INSTITUTE FOR SCIENCE AND INTERNATIONAL SECURITY
REPORT

Iranian Breakout Study Drastically Overestimates Time to Nuclear Weapon

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An Iranian website, www.nuclearenergy.ir recently posted an apparently quasi-official government study, *How long would an Iranian 'breakout' really take?* The study makes the dubious claims that Iran would need three years in the case of making a nuclear weapon with highly enriched uranium and 5-7 years to make one out of plutonium produced in the Arak reactor. Furthermore, this study asserts incorrectly that Iran would need at least 18 months to break out and produce enough weapon-grade uranium (WGU, more than 90 percent enriched) for a nuclear weapon, defined as 25 kilograms of weapon-grade uranium, or one "significant quantity." (Breakout is typically defined as only the step of producing weapon-grade uranium and does not include the other parts of making the nuclear weapon. The Iranian study uses breakout to include all the steps of making a nuclear weapon.)

This Iranian website details Iran's nuclear history and expresses common government stances on issues relating to the nuclear program. The results of the Iranian study and how it undercuts the "myth" of a few months to Iranian breakout have been espoused by senior Iranian governmental officials. However, this study contains mistakes and uses unwarranted assumptions to arrive at its conclusions. Using its data and correcting for mistakes, we arrive at a breakout estimate of 2-3 months in terms of the time to produce 25 kilograms of WGU, instead of its estimate of a minimum of 18 months. In addition, the study provides no data to understand how the authors arrived at their estimate of the time to finish the other aspects of building a nuclear weapon with weapon-grade uranium or of plutonium-based breakout (taken in the authors' manner), but even a cursory examination shows that these estimates are greatly inflated.

Detailed criticisms and questions about the Iranian report have also been published by Ferenc Dalnoki Veress in a study titled *Iranian Break Out Calculations – An Analysis of Nuclearenergy.ir Article*.

Iran has obviously been uncomfortable with the concept of breakout, particularly as applied to its gas centrifuge program, since it shows quite directly the risks of its demands in the negotiations with the P5+1 for building many more IR-1 centrifuges or an equivalent number of advanced centrifuges. The simple metric of breakout time has proven remarkably useful in allowing the evaluation of questions about centrifuge programs, requiring only a limited number of technical inputs which are derived mostly from information published by the International Atomic Energy Agency (IAEA). For example, breakout calculations can answer the question of how long Iran needs to make enough weapon-grade uranium for a nuclear weapon under a wide variety of current and posited centrifuge capabilities. Breakout estimates permit a comparison of different negotiating positions and provide a criterion helpful in identifying technically unsound compromises. They allow for key follow-on questions in negotiations, such as: Is there enough time to respond to stop Iran if it does decide to build nuclear weapons? Few international responses, even military ones which are clearly not desirable, require less than 6-12 months to organize and implement. This timeframe in turn helps define a corresponding number of centrifuges, albeit a number that is considerably less than the one Iran wants. Thus, in addition to other metrics, breakout timelines will remain a critical measure of the soundness of any agreement.

It should be noted that a large nuclear program in Iran is useful not only for breakout at declared facilities but a "sneak out" at clandestine facilities, which many analysts consider the more likely possibility due to the threat of military strikes on declared facilities if Iran was caught breaking out. If Iran is left with a large enrichment capacity, this would enable it to conduct not only a fast breakout at declared facilities, but it would also create higher risks and a faster timeline in a scenario under which Iran diverted low enriched uranium to clandestine facilities for further enrichment. All else being equal, a larger program would be more difficult to safeguard against breakout or sneak out.

Because of their value, breakout estimates are unlikely to be dropped as a metric used in evaluating negotiation positions and determining their risks. The United States and its allies have invested considerable effort into understanding breakout times in Iran, as we have done at ISIS. The methods of deriving breakout times are now well understood and a variety of governments and groups are arriving at similar results. The Iranian study refers to one of our studies and a statement before the Senate Foreign Relations Committee by Secretary of State John Kerry, who provided a specific, public breakout estimate for Iran's current centrifuge capability of about two months, the same as our estimate. Additional ISIS breakout estimates can be found here, here, and here.

Officials in Iran seem to have shifted tactics and now want to engage on the substance of breakout timelines; however, they do so in order to dismiss Western timelines as unrealistic now that they have been raised as a vital issue in the talks. As is often the case when a study is motivated by political need, the Iranian study has several basic methodological flaws that lead to inflated breakout estimates.

Uranium-Based Breakout

On the issue of breakout to enough weapon-grade uranium for a nuclear weapon, the study erroneously and problematically for its findings:

