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Iran's Rapid Expansion of its Enrichment Facilities Continues as the U.S. Concedes That Iran Is Getting "Closer and Closer" to Having Nuclear Weapons
Centrifuge Enrichment and the IAEA February 21, 2013 Safeguards Update

In various papers since 2008, this author has outlined how Iran's growing centrifuge enrichment program could provide it with the ability to produce Highly Enriched Uranium (HEU) and thereby the ability to manufacture nuclear weapons.[2] On February 21, 2013, the International Atomic Energy Agency (IAEA) published its latest safeguards update which shows that Iran has continued its rapid expansion of its enrichment program.

At the end of the summer of 2011, Iran had installed approximately 8,000 centrifuges at its main enrichment facility at Natanz and some pundits were claiming that sanctions had cut off Iran's supply of materials needed to build new centrifuges, thereby capping Iran's enrichment capacity. Since that time Iran has increased the number of centrifuges at Natanz to nearly 12,700, installing 2,255 centrifuges in just the last quarter. In addition, since the summer of 2011 Iran installed over 2,700 centrifuges at its underground facility at Fordow. Iran has installed enough new centrifuges at these two facilities so as to nearly double its number of centrifuges in just one and one-half years. Iran has begun to install more advanced centrifuges at Iran's main enrichment facility at Natanz, installing 180 up to now and has announced plans to install 3,000 such centrifuges. Iran also has announced plans to start enriching uranium using 326 advanced centrifuges that are operating at its pilot enrichment facility at Natanz. Despite converting increasing amounts of its stockpile of 3.5% enriched uranium to 20% enriched uranium, Iran's production rate of 3.5% enriched uranium is sufficiently high so that in the last year and one-half Iran's stockpile of 3.5% enriched uranium has increased from about 2,700 kilograms to over 4,000 kilograms. And despite converting some of its stockpile of 20% enriched uranium to research reactor fuel, in the last year and one-half Iran's stockpile of 20% enriched uranium has grown from 48 kilograms to 113 kilograms, increasing 13 kilograms in the last quarter. (This stockpile is in the form of 167 kilograms of uranium hexafluoride).

With this enrichment capacity and these enriched uranium stockpiles, Iran has two different ways to quickly produce the HEU required for nuclear weapons should it decide to do so (I assume that 20 kilograms of HEU is required per weapon). I have analyzed this issue in detail in Appendix 1 and summarize the results here in Table 1. Iran can produce the HEU for nuclear weapons by using batch recycling. In this process the enriched uranium is run through Iran's enrichment facilities multiple times until it reaches the required enrichment level. This process has the advantage of requiring only slight modifications to Iran's enrichment facilities and is entirely permitted by the IAEA as long as Iran notifies it in advance. It does have the

[1] The author has multiple affiliations. This paper was produced for the Nonproliferation Policy Education Center. Though the author is also a part-time adjunct staff member at the RAND Corporation, this paper is not related to any RAND project and RAND bears no responsibility for any of the analysis and views expressed in it.
[2] My most recent report is: Gregory S. Jones, "Not a Game-Changer But Is the West Playing a Game With Iran That It Has Already Lost?: Centrifuge Enrichment and the IAEA's August 30, 2012 Safeguards Update," September 10, 2012 http://www.npolicy.org/article_file/Iran_Enrichment_Update_9-2012.pdf

disadvantage of using Iran's enriched uranium stockpiles inefficiently and in the past Iran would have been able to produce only one nuclear weapon's worth of HEU by this method. However now Iran's stockpiles of enriched uranium have grown large enough that Iran can produce two nuclear weapon's worth of HEU using batch recycling. Using Iran's currently operating enrichment capabilities, Iran could produce the HEU for a nuclear weapon in just two months and enough HEU for a second nuclear weapon two months after that. Roughly 4,000 of the centrifuges that Iran has installed are not yet enriching uranium. It is not hard to imagine that these additional centrifuges could come on-line in the next three to six months (i.e. in the "near-term"). If they do, then by using batch recycling Iran could produce enough HEU for a nuclear weapon in just one and one-half months and enough HEU for two nuclear weapons in three months.

Table 1

Time Required For Iran to Produce Various Amounts of HEU For Nuclear Weapons Should Iran Decide to Do So Quickly
Capabilities are Either "Current" or Ones That Could Come On-line in the Next 3 to 6 Months ("Near-Term")

Number of Nuclear Weapons (HEU)	Batch Recycling in Existing Enrichment Plants Current	Batch Recycling in Existing Enrichment Plants Near-Term	Clandestine Enrichment Plant Current	Clandestine Enrichment Plant Near-Term
One (20 kg)	2 months	1 ½ months	1 ½ months	1 month
Two (40 kg)	4 months	3 months	3 months	2 months
Five (100 kg)	N/A*	N/A*	7 ½ months	5 months

*Iran's current enriched uranium stockpiles are only large enough to allow it to produce two nuclear weapon's worth (40 kg) of HEU by batch recycling.

Iran can also produce the HEU for nuclear weapons by building a clandestine enrichment facility specifically designed to enrich uranium from 20% to 90%. A small such facility using centrifuges of the type that Iran currently uses could produce enough HEU for a nuclear weapon in just one and one-half months. A major advantage of such a facility would be that it would use Iran's stockpile of enriched uranium much more efficiently than would batch recycling and Iran could produce enough HEU for five nuclear weapons (i.e. a small arsenal) with one nuclear weapon's worth of HEU being produced every one and one-half months. In the "near-term" Iran may be able to build a clandestine enrichment facility using the advanced centrifuges of the type that it has begun to install at Natanz and then Iran could produce a nuclear weapon's worth of HEU in just one month and enough HEU for five nuclear weapons in just five months. A disadvantage of using a clandestine enrichment facility is that this process would require violating IAEA safeguards, though the time needed for Iran to produce HEU is becoming so short as to make it doubtful that any effective counteraction could be taken before Iran obtained a nuclear weapon.

However, this does not mean that I think Iran will become an overt nuclear weapons state in the near future. As I stated in September 2011:

> That is not to say that I expect Iran to divert nuclear material from IAEA safeguards anytime soon. After all, why should it? It can continue to move ever closer to the HEU required for a nuclear weapon with the blessing of the IAEA. Iran would only need to divert nuclear material from safeguards when it would want to test or use a nuclear weapon. Recall that the U.S. was unable to certify that Pakistan did not have nuclear weapons in 1990, but it was only in 1998 that it actually tested a bomb. Similarly, though it could be many years before Iran becomes an overt nuclear power, it needs to be treated as a de facto nuclear power simply by virtue of being so close to having a weapon.[3]

Most media assessments of the February 21, 2013 IAEA safeguards update focused mainly on the size of Iran's stockpile of 20% enriched uranium and the fact that this stockpile is not growing as fast as it might. The slower growth of its 20% enriched uranium stockpile was due to the fact that though Iran had produced 32 kilograms of 20% enriched uranium this quarter, it had put 19 kilograms (59%) of this uranium into the conversion process to produce an oxide form for research reactor fuel which would be difficult to further enrich to HEU for nuclear weapons. As a result, Iran's stockpile of 20% enriched uranium that could quickly be further enriched grew only by 13 kilograms this past quarter. Some in the media erroneously reported that Iran had "capped" its production of 20% enriched uranium.

