment Plant. At that time, Iran stated that the Fordow plant was designed for the production of 5 percent enriched uranium and would contain 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 as well as produce 5 percent enriched uranium with the older-generation centrifuges. 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 request for access to design development information and to the companies that are designing the Fordow plant.

Since the plant was revealed, Iran has announced that it wants another 10 enrichment facilities, but it has not given the IAEA the requested information about the proposed sites and design details of these facilities. Such information would help the IAEA greatly in determining where best to place monitoring equipment in safeguarded facilities before they are built. Once a facility has been built, it can be very difficult to obtain access to parts of the facility that are considered proprietary. 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.

The impasse over access also has impeded the IAEA’s ability to assess Iran’s work on heavy-water production. In particular, Iran has not provided access to the production plant at Arak. The Security Council has called on Iran to suspend work at this facility. According to the IAEA’s November 2010 report, satellite imagery indicates that this work is continuing. 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.

**Proliferation Pathways**

A non-nuclear-weapon state has three proliferation pathways that it could try to exploit:

1. Operation of a clandestine nuclear weapons program that would as much as possible be parallel to and separate from a declared, safeguarded nuclear program.

2. Diversion of weapons-usable material and technologies, such as centrifuges, from a declared, safeguarded program into a weapons program.

3. Withdrawal from the nuclear Nonproliferation Treaty (NPT) and the IAEA safeguards system and then use of the acquired nuclear technologies to make fissile material for nuclear weapons.

The first pathway is the most worrisome because, under the current safeguards approach, the IAEA has access that is limited only to declared facilities and thus is constrained in its ability to determine if there are any undeclared facilities, materials, or activities. One of the first major steps that Iran can and should take is to ratify an additional protocol to its comprehensive safeguards agreement. The inspections for the protocol’s implementation would require an assessment of whether Iran has nuclear materials and facilities that it has not declared. The Model Additional Protocol expands safeguards to cover all activities in the nuclear fuel cycle depicted in figure 1 (see print edition). 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.
In addition, the Model Additional Protocol offers complementary access to sites and facilities where inspectors need to resolve unanswered questions and concerns. This access does 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. Because inspections under the Model Additional Protocol are more resource intensive and burdensome to the state than inspections under a comprehensive safeguards agreement, the IAEA offers integrated safeguards for those states in which 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.

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 then could apply an additional protocol and eventually an integrated safeguards system to reduce the burdens of safeguards. Under an additional protocol-plus system, inspectors would want especially to determine whether Iran has any clandestine nuclear materials and facilities. Methods to uncover these materials and facilities include satellite monitoring, wide-area environmental sampling (WAES), and human intelligence.

Regarding satellite monitoring, the IAEA in recent years has established a satellite-imagery laboratory. The IAEA has acquired high-resolution commercial images obtained by 16 satellites operated by 11 imagery providers in eight states.[7] In the past few years, the IAEA has purchased and analyzed several hundred images.

WAES monitors the air to search for the presence of radioactive materials that could indicate clandestine nuclear activities, such as hidden enrichment and reprocessing plants.[8] Although WAES is permitted under the Model Additional Protocol as long as the Board of Governors has approved its use, its approval depends on a demonstration of the effectiveness of this method and consultations between the IAEA and the state. Because there is no precedent for applying WAES under a state’s additional protocol, this measure effectively would 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. WAES can do so by measuring the ratio of U-235 and U-238. If the measured ratio were greater than 0.72 divided by 99.28, the concentrations respectively of U-235 and U-238 in natural uranium, then there would be possible evidence of clandestine enrichment. The WAES monitoring station also would look for the presence of fluorine that is chemically combined with the uranium. Uranium hexafluoride would indicate the presence of uranium-conversion and -enrichment plants. The evidence would not necessarily be a smoking gun because, in a state with a declared enrichment plant, the inspectors would have to establish that the detected enriched uranium did not leak from that plant. Moreover, as mentioned earlier, modern enrichment plants usually leak very little uranium in the form of uranium hexafluoride.

Consequently, significantly increasing the likelihood of detecting enriched uranium in a relatively large country such as Iran would require at least a few tens of thousands of WAES monitoring stations, assuming a detection range of about 10 kilometers from 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.[9] The high cost and the low likelihood of detection raise substantial barriers to the use of this technique in Iran. In contrast to enrichment plants, reprocessing plants are likely to be easier to detect because of the relatively large and distinctive releases of krypton-85, a radioactive gas that does not occur naturally. Nevertheless, a state may try to hide reprocessing by spending money on installing filtering systems.

