A Witches’ Brew? Evaluating Iran’s Uranium-Enrichment Progress

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Why A Military Attack is Not An Option

What a difference a year makes. In November 2006, Iran had slightly more than 300 gas centrifuges running at its pilot uranium-enrichment plant at Natanz, approximately 200 kilometers south of Tehran. One year later, Iran has close to 3,000 centrifuges installed in a vast underground hall of the commercial-scale Fuel Enrichment Plant (FEP) at Natanz. It has also stockpiled enough of the enrichment feedstock uranium hexafluoride to produce enriched uranium, whether for nuclear energy or for nuclear weapons, for years to come.

This period has also seen two UN Security Council sanctions resolutions: Resolution 1737 was adopted December 27, 2006, and its sibling, Resolution 1747 was approved only three months later, on March 24, 2007. Each demands that Iran suspend its enrichment program and imposes what are arguably mild sanctions, cutting off arms exports and curtailing certain banking and overseas investment. Iran has flatly ignored the call to suspend uranium enrichment, seemingly determined to have its centrifuges and run them too. It has flouted not only the Security Council but also and, perhaps, more importantly the Bush administration’s determination that Iran not achieve a nuclear weapons capability.

To be sure, despite installing close to 3,000 centrifuges, Iran is not enriching uranium on a sustained basis. Yet, neither the UN measures, nor unilaterally imposed sanctions by the United States and some European Union countries, have caused sufficient economic hardship for Iran to halt its enrichment program. Stronger and better-implemented sanctions, coupled with an aggressive and creative diplomatic effort, offer the most realistic means of turning back Iran’s nuclear program. Nevertheless, the date when Natanz can enrich uranium competently may not be far off.

A senior European diplomat involved in negotiations on the next round of proposed sanctions summed up the situation as a “race between how fast they can build centrifuges and we can turn up the pain.”[1]

Timeline to the Bomb

Of course, Iran steadfastly maintains that it has never had a nuclear weapons program and has no intention of ever building such arms. Few experts accept these claims, given the information to the contrary and Iran’s established violations of its verification commitments under the nuclear Nonproliferation Treaty (NPT) and its associated International Atomic Energy Agency (IAEA) safeguards agreement. These safeguards agreements establish the rules and procedures for IAEA monitoring of a country’s nuclear program under the NPT. Of particular concern are inconsistent Iranian statements about the origin and history of its gas centrifuge program, documents in Iran’s possession describing work producing enriched-uranium metal hemispheres, and allegations surrounding a seized laptop containing studies of the “Green Salt Project,” high-explosive testing, and the design of a missile re-entry vehicle that the U.S. intelligence community says is consistent with carrying a nuclear warhead. Besides indicating a possible military nuclear dimension, the laptop documents also appear to show an administrative interconnection between Iran’s nuclear program
and its military. Iran’s numerous safeguards violations, detailed in IAEA reports, include not declaring that it imported uranium hexafluoride gas and enriched it in centrifuges that Iran had built and operated in secret. Other safeguards violations involved experiments with laser isotope separation of uranium and the separation of plutonium.

Predicting when Iran could have nuclear weapons is more art than science. Setting aside the political decision that would precede Iran’s acquisition of a nuclear weapon, the country faces the hurdles of acquiring sufficient nuclear explosive material for its first nuclear weapon and weaponizing that material into a workable, deliverable design. These hurdles are surmountable with time. Nonetheless, Iran’s quest for nuclear weapons has gone more slowly than expected, given that Iran began its gas centrifuge program in 1985, at the height of the bloody Iran-Iraq War. According to IAEA officials, the program originated as a military one. The early centrifuge program, however, ran into multiple problems and stalled. It was only with the help of the notorious Abdul Qadeer Khan of Pakistan and another 20 years of effort that Iran has arrived at its current situation with nearly 3,000 centrifuges installed at Natanz.

For the last few years, we have assessed that Iran will not be able to produce its first nuclear weapon before 2009, although the actual date may well be later. The U.S. intelligence community has given the date as no sooner than 2010 but before 2015, and a new National Intelligence Estimate (NIE) reportedly contains the same projected estimate. This NIE and earlier estimates, however, remain classified; and the basis for their projected timelines remains unknown, particularly the justification for the later portion of the estimate that it could take Iran six to eight more years to obtain nuclear weapons. This later estimate stands in contrast to the technical data released by the IAEA.