However, the time required for Iran to produce the HEU for nuclear weapons depends not only on the size of its 20% enriched uranium stockpile but also strongly on Iran's overall enrichment capacity. Since this capacity has been growing rapidly, the time that would be required for Iran to produce the HEU for nuclear weapons has been continuing to decline. Indeed, even if Iran were to agree to relinquish its stockpile of 20% enriched uranium, it could currently use batch recycling to produce a weapon's worth of HEU in three months. (See discussion in Appendix 1 and Appendix 2.) As Iran's enrichment capacity continues to grow, this time will decrease. As it is, Iran's 20% stockpile still grew by 13% last quarter and the 19 kilograms that were put into the oxide conversion process represent less than two months of Iran's current production rate of 20% enriched uranium.

In my March 2012 assessment of Iran's nuclear program, I pointed out that Iran's progress in its uranium enrichment program was so steady and rapid that soon even some of those who at that time disagreed with my assessments would have no choice but to come to the same conclusions that I had. For example, David Albright at the Institute of Science and International Security has changed his position as Iran's uranium enrichment program has progressed. In October 2011 Albright claimed to be "debunking" my assessments but in October 2012 he published an

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[3] Gregory S. Jones, "No More Hypotheticals: Iran Already Is a Nuclear State, *The New Republic*, September 9, 2011, http://www.tnr.com/article/environment-and-energy/94715/jones-nuclear-iran-ahmadinejad

analysis that essentially agrees with mine. [4] In particular Albright's October 2012 analysis shows that based on the IAEA's August 2012 update, if Iran were to utilize what was then its entire supply of 20% enriched uranium that was in the form of hexafluoride, then Iran could produce the HEU for a nuclear weapon in 2.3 to 2.5 months.[5] My analysis of September 2012 published prior to Albright's, using the same IAEA data, showed that Iran could produce enough the HEU for a nuclear weapon in 2.4 months.[6] Thus, Albright has fallen into line with my assessments.

Not all are willing to face the fact that Iran is so close and growing ever closer to the HEU for nuclear weapons. In February 2013 the Arms Control Association issued a "Briefing Book" on Iran's nuclear program. This report claims: "Estimates for the time it would take Iran to bolster the enrichment level of its LEU stockpile from 3.5 percent to weapons-grade range from four to 12 months using the commercial-scale Natanz enrichment plant."[7] The source for this estimate is unclear, since the Arms Control Association has done no independent calculations and the only two published estimates from the latter part of 2012 (Albright's and mine) both demonstrate that Iran could produce HEU for a nuclear weapon in about 2.4 months. Strangely this Briefing Book cites Albright's work but chooses to use his September *2011* estimate rather than his October 2012 estimate.

The Arms Control Association claims that the 12-month estimate is being used by the U.S. government but this clearly is not the case. In the October 2012 Vice Presidential debate, Vice President Biden made it clear that the U.S. is essentially conceding Iran the capability to produce the HEU for nuclear weapons. Biden instead focused on the fact that currently Iran lacks the non-nuclear components to produce a nuclear weapon: "What Bibi [Benjamin Netanyahu] held up there was when they get to the point where they can enrich uranium enough to put into a weapon. They [Iran] don't have a weapon to put it into."[8]

In the past there have been some (including some in the U.S. government) who contended that it would take years for Iran to produce the non-nuclear components for a nuclear weapon. This would run counter to historical experience, even if Iran were to start from scratch. However, given the significant aid that Iran has received from a Russian nuclear weapon designer, Iran is not starting from scratch. In December 2011 I estimated that Iran could produce an implosion type nuclear weapon (the design of most nuclear weapons) in just two to six months and that this

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[4] William C. Witt, Christina Walrond, David Albright and Houston Wood, "Iran's Evolving Breakout Potential," ISIS Report, October 8, 2012.

[5] *Ibid.*, p.13. This 2.3 to 2.5 month estimate assumes that Iran uses 78.7 kilograms of 20% enriched uranium (in the form of 116.45 kilograms of uranium hexafluoride) which at the time was Iran's entire stock of this material in hexafluoride form. If Iran were instead to use only 61.8 kilograms of 20% enriched uranium then this report estimates that it would take Iran 2.5 to 4.1 months to produce a weapons worth of HEU. Since this report does not provide details of its calculations it is unclear why such a small difference in 20% enriched uranium stocks makes such a large difference in the time required for Iran to produce enough HEU for a nuclear weapon. At any rate, since Iran now has 113 kilograms of 20% enriched uranium and has further expanded its uranium enrichment capacity, presumably this report would calculate that an even shorter time would be required by Iran today.

[6] Gregory S. Jones, "Not a Game-Changer But Is the West Playing a Game With Iran That It Has Already Lost?: Centrifuge Enrichment and the IAEA's August 30, 2012 Safeguards Update," September 10, 2012, Table 2, p.11, http://www.npolicy.org/article_file/Iran_Enrichment_Update_9-2012.pdf

[7] ACA Research Staff, "Solving the Iranian Nuclear Puzzle," An Arms Control Association Briefing Book, February 2013, p.7.

[8] "Full Transcript of the First Vice Presidential Debate," October 11, 2012, ABC News.

development could take place in parallel with or prior to the production of the HEU.[9] Since 2011, Iran's continuing efforts have shortened this time. In July 2012 John Sawers the chief of British intelligence MI6 said: "The Iranians are determinedly going down a path to master *all* aspects of nuclear weapons; all the technologies they need."[10] [Emphasis added] Recently Secretary of State Kerry agreed that Iran was getting "closer and closer" to a nuclear weapon.[11] Reports that senior Iranian officials attended North Korea's February 2013 nuclear test indicate that Iran may be receiving nuclear weapon design assistance from more than just the Russians.[12]

Further as Iran's ability to produce HEU continues to grow, Iran could produce a gun type nuclear weapon. This was the weapon type that the U.S. used to destroy Hiroshima. This type of nuclear weapon is very simple to design and produce, so much so that it does not require prior nuclear testing. It has the disadvantage of requiring 40 to 50 kilograms of HEU per weapon but as my calculations show, Iran can now produce these amounts of HEU.[13]

The bottom line is that should it choose to do so, Iran could produce enough HEU for a nuclear weapon in a month or two and by using either implosion or gun type nuclear weapon's designs, Iran could likely produce a complete nuclear weapon rather quickly (within days or weeks) after producing the required HEU.[14] Olli Heinonen, former head of the IAEA's safeguards division, has recently come to the same conclusion, saying that Iran can now produce a nuclear weapon in "a month or two."[15]

Recently Director of National Intelligence, James Clapper stated that U.S. intelligence assesses that Iran's preferred nuclear delivery mode will likely be by ballistic missile.[16] Apparently U.S. intelligence believes that it would take Iran some time to develop a nuclear weapon small enough to fit onto its ballistic missiles and to conduct the flight tests needed to assure that the warhead was functional. This assessment may be the basis for President Obama's recent statement that "it

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[9] Gregory S. Jones, "Iran's Efforts to Develop Nuclear Weapons Explicated, Centrifuge Uranium Enrichment Continues Unimpeded, the IAEA's November 8, 2011 Safeguards Update," December 6, 2011, http://npolicy.org/article_file/Iran_Efforts_to_Develop_Nuclear_Weapons_Explicated.pdf

[10] Christopher Hope, *The Telegraph*, July 12, 2012, http://www.telegraph.co.uk/news/uknews/terrorism-in-the-uk/9396360/MI6-chief-Sir-John-Sawers-We-foiled-Iranian-nuclear-weapons-bid.html

[11] "John Kerry Concedes Iran is Moving Closer to Possessing Nuclear Weapon," Secretary of State Interviewed by Martha Raddatz in Qatar, ABC News, March 5, 2013.

