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Iran's Critical Capability in 2014: Verifiably Stopping Iran from Increasing the Number and Quality of its Centrifuges

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Iran is expected to achieve a critical capability in mid-2014, which is defined as the technical capability to produce sufficient weapon-grade uranium from its safeguarded stocks of low enriched uranium for a nuclear explosive, without being detected. Iran would achieve this capability principally by implementing its existing, firm plans to install thousands more IR-1 centrifuges, and perhaps a few thousand IR-2m centrifuges, at its declared Natanz and Fordow centrifuge sites. Iran's criticality date could be achieved a few months earlier, if Iran successfully deploys and operates several thousand advanced centrifuges and continues installing thousands of IR-1 centrifuges. A priority is preventing Iran from achieving a critical capability through sanctions, increased frequency of international inspections, and negotiations.

Iran's nuclear weapons capabilities continue to grow. However, by charting Iran's possible future paths to obtaining a nuclear weapon, the United States and its allies can identify opportunities to slow this growth. One critical factor affecting Iran's potential timeline to the bomb is the speed at which its declared centrifuge capacity could reach a level where it could use its existing, safeguarded stockpile of low enriched uranium to "dash," without timely warning for the international community, to the production of sufficient weapon-grade uranium for a nuclear explosive device. Adequate warning would allow enough time for a response to this action. During the final presidential debate of the 2012 campaign, President Barack Obama characterized such a time as when "we would not be able to intervene in time to stop [Iran's] nuclear program." When Iran reaches the technical capability to produce sufficient weapon-grade uranium for a nuclear explosive without being detected, it can be understood to have achieved what is defined here as a "critical capability."

ISIS has assessed that in a breakout or dash to nuclear weapons Iran could produce a significant quantity (25 kilograms of uranium enriched to above 90 percent U-235) at its declared centrifuge enrichment plants in as little as a few months.[1] During the next several months of 2013, this minimum timeline could decrease to about one month, depending on the growth of Iran's stock of near 20 percent low enriched uranium and the number of centrifuges it deploys to enrich uranium. The International Atomic Energy Agency (IAEA), which regularly inspects Iran's declared centrifuge plants and the low enriched uranium these sites have produced, would be able to detect breakout within these time periods.

[1] See William C. Witt, Christina Walrond, David Albright, and Houston Wood, *Iran's Evolving Breakout Potential*, ISIS Report, October 8, 2012; and an update to be published.

As Iran continues to expand the numbers of its deployed centrifuges at its declared Natanz and Fordow gas centrifuge sites, its breakout times are expected to further decrease. The number of centrifuges it can build and install in cascades depends, among other factors, on its ability to smuggle key goods in violation of other countries' national trade control laws and United Nations Security Council sanctions. But current efforts to stop Iranian smuggling are not sufficient. Iran has installed new centrifuges at a very fast rate over the past year, implying that it is still obtaining key supplies from abroad for its IR-1 centrifuges. Nonetheless, the available information is insufficient to conclude Iran has all it needs in hand to deploy thousands more IR-1 centrifuges or predict with certainty how many additional IR-1 centrifuges Iran will deploy in the next year.

Another factor that will likely decrease breakout times is Iran's deployment of the advanced centrifuge, the IR-2m, at the Natanz Fuel Enrichment Plant. Predicting the effect of this deployment remains difficult because Iran has not begun enriching in these centrifuges as of mid-June 2013 and little hard data are available about their performance.

Given uncertainty over the success of efforts to stop Iranian smuggling efforts to outfit its centrifuge program and its continued deployment of centrifuges, an assessment of future enrichment capabilities and reduced breakout timelines is warranted. This report evaluates Iran's ability to increase its number of deployed centrifuges beyond current levels and when Iran could produce sufficient weapon-grade uranium without the IAEA being able to provide timely and reliable warning of that breakout, or when Iran is first estimated to reach what is defined here as a critical capability. The report assesses this date by projecting the number of IR-1 and IR-2m centrifuges Iran could deploy in the next year and by estimating the resulting impact on breakout times.

A central conclusion is that Iran is expected to achieve a critical capability in mid-2014. To delay that date, this report recommends measures to head off significant increases in deployed centrifuges and improve chances of timely detection of a breakout.

Background

As of the May 2013 IAEA safeguards report, Iran had continued to deploy its IR-1 centrifuges at both the Fordow and Natanz Fuel Enrichment Plants, although at a slower rate than during the three previous reporting periods. It also continued to deploy IR-2m centrifuge casings and rotors, but it did not begin enriching in these advanced machines. As of May 15, 2013, Iran had installed:

- 13,555 IR-1 centrifuges at the Natanz underground Fuel Enrichment Plant (FEP)
- 689 fully or partially installed IR-2m centrifuges at the Natanz FEP; the number of partially installed centrifuges is unknown
- 328 IR-1 centrifuges in two tandem cascades at the Natanz above ground Pilot Fuel Enrichment Plant (PFEP) plus 326 IR-2m and IR-4 centrifuges installed in two cascades at the Natanz Pilot Fuel Enrichment Plant
- 2,710 IR-1 centrifuges at the deeply buried Fordow Fuel Enrichment Plant

for a total of 16,593 IR-1 centrifuges and 1,015 fully or partially installed IR-2m and IR-4 centrifuges. In total, Iran had installed 17,608 centrifuges at Natanz and Fordow. Up to 10,016 IR-1 centrifuges were enriching uranium as of the above date. No advanced centrifuges were enriching by this date.[2]

[2] Although natural uranium is fed into the two cascades of advanced centrifuges at the Natanz pilot enrichment plant, Iran mixes together the resulting product and waste, giving natural uranium once again.