Two basic scenarios capture Iran’s most likely routes to developing highly enriched uranium (HEU) for its first nuclear weapons. The first would be for Iran to build and operate a secret gas-centrifuge plant. The second would be for Tehran to “break out” after producing a stock of low-enriched uranium (LEU) that would then be used to jump-start the production of weapons-grade uranium either at its enrichment plant at Natanz or in a secret site.

A centrifuge works by increasing the percentage of the key isotope uranium-235 to a concentration higher than the less than one percent concentration found naturally in uranium. LEU fuel typically has less than a five percent uranium-235 concentration, while weapons-grade uranium has more than 90 percent of the uranium-235 isotope. A breakout scenario would involve using an accumulated stock of LEU in centrifuges to greatly shorten the amount of time needed to produce weapons-grade uranium.

These scenarios depend on the operational flexibility of gas centrifuges, which are operated together in cascades. Iran’s workhorse cascade consists of 164 centrifuges connected by pipes and designed to make LEU. Eighteen cascades are operated as a unit called a module. At the FEP, uranium hexafluoride is fed through a single point connected to each of the 18 cascades, operating in parallel to one another. At the end of each cascade, or “top,” is additional piping that transports the enrichment product to a single collection point.

In a matter of weeks, Iran could reconfigure the piping in the cascades and start producing weapons-grade uranium. Reconfiguring the cascades would involve rerouting the piping to allow the uranium feed to travel from one cascade to the next in series. In doing so, Tehran would also have to ensure that the HEU inside the plant did not accumulate, reaching a “critical state” where a chain reaction could start spontaneously and cause a dangerous, potentially fatal accident. Iran reportedly acquired information from Khan about how to build cascades to make HEU while avoiding criticality, which it could apply to a reconfiguration scenario.

Iran could also produce HEU without reconfiguring the cascades, although steps to prevent criticality would also be necessary. In this method, called batch recycling, the cascade product is fed back into the same cascade for subsequent cycles of enrichment. The head of the Atomic Energy Organization of Iran (AEOI) stated in an interview that weapons-grade uranium could be produced in four passes in this manner.
Alternatively, if IAEA inspections were to end, Iran could achieve the same goal by adding three smaller centrifuge modules in a secret centrifuge plant or in the FEP. Pakistan designed its centrifuge plant in this manner, and Khan provided Iran with the detailed blueprints for designing such a set of cascades. In the case of the FEP, such an approach would require additional construction and thus take longer to accomplish than reconfiguration or batch recycling.

**Enrichment Capabilities**

One of Iran’s most significant achievements in the past year was gaining the ability to produce large quantities of sufficient quality feedstock for enrichment. Once viewed as a bottleneck in the enrichment program, the uranium-conversion facility near Isfahan has produced enough uranium hexafluoride for tens of nuclear weapons. Iran’s production of uranium hexafluoride at Isfahan has grown from 55 metric tons, reported by the IAEA in its November 2006 report, to more than 330 tons as of August 14, 2007. Although the quality of Iran’s uranium hexafluoride has been doubted, and centrifuge operation will improve with higher-quality feedstock, most of it is sufficient for centrifuges.

In less than one year, Iran has successfully installed, far from perfectly as we discuss below, 2,952 gas centrifuges in 18 cascades in the underground A1 hall at Natanz. As of August 19, the IAEA reported that 1,968 centrifuges in 12 cascades were enriching uranium simultaneously at the Natanz FEP. Another two cascades were on the verge of operating, and two more were under construction. Since late August, the final two cascades have reportedly been installed. With these two cascades, Iran will soon or has achieved its objective to install a complete module, consisting of 18 cascades.

**The P-1 Centrifuge**

During the last year, more information has emerged about Iran’s ability to operate centrifuges, and one conclusion is clear. Iran will not operate centrifuges as well as the European enrichment consortium, Urenco, whose earlier-version machines Khan stole and later sold to Iran. Iran operates the P-1 centrifuge, a design of Dutch origin that is neither as reliable nor as economical as the German centrifuges that replaced it at Urenco. In particular, the rate at which the Dutch centrifuges break, or “crash,” is higher than the rate of crashes of the German one. Khan himself described the P-1 centrifuge as “not error free.”