[12] "Iranian nuclear chief observed Korean nuke test," *Jerusalem Post*, February 17, 2013.

[13] Theodore B. Taylor, a former nuclear weapons designer at Los Alamos, has indicated that 40 kilograms of HEU with a 3 inch steel reflector can be used to produce a gun-type nuclear weapon with a yield of one kiloton. This weapon would be eleven inches in diameter, three and one half feet long and weigh just 250 kilograms. See: John McPhee, *The Curve of Binding Energy*, Farrar, Straus and Giroux, New York, 1974, pp. 189-193. A nuclear weapon with these characteristics could be easily fitted onto an Iranian ballistic missile. Further it is important to note that the lethal area of a nuclear weapon does not scale linearly with yield, especially at low yields. Though one kiloton is only one sixteenth of the yield of the Hiroshima bomb, the lethal area of such a weapon would still be about 2 km^2 (0.75 sq mi) which is about one quarter the lethal area of the Hiroshima bomb and would kill tens of thousands if exploded over a city.

[14] The development of the non-nuclear components for the nuclear weapon could take place in parallel with or prior to the production of the HEU.

[15] David Feith, "How Iran Went Nuclear," *The Wall Street Journal*, March 2, 2013, p.A13.

[16] James Clapper, "Statement for the Record, Worldwide Threat Assessment of the US Intelligence Community," Senate Select Committee on Intelligence, March 12, 2013, p.7.

would take over a year or so for Iran to actually develop a nuclear weapon."[17] However, there are several problems with this assessment. The nuclear weapon design that the Russian nuclear weapon expert provided to Iran was specifically designed to fit upon Iran's ballistic missiles. North Korea may also have already developed such a lightweight nuclear warhead and may be providing aid to Iran. In addition, a small gun-type nuclear weapon would easily fit upon a ballistic missile. Thus it is not clear that Iran would require anywhere close to a year to develop a nuclear-armed ballistic missile.

The more serious problem with this intelligence assessment is that Iran does not have to deliver its nuclear weapons by ballistic missile. Indeed, given the missile defenses of the U.S. and Israel, it is not clear that Iran's preferred delivery method would be ballistic missiles or why U.S. intelligence believes that it is. As I have discussed previously, Iran could deliver its nuclear weapons by vehicles, i.e. trucks or ships. Such delivery could be particularly effective against U.S. military forces in the region.

Many hope that sanctions on Iran will convince it to scale back or stop its nuclear program. However, since 2011 Russia and China have refused to support any additional sanctions against Iran and therefore sanctions on Iran after 2011 have only been imposed by the U.S. and the EU and not the U.N. Russia, China and other important countries such as India have said that they will not follow what they call "unilateral" sanctions against Iran. For example, on March 7, 2013, Pakistan said that it will complete a $7.5 billion gas pipeline with Iran "despite U.S. pressure."[18] Most importantly, the sanctions have not slowed Iran enrichment program. Asked about effectiveness of sanctions, Yukiya Amano, director-general of the IAEA said: "We are verifying the activities at the nuclear sites in Iran and we do not see any effect. They are, for example, producing enriched uranium up to 5 percent and 20 percent with a quite constant pace."[19]

Nor have sanctions motivated Iran to conduct serious negotiations. Three rounds of negotiations in 2012 went nowhere. After an eight month pause, another round of negotiations last month produced no result other than the promise of yet more negotiations. Further the measures proposed by the P5+1 countries, even if Iran agreed to them, would not do much to eliminate the danger. For example, it has been proposed that Iran give up its stockpile of 20% enriched uranium. But as I have calculated in Appendix 1, in the near-term Iran could produce a weapon's worth of HEU in just six and one-half weeks with its stockpile of 20% enriched uranium and in nine weeks without the stockpile of 20% enriched uranium. This is a difference of only two and one half weeks (compare tables 5 & 6). As Iran further expands its enrichment capacity, this difference will only further diminish.

What is worse, the P5+1, in a desperate attempt to reach any kind of agreement, has watered-down this proposal, now suggesting that Iran might be able to keep some of its 20% enriched uranium stockpile. This has led some to suggest that the P5+1 may be negotiating with itself.[20]

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[17] Michael D. Shear and David E. Sanger, "Iran Nuclear Weapon to Take Year or More, Obama Says," *The New York Times*, March 14, 2013. Note that it is unclear whether Obama meant "over a year," or "a year or so."
[18] "Islamabad to complete Iran-Pakistan pipeline despite U.S. pressure," *Dawn*, March 7, 2013.
[19] "Iran nuclear work at constant pace despite sanctions-IAEA, *Reuters*, November 20, 2012.
[20] Michael Singh, "Is Iran Out-Negotiating the Obama Administration?," *Foreign Policy*, March 4, 2013.

In order to prevent Iran from having the ability to quickly produce the HEU required for nuclear weapons, it would be necessary to shut down and eliminate Iran's entire enrichment program. Those who favor continued negotiations with Iran have called this proposal "unrealistic," which is just another way of saying that no satisfactory negotiated outcome is possible.

There has been much public discussion about a possible Israeli strike against Iran's nuclear facilities. I continue to believe that such a strike is quite unlikely. As Israel showed with its strike on the plutonium production reactor in Syria in 2007 and more recently with its January 2013 strike on a weapons convoy in Syria, if Israel plans to actually strike a target, there is no prior public discussion. Israel simply carries out the strike. Israel's public threats have two purposes: to attempt to intimidate Iran; and, most importantly, to attempt to prod the U.S. into taking military action against Iran. For example, in January 2011 Israeli Premier Benjamin Netanyahu said: "You have to ratchet up the pressure…I don't think that this pressure will be sufficient to have this regime change course without a credible military option that is put before them by the international community *led by the United States*."[21] [Emphasis added.] In the run up to the U.S. 2012 presidential election Netanyahu ratcheted up his pressure on the Obama administration to take military action but as it became clear that the Obama administration was not going to act, Netanyahu was forced to back down.

At one time it appeared that Netanyahu had raised his rhetoric to such a high level that he would be force to carry out a military strike against Iran just to save political face. However, he managed to back down without many realizing that he had done so. In a speech to the U.N. in September 2012, Netanyahu delineated his "red line" on the Iranian nuclear program, which he stated would be when Iran accumulated enough 20% enriched uranium to produce the HEU for a nuclear weapon. The media usually quantifies this amount as about 165 kilograms (240-250 kilograms of uranium hexafluoride) of 20% enriched uranium. Since it is thought that Iran will not have this amount of 20% enriched uranium until mid-2013, one can see that the setting of the "red line" was a de-escalation of the threat of military action against Iran. In fact the amount of 20% enriched uranium required for a nuclear weapon is a range which depends on how the enrichment to HEU is carried out and can be as little as 94 kilograms or as much as 225 kilograms. Since Iran already has 113 kilograms, Netanyahu could claim that Iran has already crossed his "red line" but he has not done so. Further, by focusing just on Iran's stockpile of 20% enriched uranium, Netanyahu can ignore other aspects of Iran's nuclear enrichment program that are just as important for the production of HEU for nuclear weapons, namely Iran's expanding enrichment capacity and its growing stockpile of 3.5% enriched uranium. In a speech on March 6, 2013, Netanyahu said that a "credible military threat" was needed to stop a nuclear-armed Iran but he gave no indication that Israel would be the country providing this threat.[22]

President Obama and more recently Vice President Biden have said that they are not bluffing and that Iran will not be allowed to acquire nuclear weapons. Additionally, both Biden and Secretary of State Kerry have indicated their belief that the U.S. possesses nearly perfect near real time intelligence on Iran's nuclear program. It appears that the Obama administration plans to wait until Iran actually begins to manufacture a nuclear weapon before the administration undertakes

[21] "Netanyahu: Only 'credible' military threat led by U.S. can stop nuclear Iran," *Haaretz*, January 11, 2011.
[22] Matt Spetainick and Paul Eckert, "Biden, Netanyahu set tone on Iran for Obama visit to Israel," *Reuters*, March 4, 2013.

any military action. This has the political advantage of pushing such an unpleasant action off for many years, since no one, including myself, expects Iran to actually manufacture nuclear weapons anytime soon.