The 13,555 IR-1 centrifuges in the Natanz Fuel Enrichment Plant are in single, 164 15-stage and 174 17-stage cascades that produce approximately 3.5 percent low enriched uranium (LEU). A total of 8,992 IR-1 centrifugues were enriching at the FEP. At the Pilot Fuel Enrichment Plant at Natanz, Iran is producing near 20 percent LEU in two production-scale, 15-stage cascades each containing 164 IR-1 centrifuges that are connected together into a tandem cascade. The Fordow plant contains 2,710 IR-1 centrifuges in various states of deployment. Two sets of tandem cascades (four individual cascades each involving 174 IR-1 centrifuges organized in 17-stages) are enriching to near 20 percent. The remaining centrifuges at Fordow have been installed in the facility since November 2012, but Iran has yet to begin enriching in these cascades. Though they do not contribute to Iran's current output of LEU, they could be readily employed in a breakout scenario.

Iran has declared its intention to install thousands more IR-1 and IR-2m centrifuges at the Natanz FEP. Indeed, recent IAEA safeguards reports state that construction activities at the FEP are on-going with the apparent intention to install many more centrifuges. According to design information submitted by Iran to the IAEA, the Natanz Fuel Enrichment Plant is composed of Production Halls A and B. Eight units are planned for Production Hall A, with 18 cascades in each unit and a total of about 25,000 centrifuges in 144 cascades. It is expected that Production Hall B will be similarly organized. As of February 19, 2013, Iran had fully installed 74 cascades in Production Hall A, partially installed three other cascades, and completed preparatory installation work for 67 other cascades, for a total of 144 cascades installed or in various states of installation in both Halls A and B. Several of these cascades, namely ones for IR-2m centrifuges, were in Production Hall B, where Iran had started preparatory work as of the summer of 2012. As of May 15, 2013, Iran had fully installed 79 IR-1 cascades in Production Hall A, partially installed one other IR-1 cascade and completed preparatory installation work for another 46 IR-1 cascades, for a total of 126 IR-1 cascades likely all in Production Hall A. Based on a mixture of 164 or 174 centrifuges per cascade, Iran has firm plans to install a total of about 21,000 IR-1 centrifuges in the FEP in these 126 cascades. It also plans to install 3,132 IR-2m centrifuges in 18 cascades in the FEP. In total, Iran plans to install at least 24,132 centrifuges at the FEP. Based on the IAEA's reporting, Iran thus has firm intentions to install about 10,000 more IR-1 and IR-2m centrifuges at the FEP. It is likely to seek to add even more centrifuges, given the available space in both halls.

To the total number of centrifuges at the FEP must be added the 2,710 IR-1 centrifuges already installed at the PFEP and Fordow site. Thus, Iran has firm plans to deploy about 24,000 IR-1 centrifuges and about 3,300 IR-2m centrifuges.

Limit to Deployment of IR-1 Centrifuges?

Can Iran build enough IR-1 and IR-2m centrifuges to meet its goals? It is not clear.

Three years ago, based on known information about the supplies of maraging steel bar Iran acquired illicitly from Britain in the 1990s and possibly elsewhere, ISIS assessed that Iran could manufacture a total of up to 12,000 to 15,000 IR-1 centrifuges. This assessment was based in part on a known bottleneck in Iran's centrifuge program. Each IR-1 requires three maraging steel bellows. Iran has had difficulty obtaining suffient maraging steel abroad and has been unable to make its own indigenously. The maraging steel bar acquired in Britain had a diameter of about 100 millimeters, which is the diameter of the IR-1 rotor assembly. Because Iran obtained maraging steel bar but not tube, the desired shape, it had to waste much of the maraging steel in the process of fashioning the bellows. Iran in essence needed to hollow out the bar to make a bellows with a wall thickness of about one millimeter.

To date, as mentioned above, Iran has installed 16,593 IR-1 centrifuges in its centrifuge plants. Adding at least 1,000 IR-1 centrifuges destroyed by the Stuxnet malware during 2009-2010 and those that have broken during routine operation (20 percent in the early years of the plant and up to 10 percent afterwards), Iran has easily exhausted its supply of known amounts of maraging steel for IR-1 centrifuges, based on this earlier supply of maraging steel from Britain. Thus, Iran has managed to procure sufficient maraging steel for many additional centrifuges.

Based on discussions with experts and governments, ISIS continues to assess that Iran is currently unable to produce sufficient quality maraging steel indigenously for IR-1 and IR-2m centrifuge bellows. Iran's continued attempts to procure maraging steel abroad in violation of national trade control laws and United Nations Security Council resolutions support this assessment.

Iran has tried to illicitly acquire high quality maraging steel abroad and some of these attempts may have succeeded. A recent U.S. prosecution against an Iranian procurement agent has revealed an unsuccessful effort to procure about 20 tonnes of U.S. 350 grade maraging steel in the late 2000s via a Chinese national. This is sufficient maraging steel for about 5,000 or more centrifuges, depending on whether the maraging steel was in the shape of bar or rod.