Iran is unlikely soon to master the operation of a centrifuge, but it can be expected to become competent enough, despite inefficiencies and setbacks, to produce significant quantities of LEU.

The August IAEA report does not state how much LEU Iran has produced, only that the IAEA has verified enrichment to levels up to 3.7 percent, though Iran has claimed enrichment up to 4.8 percent. One way to derive how much enriched uranium Iran is producing is to examine how much uranium hexafluoride it is feeding into the cascades at the FEP.

An April 12, 2006 statement from an Iranian official describes the optimal production for the FEP. In remarks carried on Iranian television, Gholamreza Agazadeh, head of the AEOI, said, “In the 164 chain, the maximum amount of material that we can feed the system is 70 grams an hour, with a 10 percent product of 7 grams. The product is 7 grams.”

If Iran were feeding uranium hexafluoride at Agazadeh’s rate and operating on a continuous basis, one would expect about 50 kilograms per month of uranium to be introduced into a single 164-machine cascade, or about 400 kilograms per month if eight cascades were operating or 600 kilograms per month if 12 cascades were operating. These values are far higher than what Iran has achieved so far.

To be sure, Iran did not start feeding the cascades with uranium hexafluoride until about mid-April 2007, a step reported by the IAEA in a communication to the IAEA Board of Governors on April 18. This letter states simply that Iran fed “some” uranium hexafluoride into eight cascades.

From early 2007 to August 2007, Iran fed a total of some 690 kilograms of uranium hexafluoride into the cascades at the FEP. According to the August IAEA report, this is “well below the expected
quantity for a facility of this design.”

Based on this quantity of uranium hexafluoride, we estimate that Iran has produced 70 kilograms of LEU at the FEP from February through August 2007.[10] According to IAEA officials, the actual total may be even less. During the most recent May-August reporting period reflected in the August safeguards report, we estimate that Iran produced no more than 43 kilograms of LEU, or about 14 kilograms per month.[11] For comparison, 2,000 centrifuges operating at the level Pakistan is said to have achieved for P-1 centrifuges would have produced about 90 kilograms of LEU per month.[12] Indeed, if the P-1 centrifuges were operating at their maximum outputs, 2,000 P-1 centrifuges could produce as much as 140 kilograms per month of LEU.[13] Iran is thus achieving only about 10-15 percent of an optimal output of enriched uranium.

Iran’s reduced values for enrichment suggest that it has either encountered technical difficulties in operating its centrifuge cascades or has chosen to operate at this level for some unstated purpose. Iran likely has managed to learn how to operate individual centrifuges and cascades adequately, but it may still be struggling to operate a large number of cascades at the same time in parallel.

If Iran has been deliberately underfeeding the cascades, operators may be uncertain about what could occur in the cascades. Concerns could include the possibility of large-scale crashing of centrifuges or unexpected interruptions in cascade operations. This caution could be driven by inexperience in operating and controlling a large number of cascades, particularly involving centrifuges subject to excessive vibration. It is also possible that Iran has taken a technological risk, jumping as quickly as it can into industrial-scale operation without an adequate testing phase. If so, the speed with which it has installed centrifuges at the FEP could later prove problematic.

Iran may have slowed down for political reasons. Its leadership may have decided to slow work in order to forestall negative reactions that would lend support for further sanctions by the UN Security Council, Europe, or Japan. Although this possibility may have been part of the reason for the slowdown last summer, it may be less true now. According to a government official who spoke on the condition of anonymity, senior Iranian centrifuge scientists are working under a great deal of pressure from their senior political leaders to demonstrate that the centrifuges will work as intended.

We cannot yet estimate how well Iran’s centrifuges at the FEP will perform over time. Iran is likely to need several more months to get the module fully operational. On balance, the Iranian centrifuge project leaders appear to have run into several problems and have made several mistakes that are leading to reduced centrifuge performance. A key variable to continue watching, which will help indicate how well the centrifuges are operating, is how much uranium hexafluoride Iran introduces into the cascades over the next six months to a year.

How Much LEU Is Enough for a Breakout Capability?