A more serious question is what sort of military action would be needed to stop Iran from manufacturing a nuclear weapon. Though military strikes to destroy nuclear reactors in Iraq and Syria have been quite effective, attacking Iran's centrifuge enrichment program would be quite different. At its main enrichment facility at Natanz, Iran has 53 cascades operating in parallel with another 21 cascades installed. An air strike on Natanz that scored multiple bomb hits would shut down the entire facility. But the majority of the cascades would be undamaged and not able to operate only due to damage to piping and the loss of utilities. It would only take a few months of repairs before these undamaged cascades were back in operation. Even for the cascades that suffered bomb hits, the majority of the centrifuges would still be undamaged. Iran could pull out the undamaged centrifuges and use them to build new cascades. At the underground enrichment facility at Fordow, an attack might not be able to destroy any centrifuges, though an attack could certainly collapse the entrance tunnels and cut off utilities. Iran could quickly repair the damage from such attacks and be back in production in roughly two months and back to nearly full production in roughly six months.

Iran's current stockpiles of about 4,000 kilograms of 3.5% enriched uranium and 113 kilograms of 19.7% enriched uranium present another problem. These stockpiles represent years of centrifuge plant operation but would be very difficult to destroy by air attack. The combined volume of these two stockpiles is about one and one-half cubic yards—making them very easy to hide or protect.

Given the ease with which Iran's enrichment capacity could be restored after an attack, to achieve a long-term shutdown would require at a minimum a prolonged bombing campaign against Iran's nuclear sites. There are two problems with such a bombing campaign. First, Iran could respond by dispersing its centrifuges. Indeed, centrifuge enrichment with its many parallel cascades would be ideal for such dispersal. The U.S. would be able to find and bomb some of these dispersed enrichment sites but many would continue in operation undetected. Second, such a prolonged bombing campaign would run a serious risk of turning into a large-scale war with Iran. Though no doubt the U.S. would eventually win such a war, I think that given the financially-exhausted and war-weary condition of the U.S., such a war would be ill-advised. In any case, the current situation in which the U.S. faces the choice between accepting Iran as a nuclear weapon state or having to go to war to prevent it must be considered a policy failure.

In sum, sanctions appear to be having no effect on Iran's production of enriched uranium and negotiations are going nowhere. I and many analysts believe that a full war with Iran would be ill-advised. Consequently, as I stated a year and one-half ago, nothing can be done to stop Iran from getting nuclear weapons. At the time some accused me of being "irresponsible" for saying this but as Iran's progress has become so unmistakable, other analysts have started saying the same thing. For example, Olli Heinonen, former head of the IAEA's safeguards division recently said that the time it would take Iran to produce a nuclear weapon could now be shorter than the time required for the West to respond.[23]

[23] David Feith, "How Iran Went Nuclear," *The Wall Street Journal*, March 2, 2013, p.A13.

What, then, is to be done about a nuclear-armed Iran? Judging by the policies and actions being applied to Pakistan and North Korea, apparently very little. Some have suggested that somehow Iran might be contained but in fact, it is the U.S. that is going to be contained by Iran's nuclear weapons. As was suggested in a 2008 RAND Corporation report, "Unless and until highly reliable means of attack prevention become available, U.S. leaders will be compelled to temper their objectives vis-à-vis nuclear-armed regional adversaries, avoiding conflict with them or using military force in limited ways that minimize the adversary's incentives to escalate to nuclear use."[24]

One particular example of U.S. leaders being forced to "temper their objectives" was the 2008 attack on Mumbai by Pakistani agents, which killed six Americans. One of these six was an American rabbi along with his pregnant Israeli wife. The attackers also held two middle-aged Jewish women hostage. The attackers' commanders in Pakistan, who reveled in killing Jews, ordered the execution of these two hostages. The attackers were reluctant to carry out this order and their commanders in Pakistan repeated the order again and again over a period of hours until it was carried out. The U.S. response to this attack has been to continue to send billions in dollars in aid to its "ally."

The actual policy that is likely to be applied to Iran is the same one that has been tried for both Pakistan and North Korea, namely to deny or belittle the threat for as long as possible. In 1990 the Bush administration was forced to say that it could not certify that Pakistan did not have nuclear weapons. Yet during both the Bush administration and for most of the Clinton administration, the U.S. continued to pretend that Pakistan did not have nuclear weapons, until Pakistan's 1998 nuclear tests forced the issue. Then after a few half-hearted sanctions, Pakistan was awarded de facto nuclear weapon status.

In the case of North Korea, its 2006 nuclear test was initially declared a failure due to its low yield. Even in 2012 the Director of National Intelligence, James Clapper, still claimed that the 2006 test was a "partial failure," though the test's low yield seems to have been mainly due to the fact that North Korea tried to conserve its limited supply of plutonium by using only 2 kilograms in the weapon.[25] A larger but still low yield North Korean nuclear test in 2009 did little to alter this view. Only after the still larger yield nuclear test of February 2013 have countries, including the U.S., been required to face the fact that North Korea is a nuclear weapon state. One consequence of this North Korean nuclear test is that the U.S. feels compelled to expand its long-range ballistic missile defenses.

One constant nonproliferation concern has been that countries that obtain nuclear weapons will then either sell or give them to third parties. Thus far this has not happened. But what has happened has been nearly as serious—namely countries have sold the technology needed for other countries to produce their own HEU or plutonium for nuclear weapons. Pakistan has sold centrifuge technology to Iran, North Korea and Libya. North Korea sold a plutonium production

[24] David Ochmanek and Lowell H. Schwartz, *The Challenge of Nuclear-Armed Regional Adversaries*, RAND, Santa Monica, CA, 2008, p.xii.
[25] James Clapper, "Unclassified Statement for the Record on the Worldwide Threat Assessment of the US Intelligence Community for the Senate Select Committee on Intelligence," January 31, 2012, p.6.

reactor to Syria and ballistic missile technology to Iran and Pakistan. One can only wonder which countries Iran will favor with its nuclear technology.