There is also suspicion that North Korea may have helped Iran obtain maraging steel. Perhaps, North Korea can now manufacture high quality maraging steel sufficient for IR-1 centrifuges; some procurement information supports this assessment. North Korea acquired the raw materials to make maraging steel in China in the right proportions. However, information is lacking on whether North Korea is making maraging steel of sufficient quality for use in the centrifuges. In any case, North Korea's procurment networks are highly sophisticated, particularly in China which has weakly implemented trade controls and sanctions laws, and these networks have extensive experience procuring, via China, Western high technology goods, such as maraging steel, for North Korea's centrifuge program. Despite there being no positive proof that Iran has succeeded in procuring abroad large quantities of high quality maraging steel, it may have done so without being detected. As a result, additional supplies of maraging steel may have increased Iran's capability to make IR-1 centrifuges, perhaps even significantly.

Iran may be reusing, via remelting, the scrap generated in making maraging steel bellows from bars. Because so much of its imported maraging steel would end up as scrap, Iran would be expected to have a considerable stock of maraging steel scrap. Pakistan successfully pursued this path in the 1990s using maraging steel scrap generated from maraging steel it procured abroad. Nonetheless, remelting poses a difficult technical challenge, and views of knowledgable governmental technical experts queried by ISIS were split on whether Iran has achieved this capability. If it learned to sucessfully remelt and re-form the metal, Iran could in theory have sufficient scrap maraging steel for many thousands of centrifuges.

It is also possible that Iran has recovered used bellows it received from the A.Q. Khan network that it previously deemed unsuitable for some of its deployed centrifuges. In the 1990s, as part of purchasing 500 P1 (Pakistani) centrifuges from the Khan netword, Iran received 15,000 used P1 centrifuge bellows from the Pakistani centrifuge program. Many of them were visibly damaged, others were filthy, and some still had traces of araldite, a special resin used to seal the bellows and rotor tubes. Khan justified the supply of these bellows by saying that Iran would find at least 1,500 good bellows in the shipment, which would be sufficient for the 500 P1 centrifuges Iran bought from the Khan network in the mid-1990s. Iran complained about the quality of this supply, and Khan supplied 1,500 new bellows. However, Iran did not return the large shipment of used bellows to the network. It is possible that, facing material constraints, it has been salvaging this set of bellows, which could have resulted in finding enough good ones for several thousand more IR-1 centrifuges. But this source is not sufficient on its own to supply the large recent deployments of IR-1 centrifuges at Natanz and Fordow.

Based on interviews with knowledgeable government officials, Iran has succeeded in obtaining enough high quality carbon fiber for the rotor tubes of least 3,000 IR-2m centrifuges. Iran has successfully circumvented existing controls by deceiving suppliers and exploiting countries with weak export control and sanctions implementation. It should be noted, however, that uncertainties surround whether Iran has obtained other goods, such as 350-grade maraging steel, needed to make IR-2m centrifuges. This quality of maraging steel is used in the IR-2m centrifuge's bellows, baffles, and endcaps.

Nonetheless, Iran could have acquired sufficient goods to build thousands more centrifuges. Thus, Iran could be able to continue increasing its number of installed IR-1 and IR-2m centrifuges significantly.

How Many More Matter?

Because Iran may be capable of installing many more centrifuges at Natanz, this section assesses a potential increase of 10,000 or more IR-1 centrifuges at Natanz, the timeframe for when Iran could install that number, and the implications of the shortened breakout times once Iran has achieved this increase. It also discusses the impact of operating IR-2m centrifuges at Natanz. The concern is that at some point, Iran could have so many IR-1 and IR-2m centrifuges that it could produce enough weapon-grade uranium for a bomb before the IAEA or Western intelligence could detect the breakout. A related question is: what should be done to forestall Iran from achieving this critical capability? That question is addressed in the last section of this report.

An October 8, 2012 ISIS report estimated breakout times, namely the time Iran would require to produce 25 kilograms of weapon-grade uranium, a "significant quantity (SQ)" or enough for one nuclear weapon, at its declared enrichment plants. These estimates include the case of Iran having a total of about 9,300 IR-1 centrifuges enriching at the Natanz Fuel Enrichment Plant and eventually about 2,784 enriching IR-1 centrifuges at Fordow, for a total of 12,084. If Iran produces enough near 20 percent low enriched uranium, it could use this LEU in a breakout at either the Natanz or both the Natanz and Fordow enrichment plants and produce 25 kilograms of weapon-grade uranium in as little as one month, although practically it might take longer.[3] However, as Iran gains experience operating IR-1 centrifuges in cascades, it could more reliably achieve this minimum estimate.

What changes could significantly lower this minimum estimate? There were two parts to these ISIS October 2012 breakout estimates. The first part considered the number of IR-1 centrifuges, which numbered then at 12,084. The second considered the time necessary to adjust the cascades to allow them to produce highly enriched uranium. In certain cases, the set-up time was estimated as being one half of a month and the time to enrich to weapon-grade uranium varied depending on the scenario.[4] Once Iran would have enough near 20 percent for a nuclear weapon and Fordow would be fully

[3] ISIS estimated that, using a combined two-step process at the Natanz FEP and at the Fordow facility in 2013, Iran would require at least 0.8-1.0 months and 240-270 kg of near 20 percent LEU hexafluoride to produce 25 kg of weapon-grade uranium with its single cascades at Natanz. If Iran used Natanz only, it would take at least 0.9-1.2 months and require 320-380 kilograms of near 20 percent LEU hexafluoride. See *Iran's Evolving Breakout Potential*, op. cit.