A key milestone will be reached when Iran accumulates enough LEU to break out and relatively quickly produce weapons-grade uranium. An accumulation of approximately 700-800 kilograms of 4 percent enriched LEU would unquestionably provide it with enough LEU for a breakout capability whereby in a few months it could produce 20-25 kilograms of weapons-grade uranium, enough for a nuclear weapon. There would be little time for the international community to respond diplomatically, even though the IAEA would likely quickly detect any significant diversion of LEU.

This scenario assumes that the LEU would be enriched to weapons grade at Natanz or a secret site. The production of HEU could be accomplished in approximately three months using 2,000 P-1 centrifuges, or in about two months in 3,000 such centrifuges.[14] If Natanz were used, the IAEA would also detect such activity, leading most analysts to conclude that Iran is more likely to divert the LEU to a secret site that cannot be destroyed as easily as Natanz.

Estimating this milestone is fraught with uncertainties. Unknowns include the efficiency of the centrifuges, the likelihood of unexpected technical or political problems, and variations in operation dictated by different choices for the amount of weapons-grade uranium needed for a first weapon or key enrichment parameters, such as the tails assay, which is the fraction of uranium-235 remaining
in the waste stream after enrichment. A higher tails assay typically translates into the faster production of enriched uranium.

At current rates of production at Natanz, Iran would need a long time to accumulate this amount of LEU. If Iran’s production of LEU is assumed to rise slightly, to about 25 kilograms of LEU per month, it would take Iran more than two years to produce 700 kilograms of LEU.

If Iran achieves by the end of this year a higher but still relatively low rate of LEU production, such as 50 kilograms of LEU per month, it would take Iran 14-16 months to produce 700-800 kilograms of LEU. In this case, Iran could accumulate 700-800 kilograms of LEU by late 2008 or early 2009. If Iran were to operate the P-1 centrifuges at a high rate of 90 kilograms per month by the end of this year, it would need until late spring or early summer 2008 to accumulate this quantity of LEU.

This date, however, is not a prediction of when Iran could have its first nuclear weapon, merely of when its stock of LEU reaches a certain identified level at which point a breakout scenario would become possible. Whether Iran plans to exercise this option remains unknown.

**Fading to Black: Iran’s Increasingly Hidden Centrifuge Program**

With weakened IAEA inspections, the invisible or black areas of Iran’s gas centrifuge program are growing. The most recent IAEA reports highlight the deterioration of the IAEA’s ability to verify Iran’s current activities, stating for example in May 2007 that unless Iran implements its version of the 1997 Model Additional Protocol, the IAEA will not be able to “provide assurances” about the “absence of undeclared nuclear material and activities in Iran.”[15] In January 2006, Iran ended a period of voluntary compliance with the protocol, which gives the IAEA greater ability to ferret out undeclared nuclear activities. Iran had agreed to the protocol during the period when it suspended its enrichment activities as part of an agreement with the European Union.

Little is known now about where Iran manufactures individual P-1 centrifuge components. Before the suspension ended, the IAEA had a good understanding of the many locations that had been involved in manufacturing and assembling the P-1 centrifuges. Iran is believed capable of making the roughly 100 P-1 centrifuge components, despite still needing to acquire certain materials and equipment overseas. Iran assembles P-1 centrifuges at Natanz, although it may have other sites also equipped for assembly. Under existing safeguards, the IAEA is not allowed to visit manufacturing, assembly, or storage sites.

Another opaque area is Iran’s overseas acquisition needs for its centrifuge program. Such information can act as a barometer of Iran’s technological progress and stumbling blocks. Iran has long maintained an international illicit nuclear procurement network, which outfitted its centrifuge program in the first place. During the last few years, Iran has sought a range of items overseas for its centrifuge program, including specialized valves, vacuum pumps, oils, spare parts for its existing equipment, and possibly used manufacturing equipment.

Iran also has not provided the IAEA access to its P-2 centrifuge effort, although it has agreed to answer questions from inspectors about the history of this program. Iranian statements about this program will mean little if its safeguards inspectors cannot verify them. The Iranian P-2 centrifuge is a modified, more advanced version of a centrifuge provided by Khan. Within the next few years, Iran is expected to try to build the more powerful P-2 centrifuges, rather than P-1s. Reliably determining this program’s status and location is dependent on intelligence agencies, which are limited in their ability to collect and learn about Iran’s nuclear program.