One result of the most recent North Korean nuclear test and the resulting realization that North Korea is a nuclear-armed state is to increase pressures in both Japan and South Korea to acquire their own nuclear weapons.[26] Japan already has a plutonium stockpile of nearly 45 metric tons produced as a result of its civil nuclear power program. About 35 metric tons is stored overseas but about 10 metric tons (enough to produce thousands of nuclear weapons) is stored in Japan.[27] Though in the aftermath of the Fukushima nuclear accident Japan's future use of nuclear power is in question, Japan's nuclear industry has announced plans to further increase its domestic stockpile of plutonium.[28] Japan says that it is stockpiling the plutonium for use in a breeder reactor but it is now more than 40 years since such reactors were first supposed to come into operation and the commercial operation of such reactors is still decades away. Strangely, U.S. officials have encouraged Japan to continue with its plans to accumulate even more plutonium. In the meantime a number of Japanese political figures have openly argued that Japan should continue its plutonium program as a nuclear weapon hedge and Japan's parliament has amended its atomic energy act to explicitly include "national security" as one of the prime missions of Japan's civilian nuclear energy program.

For South Korea the pressure is considerably higher as it is the direct target of North Korea's threats, nuclear and otherwise. North Korea recently abrogated the armistice with South Korea putting these countries back into a technical state of war. Influential political figures in South Korea have suggested that now might be the time for South Korea to develop its own nuclear weapons or that at least, the U.S. should return tactical nuclear weapons to South Korea.[29] In contrast to Japan, the U.S. has not permitted South Korea to extract the plutonium from the spent fuel of its civil nuclear power reactors, because South Korea had a nuclear weapons program in the 1970s. The current U.S.-South Korea nuclear cooperation agreement is up for renewal and South Korea is pushing hard for the right to extract this plutonium. It seems unlikely that South Korea's effort is related to any belief that this plutonium has a role to play in its civil nuclear program.

These developments in East Asia provide a preview of how events in the Middle-East may play out in response to the Iranian nuclear threat. Observers have correctly pointed out that given the lack of nuclear technology in countries like Egypt and Saudi Arabia, they are unlikely to be able to emulate Iran anytime soon. However, with Saudi Arabia now expressing a strong interest in developing a broad nuclear power program (it has said it wants 16 nuclear reactors by 2030), Saudi Arabia may be starting down the road to attempt to match Iran's nuclear capability.

What then should the U.S. do to try to limit the spread of nuclear weapons? First, the U.S. needs to take action to head off nuclear weapons programs early in the process. As was seen in the

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[26] Henry Sokolski, "After North Korea's Nuclear Test," *The National Review Online*, February 12, 2013.
[27] *Global Fissile Material Report 2011: Nuclear Weapon and Fissile Material Stockpiles and Production*, Sixth Annual report of the International Panel on Fissile Materials, January 2012, p.23.
[28] Eric Talmadge, "Japan to make more plutonium despite big stockpile," Associated Press, June 1, 2012.
[29] Martin Fackler and Choe Sang-Han, "South Korea Flirts With Nuclear Ideas as North Blusters," *The New York Times*, March 10, 2013.

cases of Libya and Syria, such early action can be effective. The U.S. also needs to head off programs in South Korea and Japan, in part by continuing to prohibit South Korea from producing separated plutonium and by helping Japan find a way to dispose of its huge plutonium stockpile.

The U.S. Government has recognized the problem posed by separated plutonium and HEU, as well as by the facilities that can produce these materials. The nuclear cooperation agreement between the U.S. and the United Arab Emirates prohibits the UAE from possessing facilities that can engage in uranium enrichment or the reprocessing of spent fuel which could produce plutonium, HEU or U-233 (another material that can be used to produce nuclear weapons). The U.S. will likely place similar requirements on Taiwan, whose nuclear cooperation agreement is soon to be renewed. But the U.S. cannot solve this problem unilaterally. Jordan has recently refused to sign such an agreement and instead plans to purchase nuclear power reactors from either Russia or France, neither of which requires such restrictions.[30]

It is well past time for the IAEA to stop being complicit in this problem. The IAEA must stop pretending that it can effectively safeguard such dangerous material and activities. Nuclear safeguards are supposed to be more than an accounting system. Rather the purpose of IAEA safeguards "…is the timely detection of diversion of significant quantities of *nuclear material* from peaceful nuclear activities to the manufacture of nuclear weapons or of other nuclear explosive devices or for purposes unknown, and deterrence of such diversion by the risk of early detection."[31] [Emphasis in original] To meet the requirement to provide timely detection even the standards in the U.S./UAE nuclear cooperation agreement are not enough.

Non-nuclear weapon countries must be prohibited from possessing any materials or facilities that can quickly provide fissile material for nuclear weapons. This includes prohibiting not only enrichment and reprocessing facilities but also separated HEU, plutonium or U-233 and HEU, plutonium or U-233 that is contained in unirradiated reactor fuel (such as HEU fuel for research reactors or mixed oxide fuel for power reactors). Such restrictions would require the shutting down of enrichment facilities not only in Iran but also in Germany, the Netherlands, Brazil and Japan as well as reprocessing facilities in Japan and the removal of Japan's massive plutonium stockpile.

We are reaching a crisis point in the survival of the current non-proliferation system. Unless major changes are made to the way the IAEA conducts business, we will see countries such as South Korea, Japan, and Saudi Arabia follow Iran in using its "peaceful" nuclear program as a cover for the acquisition of nuclear weapons, all with the blessings of the IAEA. The U.S. needs to take the lead and insist that the IAEA safeguards perform the function for which they were intended and push for an international agreement that prohibits non-nuclear weapon countries from having nuclear materials or facilities that can easily provide the nuclear material for nuclear weapons.

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[30] Michael Peel, "Jordan close to commissioning two nuclear reactors, declines to sign accord with the U.S.," *The Washington Post*, March 6, 2013.

[31] "The Structure and Content of Agreements Between The Agency and States Required in Connection With The Treaty on the Non-Proliferation of Nuclear Weapons," International Atomic Energy Agency, INFCIRC/153 (Corrected), June 1972, p.9.

Appendix 1

Detailed Analysis of the IAEA February 21, 2013 Safeguards Report and Methods Whereby Iran Could Produce HEU and/or Plutonium for Nuclear Weapons

Iranian Centrifuge Enrichment of Uranium

Iran has three known centrifuge enrichment facilities. Iran's main facility is the Fuel Enrichment Plant (FEP) at Natanz. The basic unit of Iran's centrifuge enrichment effort is a cascade which originally consisted of 164 centrifuges but Iran has now modified the majority of the cascades by increasing the number of centrifuges to 174. (All centrifuges operated up to now have been of the IR-1 type.) Each cascade is designed to enrich natural uranium to 3.5% enriched uranium. As of February 19, 2013, Iran had installed a total of 74 cascades of IR-1 type centrifuges and had partially installed three additional cascades. This results in a total of 12,669 IR-1 centrifuges which is an increase of 2,255 since the IAEA's November 2012 safeguards update. Of these 74 cascades, 53 (containing 8,892 centrifuges) were declared by Iran as being fed with uranium hexafluoride and therefore were producing 3.5% enriched uranium. In addition Iran has begun to install some of the more advanced IR-2m centrifuges at the FEP. Iran's installation of these more advanced centrifuges has thus far been limited to two cascades and Iran has installed 180 of these centrifuges but thus far they have yet to begun to enrich uranium. Recently Iran announced that it would soon be installing 3,000 of these more advanced centrifuges.[32]

Iran began producing 3.5% enriched uranium at the FEP in February 2007 and as of February 3, 2013 Iran had produced a total of 5,591 kilograms (in the form of 8,271 kilograms of uranium hexafluoride). Since 1,517 kilograms of this enriched uranium has already been processed into 19.7% enriched uranium (see the PFEP and FFEP below) and a further 36 kilograms was used in the conversion process to produce uranium dioxide for use as fuel in the TRR, Iran's current stockpile of 3.5% enriched uranium is 4,038 kilograms. Iran's current production rate of 3.5% enriched uranium is about 162 kilograms per month.[33] This production rate has held roughly steady since early 2012 and represents about a 60% increase from 2011 when the production rate was about a steady 100 kilograms per month and is about triple the rate since 2009 (see Table 2). From the production rate of 3.5% enriched uranium, it is easy to calculate that the FEP has a separative capacity of about 7,060 separative work units (SWU) per year.[34] Assuming that 8,892 IR-1 centrifuges at the FEP are in fact operational, these centrifuges are each producing 0.79 SWU per centrifuge-year. However, since the IAEA has stated in the past that perhaps not all of the 8,892 centrifuges may be working this number should be considered a minimum value and could be higher.