[4] We ignore the case of Iran creating tandem cascades just prior to breakout at the Natanz Fuel Enrichment Plant because of the length of time needed to reorganize into tandem cascades. In the aforementioned ISIS breakout study, the estimated set-up time in reorganizing into tandem pairs is one month instead of one half month in the case of using single cascades.

operational, the lower bound of the enrichment times would became slightly less than two weeks. Because the set up time was also two weeks, the total breakout time was slightly less than about one month.

In the longer term, both of these time requirements would likely become less. If Iran can increase its currently deployed IR-1 centrifuges by about one third, which would mean deploying more at Natanz or a third site, to about 24,000 IR-1 centrifuges (or install an equivalent but smaller number of advanced IR-2m centrifuges (see below)), it could reduce the time needed to enrich one significant quantity of weapon-grade uranium by one half. Likewise, with experience, advance preparation, and gradual changes in the cascade design, Iran could cut the set-up time by half, to about one week. Considering the case where both time savings are achieved, Iran could produce enough weapon-grade uranium for a nuclear weapon in as little as 0.4 to 0.5 months, or about 12 to15 days, starting with a sufficient stock of near 20 percent LEU.[5] Similarly, with 24,000 IR-1 centrifuges, if Iran reduced the set-up time to one third of its current estimated value, breakout times would reduce to about 0.32 to 0.42 months, or about 9.6 to 13 days.

Iran may be able, with these shortened breakout times, to produce enough weapon-grade uranium for a bomb while avoiding detection by the IAEA. Currently, the IAEA inspects the Natanz pilot plant and the Fordow plant, where near 20 percent LEU is produced, on average, about every week. The Natanz Fuel Enrichment Plant is inspected on average about every two weeks. Inspection frequency is in part determined by the level of enrichment at a facility, which is to say that any facility producing 19.75 percent enriched uranium would be subject to the more frequent inspections. To reduce the chance of detection once it is capable of breakout in as few as 12-15 days, Iran could stop the IAEA from visiting either facility based on a fallacious reason such as a fire or other emergency, or on a pretext such as in protest of some contrived IAEA action it disagreed with. At current inspection frequencies, Iran may need to block only one or two inspections in order to finish making enough weapon-grade uranium without being detected by the IAEA.

Although Iran would need more time, probably at least several months, to convert the weapon-grade uranium into a nuclear explosive, it could make the bomb in small, heavily fortified, difficult to detect facilities, significantly complicating any international response. Moreover, concern is expected to grow that Iran could have pre-produced nuclear explosive components, significantly shortening the manufacturing and assembly time of an explosive. As a result, it is much easier to deter Iran from making a decision to break out if the United States and its allies can prevent Iran from accumulating sufficient weapon-grade uranium for a nuclear weapon.

How fast could Iran install this large quantity of IR-1 centrifuges? Based on IR-1 installation at the Natanz and Fordow enrichment plants over the previous four IAEA reporting periods, which cover one full year, Iran installed an average of approximately 500 IR-1 centrifuges per month, where in one reporting period the rate was as high as approximately 750 IR-1 centrifuges per month and in the most recent reporting period was as low as 310 centrifuges per month. Iran could likely install IR-1 centrifuges at a faster rate as it gains more experience. However, it may encounter problems that would reduce the average rate. For example, as discussed above, it may not have sufficient raw materials and equipment to build and install in cascades so many IR-1 centrifuges. Because of these

[5] These values are derived in two ways from the aforementioned ISIS breakout study, and in both cases nearly the same range is obtained. The first scales upwards the model using both Natanz and Fordow together to 24,000 IR-1 centrifuges and obtains 0.4-0.5 months. In this case, about 240-270 kilograms of near 20 percent LEU hexafluoride are required. In the second case, the model involving only the Natanz plant (and using single cascades) is used and scaled up to 24,000 IR-1 centrifuges, taking 0.4-0.52 months. In this case, 320-380 kilograms of near 20 percent LEU hexafluoride are required. It should be noted that the base model for Natanz used fewer IR-1 centrifuges than the Natanz and Fordow model.

uncertainties, ISIS has considered only a straightforward projection where Iran's average deployment rate is taken as 500 IR-1 centrifuges per month.

At an average rate of installation of 500 IR-1 centrifuges per month, Iran could reach a total of 17,305 IR-1 centrifuges at the Natanz Fuel Enrichment Plant by the end of 2013,[6] for a total of 20,343 IR-1 centrifuges.[7] By July 2014, the total at the FEP could reach 20,305 centrifuges, and a total of 23,343 installed IR-1 centrifuges, assuming Iran does not add a third enrichment plant. By mid-2014, therefore, Iran could achieve breakout times, as discussed above, that are as short as 12-15 days in the case of set-up time being reduced by half. If set-up time is reduced to one-third of its base value, breakout times could be 10-13 days. By the end of 2014, at this rate, Iran would have deployed a total of over 26,000 IR-1 centrifuges and reduced breakout times even more.