**Could There Be a Secret Enrichment Facility?**

An important question—even harder to answer with weakened inspections—is whether Iran could be building a secret gas-centrifuge plant. Detecting construction of such a facility would be difficult if not impossible for the IAEA considering the limitations on its inspection rights and Iran’s refusal to declare to the IAEA any enrichment-related construction projects prior to the start of construction or operation. Iran is the only country with an active nuclear program insisting on adhering to an outdated, 1976 safeguards measure that permits such inspections only six months before the
introduction of nuclear material into a facility.

Given all the discussion of attacking Iran’s nuclear facilities, it would not be surprising that Iran would consider building a backup facility to Natanz. In June, the Institute for Science and International Security detected the construction of a tunnel complex adjacent to the Natanz plant that could be used to store LEU, natural uranium, and centrifuge equipment in an emergency. Although Iran has recently increased its air defenses of Natanz with the addition of at least four sophisticated Russian-supplied Tor-M1 (SA-15) air defense missile systems, Iran may no longer be confident that the underground halls can survive a concerted attack. As discussed above, building this plant in secret would not violate any safeguards agreement, although its discovery would be shocking. If the plant were designed with cascades to make weapons-grade uranium, it would be dramatic evidence of a nuclear weapons intention. On the other hand, if the plant were designed to make LEU, the international community might divide over its significance.

**How Many Centrifuges Can Iran Make?**

If Iran were building another centrifuge plant, it would need to produce enough components for Natanz and this other plant. Could it build a secret site while maintaining and expanding the Natanz plant?

When Iran ended in its voluntary adherence to an additional protocol in early 2006, it had in hand enough components for 5,000-10,000 centrifuges, according to senior diplomats in Vienna. Several diplomats noted, however, that many of the components were not expected to pass quality control for actual use in a centrifuge. We estimate, based on interviews with IAEA officials, that in total Iran had in hand enough sets of good components for at least an additional 1,000-2,000 centrifuges, beyond the roughly 800 good centrifuges already assembled at Natanz, for a total of 1,800-2,800. The actual number of centrifuges assembled and in pieces is likely higher than this value. The rest would not be usable in a centrifuge and would essentially be junk.

Since the suspension, Iran is believed to have built many new centrifuge components in addition to assembling centrifuges out of existing and new components. One benchmark is that Iran has installed 3,000 centrifuges in the underground halls of Natanz. It also must regularly replace broken centrifuges with new ones. Currently, Iran is reported to be replacing broken centrifuges quickly. This quantity is measured in hundreds of centrifuges per year, however, not thousands.

We estimate that if Iran does not expand Natanz further, maintaining its existing module of 3,000 centrifuges, it could outfit a secret plant of similar size during this year and next. Should it install another module at Natanz, it could still produce enough P-1 centrifuges during 2008 and 2009 for a secret site composed of up to 3,000 centrifuges. To do so, however, Iran would need to produce centrifuges at its maximum estimated rate of production of 200 centrifuges per month.

**Rotors: A Clue to Centrifuge Manufacturing**

One gauge of centrifuge manufacturing is the rate at which Iran assembles centrifuge rotors at Natanz. A rotor is a thin-walled metal cylinder inside the centrifuge that spins the uranium hexafluoride gas at high speed, separating the lighter uranium-235 isotope from the heavier uranium-238 isotope. The IAEA reported during the suspension, when it still had access to Iran’s centrifuge workshops, that Iran had demonstrated an assembly rate of roughly 100 rotors per month. Some IAEA officials estimated that Iran could double this rate if Iran simply went from one to two work shifts per day. During the roughly 20 months since the suspension ended, Iran could have produced 2,000-4,000 centrifuges. Given that 3,000 centrifuges have been installed in this period, Iran’s actual assembly rate must be more than 100 per month, especially if only 800 good ones had been assembled by the beginning of 2006. In any case, if Iran continued at this rate, it could assemble another 1,500-3,000 centrifuges from now through the end of 2008 and another 1,200-2,400 in 2009.

If Iran needed 3,000 centrifuges for a new module at Natanz and roughly 500 more to replace crashed machines in this and the existing module, then it would have at most 1,300 P-1 centrifuges to install in a secret site through 2008, a modest but significant number. In 2009, Iran could make...
almost 2,000 more centrifuges for a secret site.

