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ISIS REPORT

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Iranian Breakout Estimates, Updated September 2013

By Patrick Migliorini, David Albright, Houston Wood, and Christina Walrond[1]

SUMMARY

Since October 2012 when ISIS last published detailed breakout assessments about Iran's gas centrifuge uranium enrichment program, Iran has steadily expanded the number of IR-1 centrifuges installed at both its Fordow and Natanz gas centrifuge plants.[2] Additionally, it has started installing its more advanced centrifuge model, the IR-2m centrifuge, at the Natanz Fuel Enrichment Plant (FEP). These substantial changes merit updating our previous breakout estimates of the time Iran would need to produce one significant quantity (SQ) of weapon-grade uranium (WGU), taken as 25 kilograms of WGU, using its existing safeguarded nuclear facilities and low enriched uranium (LEU) stocks as of August 2013.

For several years, experts at ISIS and the School of Engineering and Applied Science at the University of Virginia (UVA) have quantified Iran's ability to adapt its enrichment program to produce WGU. Iran maintains a number of options should it choose to breakout of the Nuclear Nonproliferation Treaty (NPT). This report evaluates those options in various realistic combinations to examine Iran's current ability to produce WGU. We also look for the first time in this report at breakout times in the case of Iran having a covert centrifuge plant of advanced centrifuges.

As in the October 2012 iteration, the estimates in this report do not include the additional time that Iran would need to convert WGU into weapons components and manufacture a nuclear weapon. This extra time could be substantial, particularly if Iran wanted to build a reliable warhead for a ballistic missile. However, these preparations would most likely be conducted at secret sites and would be difficult to detect. If Iran successfully produced enough WGU for a nuclear weapon, the ensuing weaponization process might not be detectable until Iran tested its nuclear device underground or otherwise revealed its acquisition of nuclear weapons. Therefore, the most practical strategy to prevent Iran from obtaining nuclear weapons is to prevent it from accumulating sufficient nuclear explosive material, particularly in secret or without adequate warning. This strategy depends on knowing how quickly Iran could make WGU.

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[1] Patrick Migliorini and Professor Houston Wood are affiliated with the School of Engineering and Applied Science at the University of Virginia. David Albright and Christina Walrond are affiliated with ISIS.

[2] William C. Witt, Christina Walrond, David Albright, and Houston Wood, *Iran's Evolving Breakout Potential*, ISIS Report, October 8, 2012. http://isis-online.org/uploads/isis-reports/documents/Irans_Evolving_Breakout_Potential.pdf

We evaluated a range of breakout scenarios based on the current enriching IR-1 centrifuges and LEU stockpiles, total installed IR-1 centrifuges, and a possible covert facility containing IR-2m centrifuges. This analysis utilizes a modified form of the well-known four-step enrichment process that was developed under A.Q. Khan for Pakistan's centrifuge program and transferred to other countries, such as Iran. Using all four steps, Iran would enrich natural uranium to 3.5 percent in step one, then to 20 percent in step two, then to 60 percent in step three, and finally to WGU in step four. This analysis considers the four-step, three-step, and two-step process also with the use of existing LEU stockpiles.

The table lists the major estimated breakout times of the four scenarios considered in this report. Today, Iran could break out most quickly using a three-step process with its installed centrifuges and its LEU stockpiles as of August 2013. In this case, Iran could produce one SQ in as little as approximately 1.0–1.6 months, if it uses all its near 20 percent LEU hexafluoride stockpile. Using only 3.5 percent LEU, Iran would need at least 1.9 to 2.2 months and could make approximately 4 SQs of WGU using all its existing 3.5 percent LEU stockpile.

A covert plant offers Iran additional options for cascade configuration and relatively fast breakout times, where the calculations utilize LEU stocks as of August 2013. The estimates vary based on cascade configuration and the actual separative capacity of the IR-2m centrifuge. In the ideal scenario with optimized cascade structure and very good centrifuge performance, it is possible that Iran could use a covert plant to break out in as little as approximately one to two weeks. However, it's more likely that Iran would require more time and the covert plant would have a less optimal cascade arrangement. In that case, breakout times would increase. With LEU inventory as of August 2013, Iran could break out in as little as 1.3-2.6 months in a covert plant with a more realistic cascade organization. In the case where only a stock of 3.5 percent LEU were used, Iran could break out in as little as 2.2-4.5 months. These times would be relatively long in the case of a breakout at declared centrifuge plants, where detection would be relatively prompt and where the enrichment would occur at a known location. However, when the enrichment is carried out at a secret location, these breakout times offer less assurance. Even though the IAEA would detect the diversion of the safeguarded LEU, the location of the enrichment site would be unknown, severely complicating any response aimed at stopping further enrichment.