The above discussion of breakout time did not incorporate the recently deployed IR-2m centrifuges at the Natanz FEP and the advanced centrifuge test cascades at the Natanz PFEP. In total, Iran has deployed up to about 1,015 advanced centrifuges at Natanz in production-scale cascades. The exact number is unknown because Iran has not declared the number of rotor assemblies actually in the 689 rotor outer casings deployed in the Natanz FEP. Each individual IR-2m centrifuge should have the output of 3-5 IR-1 centrifuges. So, the up to 1,015 advanced centrifuges are roughly equivalent to up to 3,045-5,075 IR-1 centrifuges. As discussed, performance data for these centrifuges are sparce, so this equivalence is rough.

Iran is currently installing the IR-2m centrifuges at the FEP at a relatively slow rate – no more than 200 per month. It must be emphasized that the actual rate of fully installed centrifuges could have been considerably below that rate so far. However, if it fully installed IR-2m centrifuges at a rate of 200 per month, Iran could install a full set of 18 cascades, containing 3,132 IR-2m centrifuges, in a total of 15.7 months. Assuming that installation started in February 2012, all 18 cascades could be installed by July 2013, although the actual date would likely be later to account for partially installed centrifuges. Nonetheless, once installed, these IR-2m centrifuges would be equivalent to a large number of IR-1 centrifuges, namely 9,396-15,660 IR-1 centrifuges. It is unknown what rate of installation Iran can practically achieve, as little concrete data about procurement and advanced centrifuge manufacturing is known.

At its current installation rate of IR-2m centrifuges, Iran could achieve a critical capability earlier than mid-2014. However, this estimate is highly speculative since Iran has not started enriching in the IR-2m cascades at the FEP, and in fact, it is unknown if Iran has even installed anywhere near 689 rotor assemblies at the FEP. Thus, postulating a future installation rate of 200 IR-2m centrifuges per month is only conjecture. With that caution, however, it is useful to make an assessment where it is assumed that Iran continuously deploys 500 IR-1 centrifuges per month and 200 IR-2m centrifuges per month, while ignoring any IR-2m centrifuges already installed to make the estimate less speculative. In total, the combined equivalent rate would be 1,100-1,500 IR-1 centrifuges per month. By the end of 2013, Iran would have an equivalent of 24,843-27,843 IR-1 centrifuges, a sufficient number to be judged as having a critical capability.

However, as mentioned, this estimate for the end of 2013 is highly uncertain for the reasons stated, namely that the IAEA has not released performance data on the IR-2m centrifuges, these centrifuges have not operated at the FEP, and enrichment startup of these centrifuges may be complicated or

[6] The number of installed IR-1 centrifuges is given by the IAEA as of May 15, 2013, so there are estimated to be an additional 3,750 Ir-1 centrifuges at the end of 2013.
[7] The number deployed in the second half of November 2012 is ignored here.

delayed. They may in particular not reach a level of 3-5 times the enrichment output of the IR-1 centrifuges.

Another consideration is that the critical capability date assumes Iran could accumulate enough near 20 percent LEU for a breakout. Achieving the necessary amount is currently unlikely by the end of 2013 unless Iran significantly changes the number of centrifuges enriching at the Fordow facility or the amount of 19.75 percent LEU that it sends to the Esfahan facility for conversion.

On balance, the uncertainties surrounding Iran's intent and ability to deploy the IR-2m centrifuge at the FEP do not warrant currently shifting the estimated critical capability date from mid-2014. However, the situation requires close attention.

The installation of the IR-2m centrifuges at the FEP would tend to support not treating the mid-2014 date as a worst case. In addition, Iran could still reach a critical capability in mid-2014 even if it soon stops its installation of additonal IR-1 centrifuges but continues with its planned installation of IR-2m centrifuges.

Discussion and Findings

Although it is too early to tell if Iran will build and deploy thousands more IR-1 and IR-2m centrifuges, it is clear that it intends to do so. Based on a straightforward projection starting from today, Iran could achieve a critical capability in mid-2014. By this time, Iran could have sufficient IR-1 and IR-2m centrifuges installed to reduce breakout times to dangerously short timelines. This date could be achieved a few months earlier, if Iran successfully deploys and operates its advanced centrifuges and continues its installation of IR-1 centrifuges.

Moreover, Iran could speed up its deployment of IR-1 centrifuges at Natanz if it has the necessary amount of raw materials and equipment. Similarly, a shortage of goods or problems with the centrifuges could slow down its deployment of centrifuges. On balance, however, achieving the equivalent of about 24,000 IR-1 enriching centrifuges, a rough benchmark for a dramatically reduced breakout estimate, appears to be feasible for Iran in 2014.

A priority is keeping Iran from reaching this dangerous critical capability and keeping breakout times as long as possible--at least at one month or longer. There are a range of actions that can delay or prevent Iran from achieving critical capability.