Of course, these projections have many caveats. Iran might have encountered technical problems leading to a slowdown in manufacturing or a high failure rate for the rotors. It is also possible that Iran could have learned how to increase its efficiency and production rates.

In addition to making enough components for a secret site, Iran would also need to carefully choose a new facility at which it could install centrifuge cascades. It would need to install electrical, cooling, control and emergency equipment; feed and withdrawal systems; and other peripheral equipment. It would then need to integrate all these systems, test them, and commission the plant. Final completion would be highly unlikely before the end of 2008.

**Bellows**

One way to illustrate this estimate is to consider one of the most difficult centrifuge components to make, the bellows, a specialized Urenco-designed component made from maraging steel, an extremely high strength, malleable alloy. Each P-1 centrifuge is comprised of four short, aluminum rotor tubes connected together by three of these thin-walled cylindrical pieces that act as a type of spring, allowing the rotor to bend ever so slightly and avoid breaking during start-up and shutdown.

In the late 1980s or in the 1990s, Iran had imported sufficient maraging steel to make bellows for about 100,000 P-1 centrifuges. Because of difficulties in making this part, however, Iran decided to buy bellows from the Khan network in the mid-1990s. As part of an order of 500 centrifuges, Khan cynically sent Iran 15,000 used bellows through intermediaries in two shipments in the mid-1990s. Khan told the Iranians that, among this large number, they would be sure to find the 1,500 good bellows needed for the 500 centrifuges. The Iranians naturally rejected this approach, particularly because so many of the used bellows were visually damaged or dirty, and demanded 1,500 new ones. These new bellows arrived in 1997. In recent years, however, Iran took Khan’s advice and began testing each of the used bellows to see if they are of high enough quality for re-use in a new centrifuge. The actual number of good ones remains unknown.

In the early 2000s, Iran finally learned to make its own bellows using imported equipment and materials from Europe and know-how from Khan. During the suspension, Iran had about 22,000 bellows, implying that Iran had made more than 5,000 new ones itself by then.

Many of these bellows are likely defective. To first appearances, 22,000 bellows would be enough for about 7,300 centrifuges. However, this does not take account of the defective ones supplied by Khan and built by Iran. One-half or more are likely to be defective. Khan himself guaranteed that only 1,500 out of 15,000 were good. A rough estimate is that, at the end of the suspension, Iran had enough good bellows for about 3,600 centrifuges either in assembled form or in storage.

To outfit Natanz and a secret site, Iran must make a considerable number of new bellows, up to 7,200 per year, assuming up to 2,400 centrifuges are made per year. This is a rate of 20 good bellows per day, an achievable but possibly high rate for Iran to sustain.

**Conclusion**

Examined in its totality, with all the caveats and unknowns, Iran’s uranium-enrichment program still has a way to go. It has achieved the appearance of success in some areas by manufacturing and installing 3,000 centrifuges and producing more than 330 metric tons of uranium hexafluoride. Iran’s consumption of uranium hexafluoride, however, remains well below what would be expected if the centrifuges were operating on a continuous basis and at optimum rates of performance. Iran has not yet therefore demonstrated competency at enriching uranium, though it is clearly on the road toward doing so.

Politically, there is great uncertainty about whether Iran will forgo its enrichment program as a result of pressure or an offer of incentives. Iran has not found persuasive the EU’s offer of carrots primarily in the form of advanced light-water reactor technology and other incentives. The sanctions contained in two UN Security Council resolutions have not swayed Iran from its present course. Without a
smoking gun beyond what the IAEA has uncovered thus far regarding links between Iran’s nuclear fuel cycle and a nuclear weapons program and with sharp memories of the Bush administration’s misuse of information about Iraq’s alleged weapons of mass destruction program, generating support for additional sanctions remains difficult.

It will be critical over the coming period not to lose sight of why, on proliferation grounds, Iran should be discouraged as strongly as possible from maintaining an enrichment program. Iran has a record of violating its IAEA safeguards obligations, adhering to the minimal possible standards of transparency, and failing to address questions about links between its program and the pursuit of a nuclear weapons capability. Simply put, the history of Iran’s efforts, the current scale of the enrichment program, and Iran’s determination to continue enriching uranium in the face of overwhelming international economic and political opposition, raise serious questions about its intentions.