Arguably, the most effective means for finding evidence on clandestine facilities is by using human intelligence. Although human intelligence 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 technical people may provide evidence of a clandestine program advertently or inadvertently. Whistleblowers likely would need protection...
against retribution. The United States should offer to facilitate protection, such as safe haven in a country other than Iran. Based on Iran’s rebuffs of several IAEA requests in recent years to question personnel, Tehran most likely would resist providing this extra measure.

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 containment and material accountancy at uranium mines and mills, measuring the mass of uranium ore concentrate entering conversion plants versus the amount of uranium hexafluoride 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 very 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 uranium hexafluoride 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 a diversion of enough nuclear material for making 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. Although the agency has been visiting the Iranian enrichment facility at Natanz on a much more frequent basis, it has performed the physical inventory verification annually. To achieve greater accuracy in detecting a diversion, the IAEA could increase the frequency of measuring material to quarterly or monthly.

To reduce the uncertainty in the measurement error further, the IAEA could increase the use of destructive analysis, 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. Because of the larger expense of destructive analysis, however, this could significantly increase the cost of inspections. Additionally, the IAEA could make independent measurements on all items of nuclear material. Although the IAEA has the legal right to do this, it typically does not. To reduce costs, it usually performs verification procedures on a randomly selected subset of items.

Verifying production of centrifuges could enhance safeguards significantly. A major concern is that Iran could be manufacturing excess centrifuges at declared production facilities or manufacturing centrifuges 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, 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.[10] However, providing detailed information on manufacturing of centrifuges would require a special agreement between Iran and the IAEA because 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.

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 after three months. 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 Security Council 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. Because Security Council 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 Board of Governors has been reluctant to exercise its authority under its own statute to call for special inspections in any state.

Of the roughly dozen options considered here, very few meet the criteria of political acceptability, technical effectiveness, and feasibility given IAEA resource constraints. Political acceptability depends both on Iran’s willingness to agree to an additional safeguards measure and on the ability of the United States and its partners to obtain agreements among many states with power on the Security Council 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 the table 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 an additional protocol voluntarily. It also provides significantly enhanced safeguards capabilities 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 United States and its allies can reach agreement with Iran on application of more safeguards options, they should focus on those, such as verifying production of centrifuges, that would provide significantly improved effectiveness.

Making a Deal

Although Iran would likely resist the more intrusive measures discussed above, a deal could propose these measures as temporary, to be lifted once Iran has provided the necessary confidence about the peaceful intent of its nuclear program. The nuclear issue is one of several contentious issues between Iran and the United States. There is no easy route to a negotiated solution, and it is not possible to predict the likely path. What follows is an assessment of some possible ways to reach an agreement.

The general concept is to connect Iran and other states in an interdependent relationship so that if one side reneges on the deal, the other side has leverage to make the violator suffer. The parties to the agreement need to form a “correlation of fortunes” to create a non-zero-sum game. Such a game does not guarantee a win-win situation. The sides could fall into lose-lose scenarios, but the key point is that each side needs to see that its enlightened self-interest is to preserve the deal.

The deal would have to play to the interests of multiple states. Specifically, it would have to underscore Iran’s right to peaceful nuclear energy and would have to address the concern of the United States and its allies about Iran’s stockpiling of enriched uranium. In particular, Washington and its allies could become clients of Tehran. The clients would buy enriched uranium at a competitive price from Iran in exchange for Tehran’s acceptance of more-rigorous safeguards on its nuclear program. The enriched uranium would be shipped out of Iran frequently enough so that not more than one bomb’s worth of uranium would be present in Iran. This deal would extend substantially beyond
the Tehran research reactor deal of late 2009 in which the United States and its allies offered to provide fuel for the
reactor in exchange for Iran shipping out an equivalent amount of LEU. In the larger deal, Iran would gain more
money from the United States and be able to take satisfaction in having “the Great Satan” as a client.

An even grander deal is conceivable. It would include access to fossil fuel energy supplies in addition to provision of
nuclear fuel. Many states are interested in getting access to Iran’s natural gas. A natural gas pipeline
from Iran to Turkey would provide needed alternative gas supplies to Turkey. The pipeline could be connected to
other states in Europe. This would provide further energy benefits and help reduce some of Europe’s dependence on
Russian gas supplies. Russia likely would not object to this deal because Russian gas experts understand that the
European Union’s demand for gas is growing and that the Iranian gas supplies, while plentiful, would not substantially
displace Russian supplies. Iran still would have leverage over Turkey and EU states because it could threaten to shut
off gas if these and other states renge on providing nuclear fuel for Iran’s nuclear power plants. 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 nonproliferation credentials and to
undermine Tehran’s stated rationale for expanding its enrichment capacity significantly.