It is important to accelerate efforts to detect and block Iran's smuggling efforts to acquire equipment and raw materials for its IR-1 and IR-2m centrifuges and cascades. Denying Iran the raw materials and equipment it needs is an important part of limiting the number of centrifuges it can build. One way is to eliminate loopholes in existing United Nations Security Council sanctions and increase them to more effectively ban materials and equipment used in Iran's nuclear programs.[8] For example, China and Turkey currently are not enforcing these sanctions effectively and should be pressed to do far more. Moreover, the European Union (EU) pays too little attention to retransfers within the EU that are actually Iranian smuggling schemes aimed at exploiting member countries with weakly enforced controls and sanctions. An intensified strategy of technology and critical goods denial is particularly important when considering Iran's ability to deploy more capable advanced centrifuges. Although Iran tries to purchase well in advance of its requirements for deploying centrifuges, it has encountered

[8] David Albright, Andrea Stricker, and Houston Wood, *Future World of Illicit Nuclear Trade: Mitigating the Threat*, ISIS, to be published in July 2013.

increasing difficulty obtaining needed goods because of the U.N. Security Council sanctions and improved national trade controls. Stronger sanctions and more aggressive implementation of both export controls and sanctions coupled with stronger enforcement can make it even harder for Iran to increase the numbers of its centrifuges.

Another priority is reducing Iran's stock of near 20 percent LEU through seeking a negotiated moratorium on further production of this material combined with the removal of existing stocks from Iran. The goal should be to keep Iran's stock of LEU enriched above five percent as low as possible, consistent with the recent P5+1 Almaty proposal, offered on March 18, 2013 during talks with Iran in Istanbul.[9]

Although this step would help build confidence and is important to pursue, by itself it is unlikely to ensure that Iran does not emerge with a critical capability in 2014. Iran needs only 240-270 kilograms of near 20 percent LEU hexafluoride to have enough to make 25 kilograms of weapon-grade uranium.[10] As of May 2013, it had about 182 kilograms in that form.[11] Even in the case of achieving such a moratorium and removing a fraction of the existing stock soon, Iran could restart such production on relatively short notice, even if the disablement steps in the P5+1 Almaty proposal were implemented. Iran could claim a need for more safeguarded LEU. Afterall, its argument for continued production beyond its needs for the Tehran Research Reactor (TRR) now rests on claims of planning to build 4-5 research reactors, one of which it recenly announced is to be located in southern Iran.[12] Although Iran will not need to produce enriched uranium for this reactor in the near-term, it may use its announced construction to justify restarting or increasing rates of 19.75 percent uranium enrichment.

Given that the Fordow plant combined with the tandem set at the Natanz PFEP could produce 45 kilograms of near 20 percent LEU hexafluoride per month, it would not take Iran long to acquire enough for a breakout, in the event it ended a moratorium. It could also use the Natanz FEP to produce this near 20 percent material from 3.5 percent LEU. The operators would also not need to re-organize the cascades at the FEP into tandem pairs. Thus, while useful in building confidence, a moratorium to the production of near 20 percent LEU combined with the removal of its stocks of near 20 percent LEU is not sufficient by itself to prevent Iran from achieving a critical capability in mid-2014.

It is important that Iran agree to halt the further installation of any centrifuges. Moreover, this halt should also include a commitment to freeze the construction of any other enrichment plants. Iran does not need to further increase its production of 3.5 percent LEU; thus it certainly does not need to increase its capability to make LEU. As of the last IAEA report, based on its record of producing near 20 percent LEU, its stock of 6,357 kilograms of 3.5 percent LEU hexafluoride was enough material to make another 810 kilograms of near 20 percent LEU hexafluoride, far more than it can use over the next several years. Immediately halting the installation of more centrifuges at any Iranian facility is a reasonable request if Iran is not intending to build nuclear weapons.

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[9] Laura Rozen, "The P5+1 Proposal to Iran in Almaty: Document," *Al Monitor*, June 9, 2013. http://backchannel.al-monitor.com/index.php/2013/06/5444/p51-almaty-confidence-building-proposal-to-iran/

[10] See *Iran's Evolving Breakout Potential*, op. cit.

[11] Iran has many tens of kilograms of near 20 percent LEU in the form of uranium oxide that has not been irradiated in the TRR. But that amount is ignored here, although much of it is unlikely to be irradiated in the TRR in the next year and could be reconverted back into hexafluoride form. This process would likely take several months unless Iran in the meantime develops the process lines necessary to do this.