- Uses only half of the installed centrifuges at the Natanz and Fordow enrichment plants to calculate breakout time. It uses only the roughly 9,000 enriching IR-1 centrifuges and ignores the other 9,000 installed but non-enriching IR-1 centrifuges and the approximately 1,000 IR-2m centrifuges installed but not enriching.
- Ignores Iran's existing low enriched uranium (LEU) stock, starting breakout from natural uranium rather than 3.5 percent and perhaps near 20 percent low enriched uranium, as most other breakout estimates do. That natural uranium is the starting point is not explicitly stated in the report, but it is indicated by the amount of separative work stated as needed to make 25 kilograms of highly enriched uranium. The report states, "Thus, it can be deducted that 6,000 [separative work units] SWU is equivalent to 25 Kg of HEU." This value of 6,000 swu is consistent with starting from natural uranium. If 3.5 percent low enriched uranium had instead been used, the separative work amount would have been roughly one third as large. We should point out another minor difference. The use of highly enriched uranium (HEU) here is ambiguous since HEU is defined as uranium enriched greater than 20 percent in the isotope uranium 235. The authors should have used weapon-grade uranium instead, which is enriched to 90 percent or more, and it is weapon-grade uranium that they are discussing in this section (see section 1-1- in their text).
- Counts cascade and other inefficiencies twice, in the estimation of the separative work per centrifuge, which they give as an average of 0.76-1.2 swu/year, and again when it arbitrarily inflates the necessary separative work to produce 25 kilograms of weapon-grade uranium from natural uranium, raising it from 6,000 to 10,000 swu. This double counting further inflates the breakout values.
- Makes unreasonable assumptions about the time needed to reconfigure the cascades. This is a sensitive subject and we do not want to discuss it in any detail, but suffice it to say that the study's statement that "Iran must reconfigure the current cascades to tandem cascades, which minimally takes 6 months" is widely viewed as far too long. Even Iranian nuclear officials have talked of being able to reconnect cascades back into a tandem combination in about a day. The study also ignores information the government received from the A.Q. Khan network, which has been documented by the IAEA, that reconfiguration into tandem cascades is not necessary to produce weapon-grade uranium. In all cases, the time to shift over from existing operations to making weapon-grade uranium is measured in weeks and not months. This time could be further shortened with extensive preparations, as is likely well known to Iranian nuclear experts.

If these errors are corrected, the resulting breakout timeline is in line with ISIS and U.S. government estimates:

- We accept their estimate that the total separative capacity of the 9,000 IR-1 centrifuges ranges from 6,860 to 10,800 swu/year. However, we believe that the value is at the lower bound rather than the upper one. The first correction involves not using 10,000 swu as necessary to produce 25 kilograms of weapon-grade uranium; instead we use the report's value of 6,000 swu. This avoids the double counting problem. The result is that if breakout is started with natural uranium and uses 9,000 IR-1 centrifuges, then the time to breakout is 6.7-10.5 months, compared to Iran's 12-18 month estimate.
- If 3.5 percent LEU is used instead of natural uranium--Iran has more than sufficient amounts of this enriched uranium for breaking out--then the breakout time using these 9,000 IR-1 centrifuges would be reduced by roughly one-third to 2.2-3.5 months.
- If 3.5 percent LEU is the starting material and all installed IR-1 centrifuges are used, not just the enriching ones, then the estimates would need to be halved. Thus, for the case of using all installed IR-1 centrifuges (ignoring the IR-2m centrifuges) and a stock of 3.5 percent LEU, the breakout times are reduced to 1.1 to 1.8 months, considerably shorter than Iran's estimate of at least 18 months. Reconfiguration times would add some weeks to these estimates, giving roughly 2-3 months.

These ISIS corrected values of 2-3 months are meant to be only rough, or "back of the envelope," calculations. Nonetheless, these values are in reasonable agreement with Secretary of State Kerry's estimate of two months and other more detailed ISIS estimates, which predicted about two months.

Other claims about the time to convert to weapon-grade uranium metal and mold and finish the weapon components are too vague to critique in any depth. However, even a cursory examination leads to conclusion that they are too long. For example, the study states, "Iran needs at least an additional 12 months to build a conversion unit able to produce pure uranium metal." It then adds 12 months to the breakout estimate. The basis for this 12 month estimate is not discussed and appears to be too long based on other countries' experience. But more importantly, no nation engaged in breakout would wait to start construction of such a facility until it had produced enough weapon-grade uranium for a bomb. It would build the facility in parallel, likely preparing many construction steps in advance of any breakout, and be ready to start the conversion process once the weapon-grade uranium were ready for conversion. This conversion would likely happen in batches as weapon-grade uranium was produced in the enrichment plants, again not once it had all been produced. So, adding the time to build a conversion plant to the breakout estimate is simply wrong.

This dubious method of adding timelines sequentially rather than treating them as parallel developments permeates the report. In fact, this methodological error is so profound that it requires all the breakout estimates to be dismissed as woefully too short.

Plutonium-Based Breakout

The vagueness applies to the study's discussion of plutonium-based breakout using the Arak reactor. The study is incomplete, as it does not discuss the plutonium in the Bushehr reactor. But ignoring Bushehr, the study does not discuss the standard diversion of plutonium scenarios in the context of IAEA safeguards approaches, which involve more cases than that considered by the Iranian authors. Some of these scenarios involve much more rapid construction of a plutonium separation plant. Moreover, the two year irradiation time given in the study appears far too long for a 40 megawatt-thermal reactor, if it were used to make weapon-grade plutonium. In addition, as discussed above, it uses the mistaken methodology of sequencing construction rather than building facilities in parallel. Overall, this breakout estimate is flawed as well and should be discounted.

Conclusion

When the authors' underlying estimates are analyzed, they are either mistaken or knowingly exaggerated. Thus, these breakout estimates should be discounted. This Iranian study is a political tool for Iranian officials to point to as negotiations unfold, but nothing more serious.