Additionally, the United States and other countries can and should take further actions to improve the political
acceptability of enhanced safeguards in Iran. The United States should redouble efforts within the Board of Governors
and the Nuclear Suppliers Group 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. If Iran tries to hide
behind the fact that Brazil has not implemented an additional protocol, the United States can argue that at least Brazil
has joined with Argentina and the IAEA to form a bilateral inspection system, known as ABACC, to provide greater
confidence about the peaceful intent of its nuclear program. More importantly, Washington needs to remind Tehran
that Japan, a leading non-nuclear-weapon state with the complete fuel cycle, was one of the first states to implement
an additional protocol. As a further step to show that the United States is making extra efforts, it should place
enhanced safeguards on enrichment plants inside the United States and work to make such behavior a standard for all
enrichment plants, whether based in nuclear-weapon states or non-nuclear-weapon states.

None of these deals or offers will work unless both sides are willing to build trust and accept that there will be risk.
Trust is essential because safeguards work best when the inspected state is fully cooperative with the inspectors. Yet,
the lack of trust runs deep between Iran and the United States, dating back at least as far as the American- and
British-orchestrated coup that ousted Iranian Prime Minister Mohammed Mosaddegh in 1953. It will take
considerable effort from both sides to bridge the mistrust that exists in many areas. Concerning the nuclear issue, the
challenge for the United States is to accept Iran’s nuclear program under adequate safeguards. This acceptance will
help recognize Iran as a significant political power in the region. For its part, Iran needs to recognize that its
enlightened self-interest is to open its nuclear program to provide assurances that its intentions are peaceful. By doing
so, Tehran will help elevate its position as a leader.

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### Table 1: Feasibility of Enhanced Safeguards Options

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<thead>
<tr>
<th>Options</th>
<th>Political acceptability to all parties</th>
<th>Technical effectiveness</th>
<th>Fit within IAEA’s resource constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional Protocol</td>
<td>Yes</td>
<td>Would provide significantly improved capability</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Satellite monitoring</strong></td>
<td>Iran cannot stop its use</td>
<td>Would provide improved capability as long as supplemented with additional information</td>
<td>Yes, but currently limited up to a few hundred images annually</td>
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<tr>
<td><strong>Wide area environmental sampling</strong></td>
<td>Not likely because of limited technical effectiveness</td>
<td>Would likely not provide substantially more capability given Iran's landmass</td>
<td>Would require significantly more resources</td>
</tr>
<tr>
<td><strong>Interviews with Iranian nuclear personnel</strong></td>
<td>Unlikely</td>
<td>Would likely provide significantly improved capability</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Physical containment of mines and mills</strong></td>
<td>Unlikely</td>
<td>Would likely not provide significantly improved capability</td>
<td>Would require some more resources</td>
</tr>
<tr>
<td><strong>Material accountancy at mines and mills</strong></td>
<td>Unlikely</td>
<td>Would likely not provide significantly improved capability</td>
<td>Would require some more resources</td>
</tr>
<tr>
<td><strong>Measuring the mass balance at uranium conversion plants to compare the mass of uranium going into and out of the plants</strong></td>
<td>Likely to obtain especially if Iran would agree to an additional protocol because this measure would not go significantly beyond such a protocol</td>
<td>Would likely provide significantly more capability</td>
<td>Would require some more resources</td>
</tr>
<tr>
<td><strong>Improved measurements at enrichment plants</strong></td>
<td>Likely to obtain if it can go not too far beyond an additional protocol and as long as proprietary information is protected</td>
<td>Would likely provide significantly more capability</td>
<td>Would require some more resources</td>
</tr>
<tr>
<td><strong>Verifying production of centrifuges</strong></td>
<td>Unlikely to obtain because of likely Iranian perception of intrusiveness on its proprietary information</td>
<td>Would provide significantly more capability</td>
<td>Would require some more resources</td>
</tr>
<tr>
<td><strong>Facility–specific safeguards</strong></td>
<td>Very unlikely to obtain agreement</td>
<td>Would likely provide significantly more capability</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Special inspections</strong></td>
<td>Very difficult to pass UN Security Council resolution or obtain Board of Governors agreement</td>
<td>Would provide significantly more capability</td>
<td>Would require more resources</td>
</tr>
</tbody>
</table>

ENDNOTES


7. Diane M. Fischer, “The Role of the Nuclear Watchdog: Monitoring Nuclear Safeguards” (presentation from Division of Information Management, Department of Safeguards, IAEA, 2010).


10. IAEA, “Model Protocol Additional to the Agreement(s) Between State(s) and the International Atomic Energy Agency for the Application of Safeguards,” INFCIRC/540 (corrected), art. 2.a (i).


14. Ivan Safranchuk, an independent analyst based in Moscow, suggested how to establish a linkage between Iran’s receipt of nuclear fuel and the client states’ receipt of natural gas supplies. Ivan Safranchuk, communication with author, February 11, 2011.