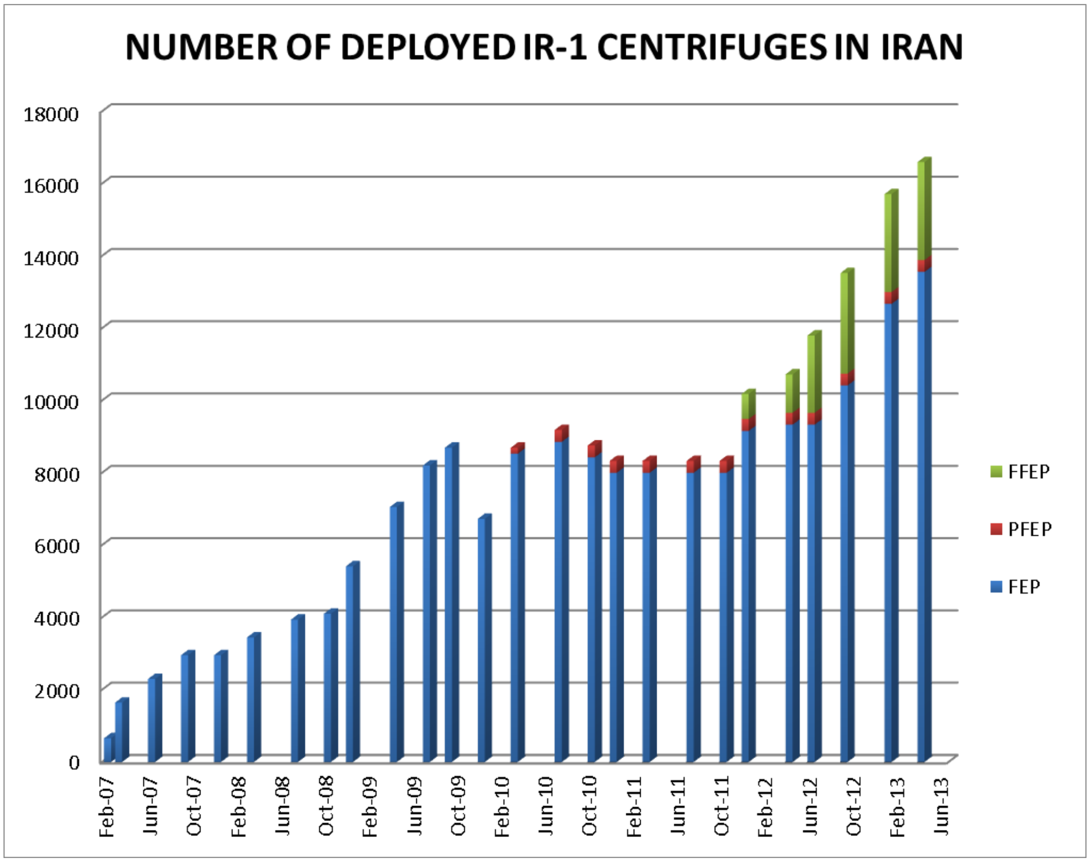
[12] "Iran picks site for new reactor," The Associated Press. June 20, 2013.

A freeze in centrifuge deployment should additionally be accompanied by Iran agreeing to halt its illicit procurement activities for its centrifuge and other nuclear programs. Iran is unlikely to have purchased abroad all it needs to build another 10,000-20,000 IR-1 centrifuges and install them in cascades. A halt to overseas procurement would provide additional assurance that Iran is not preparing for a surge in the number of installed centrifuges. This step would merely mean that Iran would stop its smuggling activites, which are viewed internationally as illegal and a source of tension with most nations which are responsibly committed to preventing illicit nuclear trade.

Although it should be recognized that the IAEA may have trouble delivering a timely warning when Iranian breakout times reach less than two weeks, it makes sense for the IAEA to further increase the frequency of both routine and unannounced inspections of Iran's enrichment plants. The inspectors may afterall be able to detect a breakout, and increased frequency would likely create more deterrence against Iran trying. The goal should be to have inspections occur well within the timeframe of a breakout. So, if breakout can occur in 12-15 days, inspections should occur frequently enough to have a chance of providing early warning of such an event. Iran could claim that it cannot allow an inspection on one or two occasions for reasons that could appear reasonable, or at least plausible enough for several states despite suspicions otherwise to conclude that breakout is not occuring. But if Iran continued to refuse the inspectors access to the enrichment sites, it would be reasonable to conclude that breakout is indeed occuring. As such, the frequency of inspections should be at least one-quarter of the estimated breakout time, or in this case there should be four inspections in that 12-15 day period. So, if breakout times are 12-15 days, inspections should occur on average of every 3-4 days. Thus, to better detect and increase deterrence against breakout, IAEA inspection frequencies should increase to twice a week at all enrichment plants.

If tensions become high, the IAEA may be pressed to station personnel permanently at the enrichment plants with reliable, independent communication gear. However the IAEA may not want to risk the safety of its inspectors in case a breakout does occur. In that scenario, Iran would be unlikely to let them report on a breakout and may use them as hostages. An alternative is to press for remote camera monitoring of the safeguarded LEU and cascade areas of the enrichment plants that is capable of sending continuously real time encrypted images to IAEA headquarters in Vienna. A sudden halt in remote monitoring combined with a refusal for an IAEA visit should provide sufficient alarm that a breakout is underway. Although Iran has resisted this measure so far, it makes sense to raise it again and make it a condition of progress in negotiations.

The most immediate priority is preventing Iran from developing a critical capability that would allow it to far more easily produce nuclear weapons. If an Iranian breakout to nuclear weapons is detectable it becomes less likely Iran will try for fear of the repercussions. In addition to curtailing Iran's production and stockpile of near 20 percent enriched uranium, any interim negotiated deal must include a verifiable pledge by Iran not to upgrade the type and increase the number of its operational centrifuges anywhere in Iran. By agreeing to these measures, Iran would take a significant step towards building confidence that it does not intend to break out and allow time to negotiate a more lasting agreement.