While holding steadfast to the zero-enrichment objective, policymakers and diplomats should think creatively about how to nudge Iran in that direction, aside from the need for tougher sanctions. Direct negotiations without preconditions among Iran, the EU, and the United States are an obvious starting point. While talks are ongoing, Iran should be urged as a confidence-building measure to blend down its accrued LEU into natural uranium, reducing the threat of breakout. An immediate objective for talks should also be to persuade Iran to open all of its nuclear facilities to IAEA inspection, including those under construction.

Despite the unknowns, the day when Iran could have the capability to make significant quantities of HEU is firmer and is approaching. What to do about Iran will become a higher priority in 2008 and likely dominate the agenda of the next administration, perhaps as much as Iraq has.

**Why A Military Attack is Not An Option**

Iran’s determination to build and operate a uranium-enrichment plant poses difficult problems for those concerned about Iran acquiring a nuclear capability that could threaten its Arab neighbors in the Persian Gulf or Israel. The best approach for arresting Iran’s progress toward becoming a nuclear-weapon state is through a combination of creative diplomacy, sustained international pressure expressed primarily through targeted economic sanctions, and patience.

The threat that Iran could acquire a nuclear weapons capability if it remains on its present course is a serious one, regardless of how many years it might take them. Increasingly central to the debate about what to do is the issue of military force, whether and when it should be used and what it might achieve. An attack against Iran, large or small, is likely to worsen the already dangerous situation in the region and undermine larger U.S. strategic objectives throughout the world. Short of an invasion and occupation of Iran, an option no one is advocating, an attack on Iran is also a false promise because it offers no assurances that an Iranian nuclear weapons program would be substantially or irreversibly set back.

President George W. Bush, while apparently content for now to let diplomacy do its work, may not intend to leave office with Iran’s existing gas-centrifuge program intact and operating. Most recently, he warned that a nuclear Iran could “lead to World War III.” Vice President Dick Cheney stated in an October 22 speech at the Washington Institute for Near East Policy that the United States and other nations are “prepared to impose serious consequences” on Iran if it maintains its present course, adding, “We will not allow Iran to have a nuclear weapon.”[1]

Israel’s recent bombing of an alleged nuclear reactor site under construction in Syria has reminded Washington and Tehran that Israel could attack Iran on its own if it believes that diplomacy has failed and that Iran is on the verge of having a nuclear weapons capability. The Bush administration, rather than allowing Israel to act on its own and knowing the United States would be subject to retaliation as well, may be pushed to launch an attack itself.

Two options for military attacks are often discussed. One involves air attacks against sites
affiliated with Iran’s nuclear fuel cycle, in particular those near Arak, Isfahan, and Natanz. The other involves launching a wider aerial attack across Iran targeting actual and suspected nuclear facilities, as well as military command and control, missile production and storage sites, and retaliatory capabilities. Setting aside the merits, costs, and risks of these approaches from military and political perspectives, it is important to examine the more narrow issue of what impact such strikes would have on Iran’s nuclear program.

Targeted strikes against the sites affiliated with Iran’s nuclear fuel cycle would certainly set back for a number of years Iran’s heavy-water reactor construction project at Arak and its ability to convert large amounts of uranium ore to uranium hexafluoride at Isfahan. They would also likely destroy Iran’s centrifuge plant at Natanz, notwithstanding its hardening against such attacks.

But the survivability of an Iranian nuclear weapons program does not rest entirely on those sites—knowledge and experience are transferable, centrifuges are replicable. Iran could rapidly reconstitute its gas centrifuge efforts elsewhere at smaller, secret sites if it has not already begun to do so. More importantly, sites affiliated with the design and manufacture of centrifuges, the brain and heart of any centrifuge program, have been off limits to IAEA inspectors for over a year and may no longer be known to U.S. and Israeli intelligence.

Before the 2003-2005 enrichment suspension, Iran’s centrifuge manufacturing complex was highly dispersed in a variety of Defense Industries Organization facilities, companies owned by the enrichment program, and small private companies contracted to make specific parts. Any of these companies could still be involved, or a whole new set of unknown companies could be engaged in making centrifuge components. Intelligence about this vital part of the program is sparse absent International Atomic Energy Agency (IAEA) monitoring of an enrichment suspension agreement and Tehran’s adherence to an additional protocol to its safeguards agreement with the agency.