If Iran had a stock of about 250 kg of near 20 percent LEU hexafluoride, breakout times would be significantly shorter in the two step process than in the three step arrangement. However, when the stock of near 20 percent LEU hexafluoride falls to about 205 kg, then the three step process with the use of the LEU inventory is about the same as the two step process with 205 kg of near 20 percent LEU hexafluoride.

The shortening breakout times have implications for any negotiation with Iran. An essential finding is that they are currently too short and shortening further, based on the current trend of centrifuge deployments. As a result, the current negotiations should result in:

- lengthening the breakout times,
- shortening the time to detect breakout, and
- gaining assurance that a secret centrifuge plant is unlikely to be built or finished.

Increased transparency. There are several additional transparency measures that are important, although a discussion of these measures is outside the scope of this report. But two points are worth mentioning. The first is that transparency measures by themselves have inherent limits and cannot address fully the risk posed by short breakout times.[3] Nonetheless, Iran should be pressed to increase the frequency of inspections at enrichment plants, install remote camera monitoring at enrichment plants, implement early notification of the construction of nuclear plants[4], ratify the Additional Protocol, and establish full inspections of its centrifuge research, development, and manufacturing complex.

Lengthening breakout. A negotiation should be guided by the need to lengthen breakout times significantly from their current values. A reasonable minimum breakout time should be six months or preferably longer. If breakout took greater than or equal to six months, the IAEA could clearly detect it long before one SQ is produced, and the international community would have time to marshal a response to stop Iran producing enough WGU for a nuclear weapon.

The process of lengthening breakout times involves several variables. The key ones are the number of centrifuges, the stocks of LEU, the enrichment level of the LEU, and the type of centrifuges installed. In practical terms, a six month breakout at declared sites could be achieved several ways. Based on the estimates in this report, four cases are evaluated that result in a breakout time of at least six months.

1) The near 20 percent LEU hexafluoride stock is frozen at an August 2013 level and no further near 20 percent is produced. Any amount of near 20 percent LEU hexafluoride in excess of the August level is blended down to 3.5 percent LEU hexafluoride or shipped out of the country. All existing near 20 percent LEU oxide is shipped out of the country or irradiated in the Tehran Research Reactor (TRR), since this stock could be reconverted into hexafluoride form well within six months and used in a breakout. No IR-2m centrifuges are involved in enriching uranium. And stocks of 3.5 percent LEU are not affected. In this case, extrapolating one of the subcases of Scenario 2, namely the three-step process with the use of all installed IR-1 centrifuges and all near 20 percent LEU hexafluoride inventory, a six month breakout limit would necessitate Iran having no more than 3,000-5,000 centrifuges at Natanz and Fordow.

2) Iran no longer has near 20 percent LEU. In this case, Iran would need to blend down or ship out of the country all its stock of near 20 percent LEU, other than what is irradiated in the TRR. In addition, only IR-1 centrifuges would be enriching uranium. Extrapolating Scenario 2, in this case the three-step process with all installed IR-1 centrifuges and only a 3.5 percent LEU stock, a six month breakout limit would necessitate Iran having no more than 5,800 to 6,800 IR-1 centrifuges.

3) There is no inventory of LEU in Iran. In this case, Iran would need to blend down or ship out all its stocks of 3.5 percent and near 20 percent stocks of LEU, leaving in Iran only those stocks irradiated in the TRR. Any new 3.5 LEU produced would need to be rapidly blended down or shipped out of Iran. In addition, no IR-2m centrifuges are involved in enriching uranium. Extrapolating Scenario 2, namely the four-step process with all installed centrifuges, a six

[3] *Critical Capability*, ISIS Report, op. cit. http://isis-online.org/isis-reports/detail/critical-capability/8 ;

[4] More formally implement modified code 3.1. of the Subsidiary Arrangements to Iran's Comprehensive Safeguards Agreement.

month breakout limit would require Iran having no more than 16,600 to 20,900 IR-1 centrifuges. However, this case is not realistic in a centrifuge plant with so many centrifuges. There would be expected to be several product tanks in the plant that would receive 3.5 percent LEU from the cascades. And these product tanks would be expected to hold at least one tonne of 3.5 percent LEU hexafluoride.