NUMBER OF DEPLOYED IR-1 CENTRIFUGES IN IRAN
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Feb-07
Jun-07
Oct-07
Feb-08
Jun-08
Oct-08
Feb-09
Jun-09
Oct-09
Feb-10
Jun-10
Oct-10
Feb-11
Jun-11
Oct-11
Feb-12
Jun-12
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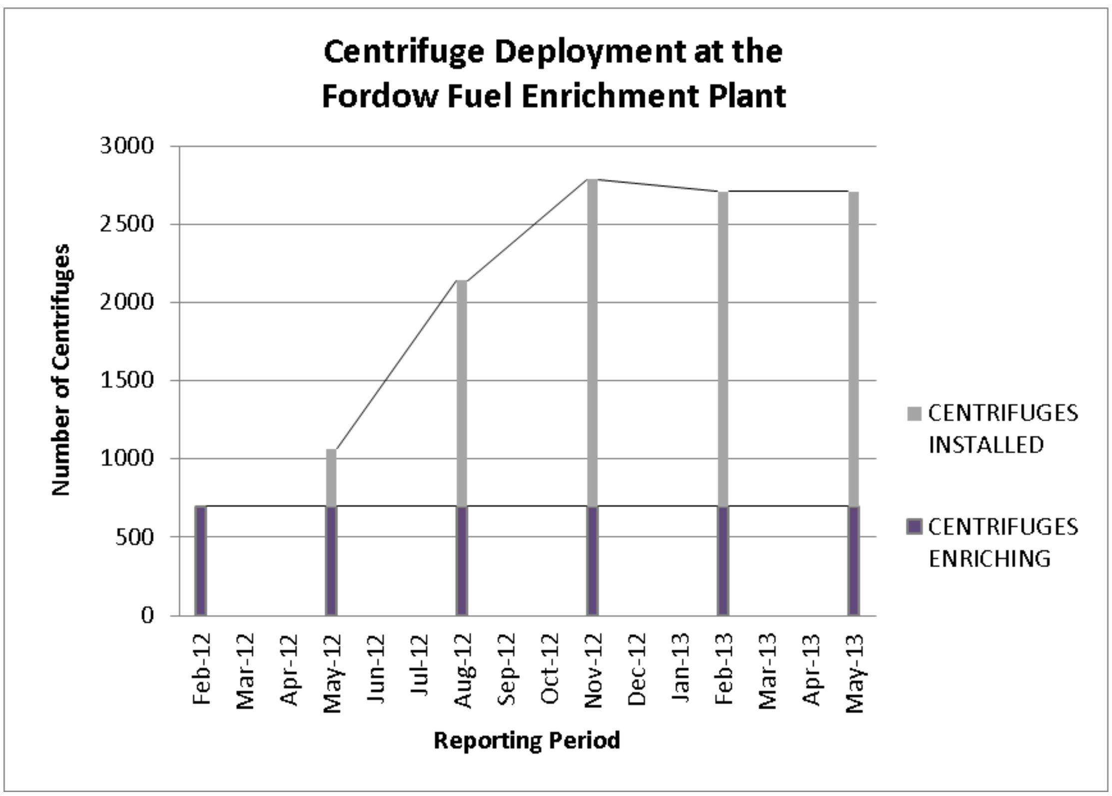
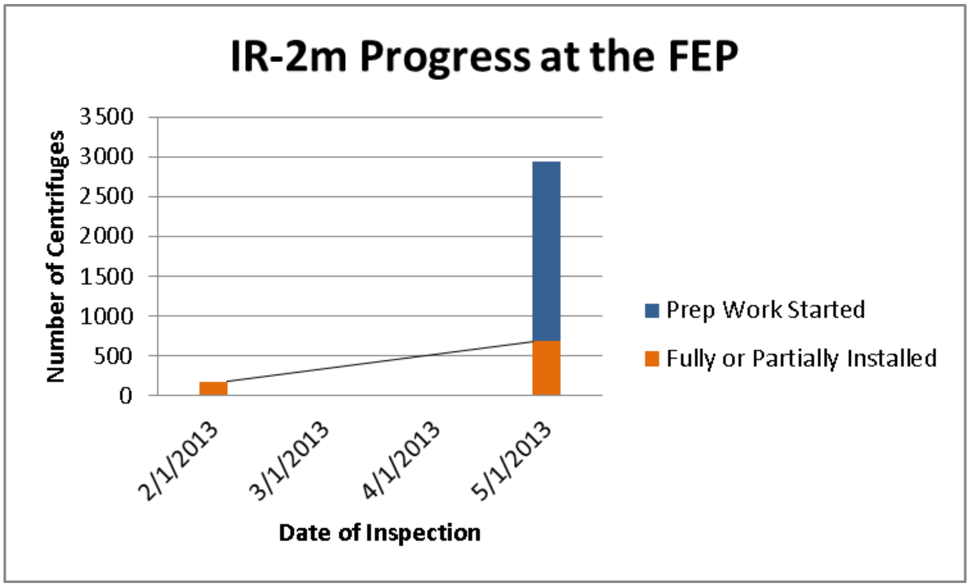
Feb-13
Jun-13
FFEP
PFEP
FEP


Centrifuge Deployment at the
Fordow Fuel Enrichment Plant
Number of Centrifuges
3000
2500
2000
1500
1000
500
0
Feb-12
Mar-12
Apr-12
May-12
Jun-12
Jul-12
Aug-12
Sep-12
Oct-12
Nov-12
Dec-12
Jan-13
Feb-13
Mar-13
Apr-13
May-13
Reporting Period
CENTRIFUGES INSTALLED
CENTRIFUGES ENRICHING


IR-2m Progress at the FEP
Number of Centrifuges
3500
3000
2500
2000
1500
1000
500
0
2/1/2013
3/1/2013
4/1/2013
5/1/2013
Date of Inspection
Prep Work Started
Fully or Partially Installed