Iran also has the Pilot Fuel Enrichment Plant (PFEP) at Natanz, which is used to test a number of more advanced centrifuge designs. These are usually configured as either single centrifuges or

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[3232] Yeganeh Torbati, "Iran says building 3,000 advanced centrifuges," *Reuters*, March 3, 2013.

[33] To avoid problems with the fact that the length of a month is variable, I have adopted a uniform month length of 30.44 days.

[34] Assuming 0.4% tails. A Separative Work Unit is a measure of the amount of enrichment a facility can perform. The SWU needed to produce a given amount of enriched uranium product can be calculated if the U-235 concentration in the product, feed and tails are known.

test cascades containing various numbers of centrifuges. Two of these test cascades are complete cascades. One contains 164 IR-4 centrifuges and one contains 162 IR-2m centrifuges. Up to now no enriched uranium has been produced by these test cascades but Iran has informed the IAEA that it plans to begin to produce enriched uranium with these two complete test cascades. Since each of these cascades will be equivalent to multiple IR-1 cascades, the enriched uranium output will be significant.

In addition, there are two full cascades each with 164 IR-1 type centrifuges at the PFEP. These two cascades are interconnected and are being used to process 3.5% enriched uranium into 19.7% enriched uranium. In February 2010, Iran began producing 19.7% enriched uranium at the PFEP using one cascade. It added the second cascade in July 2010. As of February 12, 2013, Iran had produced 101.3 kilograms of 19.7% enriched uranium (in the form of 149.9 kilograms of uranium hexafluoride) at this facility. Iran's production rate of 19.7% enriched uranium at the PFEP has been fairly steady over the past two years and is currently about 2.79 kilograms per month. The centrifuges at this facility are each producing about 0.83 SWU per centrifuge-year.

Table 2
Average Iranian Production Rate of 3.5% Enriched Uranium
November 2008 to February 2013

IAEA Reporting Interval	Average 3.5% Enriched Uranium Production Rate (Kilograms Uranium per Month)
11/17/08-1/31/09	52
2/1/09-5/31/09	53
6/1/09-7/31/09	57
8/1/09-10/31/09	57
11/22/09-1/29/10	78
1/30/10-5/1/10	81
5/2/10-8/6/10	80
8/7/10-10/17/10	95
10/18/10-2/5/11	88
2/6/11-5/14/11	105
5/15/11-8/13/11	99
8/14/11-11/1/11	97
11/2/11-2/4/12	115
2/5/12-5/11/12	158
5/12/12-8/6/12	161
8/7/12-11/11/12	156
11/12/12-2/3/13	162

Finally, Iran has constructed an enrichment facility near Qom. Known as the Fordow Fuel Enrichment Plant (FFEP), Iran clandestinely started to construct this plant in violation of its

IAEA safeguards. Iran only revealed the existence of this plant in September 2009, after Iran believed that the West had discovered the plant.

The FFEP is designed to hold a total of 16 cascades (each cascade holds 174 IR-1 type centrifuges for a total of 2,784 centrifuges). Fifteen of the sixteen cascades have been vacuum tested and could operate at any time. The sixteenth cascade had been fully installed in November 2012 but for some reason, some of the centrifuges in this cascade have since been removed.

Only four of the fifteen cascades are producing enriched uranium. They are configured as two sets of two interconnected cascades so as to produce 19.7% enriched uranium from 3.5% enriched uranium as is being done at the PFEP. The first of these two sets began production on December 14, 2011 and the second set began operation on January 25, 2012. As of February 10, 2013, Iran had produced 87.8 kilograms of 19.7% enriched uranium (in the form of 129.9 kg of uranium hexafluoride) at this facility. This facility is currently producing 19.7% enriched uranium at the rate of 7.69 kilograms per month. These centrifuges are each producing about 1.08 SWU per centrifuge-year.

With the start of these two sets of interconnected cascades at the FFEP, Iran has made good on its announcement in June 2011 that it would triple its production rate of 19.7% enriched uranium. Currently Iran is producing a total of about 10.5 kilograms of 19.7% enriched uranium per month. As of February 2013, Iran had produced a total of about 189 kilograms of 19.7% enriched uranium. Since Iran has converted about 75 kilograms of this uranium (contained in 111 kilograms of uranium hexafluoride) into a uranium oxide compound for use as fuel in the TRR, and further blended down about 1 kilogram to lower enrichments, Iran's current stockpile of 19.7% enriched uranium is about 113 kilograms.

Regarding the twelve other cascades at the FFEP that have yet begun operation, the IAEA has asked Iran whether these new cascades are to be interconnected to produce yet more 19.7% enriched uranium or only 3.5% enriched uranium. However, Iran says that the installation of these new cascades is not yet complete and that it will only inform the IAEA prior to the start of their operation. This development opens the possibility that Iran could further increase its rate of 19.7% enriched uranium. Using these cascades Iran could put a six more sets of two interconnected cascades into operation and increase its production of 19.7% enriched uranium to as much as 31 kilograms a month.[35] Given Iran's current rate of production rate of 3.5% enriched uranium at the FEP, Iran could run these six additional sets of two interconnected cascades (in addition to the two cascades already in operation at the FFEP and the one cascade in operation at the PFEP) to produce 30-34 kilograms of 19.7% enriched uranium per month. Given the current size of Iran's its stockpile of 3.5% enriched uranium and the capacity expansion occurring at the FEP, Iran could maintain this high rate of 19.7% enriched uranium production indefinitely.

[35] Assuming the performance of these additional cascades matches that of the four already in operation at the FFEP.

Iranian Options for Producing HEU

Given that Iran currently has a total enrichment capacity of about 8,100 SWU per year at the FEP, FFEP, and PFEP and stockpiles of 4,038 kilograms of 3.5% enriched uranium and 113 kilograms of 19.7% enriched uranium, Iran has a number of options for producing the 20 kilograms of HEU required for a nuclear weapon.

The most straightforward method Iran could use to produce HEU would be batch recycling. In this process, no major modifications are made to Iran's enrichment facilities but rather enriched uranium is successively run though the various enrichment facilities in batches until the desired enrichment is achieved. Iran could use a three-step process to produce HEU. This process is illustrated in Table 3.