4) Iran has one tonne of 3.5 percent LEU hexafluoride in the centrifuge plant and no near 20 percent LEU. The other conditions include no IR-2m centrifuges deployed and rapid blend down of the LEU or shipment of the LEU out of the country. In this case, breakout using the four-step process and all installed IR-1 centrifuges as of August 2013 would take an estimated 2.5 to 3.0 months.[5] Extrapolating this calculation, a six month breakout would require Iran having no more than 7,700-9,200 IR-1 centrifuges.

These cases show that limiting the numbers of centrifuges and eliminating the near 20 percent LEU stock are the most important goals if breakout times are to be lengthened significantly. One major implication is that Iran should not have more than about 9,000 IR-1 centrifuges and should have considerably fewer than 9,000 IR-1 centrifuges if Iran keeps a stock of near 20 percent LEU whether in the form of hexafluoride or unirradiated uranium oxide.

If Iran substitutes IR-2m centrifuges for IR-1 centrifuges, then the equivalent limits would be roughly one fifth to one third smaller. So, a limit of 9,000 IR-1 centrifuges would be equivalent to 1,800-3,000 centrifuges. However, a more effective goal is to seek a halt to the deployment and use of IR-2m centrifuges in Iran.

Reducing chances of a covert centrifuge plant. Increasing the probability that there are not additional, covert enrichment plants cannot be achieved solely by increasing transparency, such as ratifying the Additional Protocol, despite its critical value. More important is an Iranian commitment to confine its enrichment activities to Natanz, halt further centrifuge manufacturing except to replace broken ones or build new ones for declared, agreed-upon centrifuge expansions at Natanz needed to produce LEU for near-term insertion in a reactor, halt the development and deployment of advanced centrifuges, and commit not to conduct illicit nuclear smuggling to obtain centrifuge-related goods.

All of these steps are achievable and reasonable if Iran is committed to convincing the world that its nuclear program is indeed peaceful.

[5] In this case, the four-step process is used, since there is not enough 3.5 percent LEU to produce one SQ of WGU. Above an inventory of about 1.5 tonnes of 3.5 percent LEU, then case 2 applies.

Table 5 Estimated Minimal Breakout Times, in months, as of August 2013

Scenario 1: Breakout with only enriching centrifuges at Natanz and Fordow

Four step	
Without use of LEU inventory	9.0-9.6
With use of LEU inventory	2.3-3.2
Three step	1.3-2.3
Two step	n.a.

Scenario 2: Breakout with all installed centrifuges at Natanz and Fordow

Four step	
Without use of LEU inventory	5.4-6.8
With use of LEU inventory	1.7-2.3
Three step	
With use of both 3.5% and near 20%	1.0-1.6
With use of 3.5% LEU and no 20% LEU	1.9-2.2
Two step (not enough near 20 percent as of August but close)	
If 205kg near 20% LEU hexafluoride	1.0 – 1.2
If 250 kg near 20% LEU hexafluoride	0.7 – 0.8

Scenario 3: Covert Facility of IR-2m Centrifuges Optimized for WGU Production with Separative power of 3-5 SWU/yr

From 0.7% to 90%	2.55-4.25
From 3.5% to 90%	0.73-1.22
From 19.75% to 90%	0.15-0.25

Scenario 4: Covert Facility of IR-2m Centrifuges Using More Realistic, Multi-Step Cascade Setup and Separative Power of 3-5 SWU/yr

Four step	
Without use of LEU inventory	6.4-11.3
With use of LEU inventory	1.6-2.6
Three step	
With use of both 3.5% and near 20%	1.3-2.3
With use of 3.5% LEU and no 20% LEU	2.2-4.5
Two step	
With 250 kg near 20% LEU hexafluoride	0.7-1.4
With 205 kg near 20% LEU hexafluoride	1.1-2.3

The full technical study is available here: **Iranian Breakout Estimates, Updated September 2013**