It should be assumed that Iran would remove key equipment and materials from its known nuclear sites in anticipation of an attack and may already maintain redundant capabilities for key centrifuge components. Iran’s uranium-conversion facility at Isfahan has already produced more than 330 metric tons of uranium hexafluoride, all of which is under IAEA safeguards. Given that fewer than 10 tons of this material is sufficient to produce one bomb’s worth of weapons-grade uranium, Iran needs only to ensure that less than 10 percent of its stock survives any raids in order to have enough material to make three nuclear weapons. In anticipation of military strikes, Iran could quickly move much of its uranium hexafluoride to safe sites, and some could find its way to a covert enrichment facility. Similarly, Iran could quickly evacuate key equipment, any enriched uranium, and components from Natanz.

In short, destroying the facilities without the equipment and materials would not set back the enrichment part of the program significantly. Moreover, rather than possibly delaying or making it impossible for Tehran to carry out a final decision to make nuclear weapons, an attack might force the Iranian leadership’s hand. Iran would almost certainly kick out IAEA inspectors and, freed of any international restraints, might well accelerate any weaponization efforts, launching a Manhattan Project-style undertaking in defense of the homeland. In such a case, the United States would likely be forced to launch and sustain a long, costly war against Iran.

In the case that the United States launched a broader attack, causing far more destruction of Iranian infrastructure and disruption of the leadership’s ability to retaliate, the United States would be faced with the same problem. There would simply be no assurance that Iran’s ability to make nuclear explosive material would be significantly curtailed as long as it possessed covert facilities or the means to build and operate them. Finding them would be like looking for a needle in a haystack.

This analysis leaves aside the other obvious, well-discussed downsides to a military attack against Iran, including the human costs, larger issues of its ramifications for U.S. interests in...
the region and the situation in Iraq, and increased instability throughout the Middle East as Iran retaliates, which it is fully expected to do. In addition, an attack would not only bring an end to the system of IAEA safeguards inspections in Iran but would dramatically reduce their credibility throughout the Middle East.

Not surprisingly, many U.S. military leaders have deep reservations about attacking Iran. Admiral William Fallon, current head of U.S. Central Command, said, “The constant drum beat of conflict is what strikes me, which is not helpful and not useful. I expect that there will be no war and that is what we ought to be working for.”[2] Later, in an interview with The New York Times, he said, “We will pursue avenues that might result in some kind of improvement in Iranian behavior,” including “a strategy to demonstrate our resolve.”[3]

At all costs, the false promise of military strikes should be avoided. They could plunge the Middle East and the United States into a far worse war and make an Iranian bomb a certainty. —David Albright and Jacqueline Shire

ENDNOTES


David Albright, a physicist, is president of the Institute for Science and International Security (ISIS) in Washington, D.C., and a former UN weapons inspector in Iraq. Jacqueline Shire, a senior analyst at ISIS, was a foreign affairs officer at the Department of State between 1990 and 1998.

ENDNOTES


7. According to government sources who spoke on the condition of anonymity, Iran continues to use imported uranium at the Isfahan conversion facility rather than domestically mined uranium, partially because the impurities are significantly less in the imported material. The uranium
hexafluoride made from imported uranium still contains impurities that complicate centrifuge operation, but overall the use of this material is not a severe problem.

8. Iranian 2007 safeguards agreement implementation.


10. The LEU is assumed to be 3.5 percent enriched on average and produced using a tails assay of 0.4 percent.

11. During this period, the IAEA reported that Iran fed about 430 kilograms of uranium into the cascades.

12. This estimate assumes that the centrifuges are operating at an annualized output of 2-kilogram uranium separative work units (swu) per year, that the average enrichment level is 3.5 percent, and that the tails assay is 0.4 percent.

13. According to a former Urenco official, the P-1 centrifuge can achieve a realistic maximum output of 3-kilogram uranium swu/year.

14. The above calculations assume a tails assay of 1 percent, and each P-1 centrifuge is assumed to achieve at least 2-kilogram uranium swu per year by the time of a breakout.

15. Iranian 2007 safeguards agreement and resolutions implementation.

17. See “Nuclear Iran,” IISS Strategic Comments, Vol. 13, No. 7 (September 2007) (upper estimate); senior IAEA official, interview with authors (lower estimate).

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