Table 3

Time, Product and Feed Requirements for the Production of HEU by Batch Recycling at the FEP (7,000 SWU per year)
Final Step at PFEP and FFEP
(7 sets of two interconnected cascades at the FFEP)

Cycle and Enrichment Plant	Product Enrichment and Quantity	Feed Enrichment and Quantity	Time for Cycle (Days)
First FEP	19.7% 97 kg	3.5% 1,145 kg	24
Second FEP	55.4% 39.8 kg	19.7% 227 kg*	8
Third PFEP & FFEP**	89.4% 20 kg	55.4% 39.0 kg	20
Total			58***

* Includes 113 kilograms of 19.7% enriched uranium that Iran has already stockpiled and 19 kilograms of 19.7% enriched uranium from the tails of the PFEP and FFEP. Plant inventory at the FEP is 2 kilograms.
** The combined plant inventory at the PFEP and FFEP is 0.8 kilogram.
***Includes six days to account for equilibrium and cascade fill time.

In the first step, Iran needs to produce 229 kilograms of 19.7% enriched uranium (including 2 kilograms for the plant inventory in the second step). However, since it has already produced 113 kilograms of 19.7% enriched uranium, and the tails from the third step are 19.7% enriched uranium, Iran needs only to produce an additional 97 kilograms. This step requires 1,145 kilograms of 3.5% enriched uranium as feed but Iran's current stockpile well exceeds this figure. In the second step, the 19.7% enriched uranium is further enriched at the FEP to 55.4% enriched uranium. This step requires the production of 39.8 kilograms of 55.4% enriched uranium (including the 0.8 kilograms for the plant inventory at the PFEP and FFEP). In the third step, the

55.4% enriched uranium is enriched to the 20 kilograms of 89.4% enriched uranium needed for a nuclear weapon. For this last step I assume that fourteen of the fifteen cascades that are ready to operate at the FFEP are used and function as seven interconnected cascades and that the one set of interconnected cascades at the PFEP is used as well. The total time required is 58 days which is about 8 weeks or about two months.

The results for the first step can be found using separative work calculations but for the other two steps a SWU calculation would not produce accurate results. Since the plants at the FEP, PFEP and FFEP are not designed to produce HEU, their cascades are more tapered than is optimal for the upper stages of an enrichment plant designed to produce highly enriched uranium. As a result, some of the SWU output cannot be utilized during the latter two cycles of the batch production process. The cascades are restricted by the flow at the product end of the cascade. Therefore the time required for these cycles is determined by the amount of product required and the amount of product the plant can produce per day and not by a SWU calculation.

Table 4

Time, Product and Feed Requirements for the Production of HEU by Batch Recycling at the FEP (7,000 SWU per year total)
Using 3.5% Enriched Uranium as the Starting Material
Final Step at PFEP and FFEP
(7 sets of two interconnected cascades at the FFEP)

Cycle and Enrichment Plant	Product Enrichment and Quantity	Feed Enrichment and Quantity	Time for Cycle (Days)
First FEP	19.7% 210 kg	3.5% 2,480 kg	53
Second FEP	55.4% 39.8 kg	19.7% 227 kg*	8
Third PFEP & FFEP**	89.4% 20 kg	55.4% 39.0 kg	20
Total			87***

* Includes 19 kilograms of 19.7% enriched uranium from the tails of the PFEP and FFEP. The plant inventory at the FEP is 2 kilograms.
** Plant inventory is 0.8 kilogram.
***Includes six days to account for equilibrium and cascade fill time

Though much attention has been focused on Iran's growing stockpile of 19.7% enriched uranium, most of the reason why Iran can produce the HEU for a nuclear weapon as quickly as it can is because of its growing enrichment capacity and not its growing 19.7% enriched uranium stockpile. As is shown in Table 4, even if Iran did not have a stockpile of 19.7% enriched uranium, it could still produce a weapon's worth of HEU in just under 3 months (twelve and one half weeks) which is only somewhat longer than the two months (eight weeks) that would be required given Iran's current stockpile of 19.7% enriched uranium (Table 3). As is shown in

Appendix 2, continued growth of Iran's centrifuge enrichment capacity, even if Iran does not stockpile 19.7% enriched uranium, means that the time required for Iran to produce the HEU required for a nuclear weapon will become quite short. This is not to say that Iran's growing stockpile of 19.7% enriched uranium is unimportant, but rather focusing only on the 19.7% enriched uranium and not Iran's growing enrichment capacity as well will not provide a solution to the problem of Iran's ability to quickly produce the HEU required for a nuclear weapon

It should also be noted that Iran's stockpile of 3.5% enriched uranium has become large enough that Iran can now produce enough HEU for two nuclear weapons by batch recycling. Iran could produce 20 kilograms of HEU using the method shown in Table 3 and still have 2,293 kilograms of 3.5% remaining. Using this material Iran could produce a second 20 kilograms of HEU by using the method shown in Table 4. The whole process could be accomplished in 129 days which is about four months.[36]

Table 5

Time, Product and Feed Requirements for the Production of HEU by Batch Recycling at the FEP (operating all 12,669 IR-1 centrifuges) and Using Advanced Centrifuges at the PFEP (10,600 SWU per year)
Final Step Using Interconnected Cascades at PFEP and FFEP
(8 sets of two interconnected cascades at the FFEP)

Cycle and Enrichment Plant	Product Enrichment and Quantity	Feed Enrichment and Quantity	Time for Cycle (Days)
First FEP & Advanced Centrifuges at PFEP	19.7% 97 kg	3.5% 1145 kg	16
Second FEP &Advanced Centrifuges at PFEP	55.4% 39.8 kg	19.7% 227 kg*	5
Third Interconnected Cascades at PFEP & FFEP**	89.4% 20 kg	55.4% 39.0 kg	18
Total			45***

* Includes 113 kilograms that Iran has already stockpiled and kilograms that Iran has already stockpiled and 19 kilograms of 19.7% enriched uranium from the tails of the PFEP and FFEP. Plant inventory at the FEP is 2 kilograms.
** The combined plant inventory at the PFEP and FFEP is 0.8 kilogram.
***Includes six days to account for equilibrium and cascade fill time.

[36] The times in Table 3 and Table 4 are not additive since while the third cycle in Table 3 is being performed using the FFEP and the PFEP, the first cycle in Table 4 can be started at the FEP.

Another concern is that Iran has installed a great number of IR-1 centrifuges at the FEP that it is not operating. Only 8892 centrifuges are operating at this site even though 12,669 centrifuges are installed. Iran could start operating these installed centrifuges in the next few months. Further Iran has indicated that it plans to start producing enriched uranium with the two cascades of advanced centrifuges (IR-2m and IR-4) at the PFEP. In addition, Iran could easily complete the last cascade at the FFEP and complete an eighth interconnected cascade at this site. If Iran were to take all of these steps, it could significantly shorten the time to produce the HEU for a nuclear weapon to only one and one half months (six and one half weeks). See table 5 (for these calculations I assume that the IR-2m and IR-4 centrifuges produce twice the separative work of an IR-1 centrifuge—this is probably a conservative assumption.)

Table 6 shows the same case but assuming that Iran has no stockpile of 19.7% enriched uranium. To produce a weapon's worth of HEU would require only about nine weeks (a little more than two months). This is only two and one half weeks longer than the case using Iran's current stockpile of 19.7% enriched uranium. Further as Iran is now installing cascades of IR-2m centrifuges at the FEP, these times are only going to decrease. Iran could carry out the enrichment as shown in Tables 5 & 6 and produce 40 kilograms of HEU (enough for two nuclear weapons) in just 89 days (about 3 months).

Table 6

Time, Product and Feed Requirements for the Production of HEU by Batch Recycling at the FEP (operating all 12,669 IR-1 centrifuges) and Using Advanced Centrifuges at the PFEP (10,600 SWU per year)
Using 3.5% Enriched Uranium as the Starting Material
Final Step Using Interconnected Cascades at PFEP and FFEP
(8 sets of two interconnected cascades at the FFEP)

Cycle and Enrichment Plant	Product Enrichment and Quantity	Feed Enrichment and Quantity	Time for Cycle (Days)
First FEP & Advanced Centrifuges at PFEP	19.7% 210 kg	3.5% 2,480 kg	35
Second FEP &Advanced Centrifuges at PFEP	55.4% 39.8 kg	19.7% 227 kg*	5
Third Interconnected Cascades at PFEP & FFEP**	89.4% 20 kg	55.4% 39.0 kg	18
Total			64***

* Includes 19 kilograms of 19.7% enriched uranium from the tails of the PFEP and FFEP. Plant inventory at the FEP is 2 kilograms.
** The combined plant inventory at the PFEP and FFEP is 0.8 kilogram.
***Includes six days to account for equilibrium and cascade fill time.

Currently the fastest way for Iran to produce the HEU for a number of nuclear weapons is by using batch recycling at the FEP combined with a clandestine "topping" enrichment plant. This method would allow Iran to produce a weapon's worth of HEU in just one and one half months (six and one half weeks). Since Iran continues to refuse to implement the Additional Protocol to its safeguards agreement, as well as the Modified Code 3.1, the IAEA would find it very difficult to locate a clandestine enrichment plant—a fact that the IAEA has continued to confirm.[37] While this has been a theoretical possibility since 2007, its salience increased with the discovery in September 2009 that Iran was actually building such a clandestine enrichment plant (the FFEP near Qom).

In this case, the enrichment plant could be designed as an ideal cascade to enrich 19.7% enriched uranium to the 90% enriched uranium needed for a nuclear weapon. By starting from 19.7% enriched uranium, this clandestine enrichment plant need only contain about 2,000 IR-1 type centrifuges to be able to produce the 20 kilograms of HEU required for a nuclear weapon in just one and one half months. See Table 7. Since Iran has shown the capability to mass produce IR-1 type centrifuges and installed 2,255 at the FEP in just the last three months, Iran could easily provide enough centrifuges for a small clandestine enrichment plant.

Table 7

Time, Product and Feed Requirements for the Production of HEU at a 2,000 Centrifuge (IR-1 type) Clandestine Plant (0.90 SWU per centrifuge-year)

Enrichment Plant	Product Enrichment and Quantity	Feed Enrichment and Quantity	Time for Cycle (Days)
Clandestine	90.0% 20 kg	19.7% 93.8 kg*	45**
Total			45

* There is additional processing of the tails of the clandestine plant at the PFEP and FFEP.
** Includes two days to account for equilibrium and cascade fill time.

Iran already has enough 19.7% enriched uranium to produce more than enough HEU for one nuclear weapon. By using the FEP to produce additional 19.7% enriched uranium, Iran could produce additional HEU. Given its current stockpile of 3.5% enriched uranium Iran could produce a total of 97 kilograms of HEU which would be enough for about five nuclear weapons. Since the FEP can produce 19.7% enriched uranium faster than the clandestine plant would use it, each weapon's worth of HEU would be produced at one and one half month intervals and

[37] "While the Agency continues to verify the non-diversion of declared nuclear material at the nuclear facilities and LOFs declared by Iran under its Safeguards Agreement, as Iran is not providing the necessary cooperation, including by not implementing its Additional Protocol, the Agency is unable to provide credible assurance about the absence of undeclared nuclear material and activities in Iran, and therefore to conclude that all nuclear material in Iran is in peaceful activities." *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, GOV/2013/6, February 21, 2013, p.12.

could have a five weapon arsenal in seven and one half months. As Iran builds more of its advanced centrifuges (such as the IR-2m), the number of centrifuges required for a clandestine enrichment plant would probably drop to only about 1,000 to 1,500 and the time required to produce a weapon's worth of HEU (20 kilograms) would probably drop below one month. Since Iran has already installed more than 500 IR-2m and IR-4 centrifuges at the FEP and PFEP and plans to build 3,000 advanced centrifuges at the FEP, again it is well within Iran's ability to provide enough centrifuges for this clandestine enrichment plant.

Nor is a multi-step enrichment process the only pathway for Iran to produce the fissile material required for nuclear weapons, though it is the process that allows Iran to produce HEU most quickly. Iran could produce HEU at a clandestine enrichment plant designed to produce 90% enriched uranium from natural uranium feed.

A clandestine enrichment plant containing 3,800 IR-1 centrifuges (0.90 SWU per centrifuge-year) could produce around 20 kilograms of HEU (the amount required for one nuclear weapon) each year using natural uranium as feed. Since this option does not require any overt breakout from safeguards, the relatively slow rate of HEU production would not necessarily be of any concern to Iran. Such production could be going on right now and the West might well not know. A clandestine enrichment plant would need a source of uranium but Iran is producing uranium at a mine near Bandar Abbas.[38] Since Iran has refused to implement the Additional Protocol to its IAEA safeguards, this uranium mining is unsafeguarded and the whereabouts of the uranium that Iran has produced there is unknown. A drawback to this stand-alone clandestine enrichment plant is that it requires more centrifuges than would the 2,000 centrifuge clandestine plant discussed above. However Iran's rapid installation of centrifuges at the FFEP and FEP means that this possibility cannot be ruled out.

Iran then, has a number of methods whereby it could produce the HEU required for a nuclear weapon. By batch recycling at the FEP, PFEP and the FFEP (Table 3), Iran could produce enough HEU for a nuclear weapon in about two months (eight weeks). Even if Iran were to give up its current stockpile of 19.7% enriched uranium (Table 4), the time required for Iran to produce the HEU for a nuclear weapon would be just under three months (twelve and one half weeks). Using its current stockpiles of 3.5% and 19.7% enriched uranium, Iran could produce enough HEU for two nuclear weapons in about four months.

If Iran were to starting operating all of the centrifuges that it has installed, these times would significantly decrease. Iran could then produce enough HEU for a nuclear weapon in just one and one half months (six and one half weeks, Table 5) and even if it did not have any 19.7% enriched uranium it could still produce enough HEU for a nuclear weapon in just nine weeks (just over two months, Table 6)—a difference of only two and one half weeks. Using its current stockpiles of 3.5% and 19.7% enriched uranium, Iran could produce enough HEU for two nuclear weapons in about three months.

If Iran were to produce 19.7% enriched uranium at the FEP and simultaneously enrich 19.7% enriched uranium to HEU at a clandestine enrichment plant using IR-1 centrifuges (Table 7),

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[38] *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, GOV/2011/7, February 25, 2011, p.9.

then it could produce a weapon's worth of HEU in one and one half months (six and one half weeks) and enough HEU for five weapons in seven and one half months. Using more advanced centrifuges at a clandestine enrichment plant, Iran could produce a weapon's worth of HEU in just one month and enough HEU for five weapons in five months. Alternatively, Iran might build a stand-alone clandestine plant to enrich natural uranium to HEU. Such a plant would only produce enough HEU for one weapon a year but since the plant could go undetected for many years, Iran could produce a sizable stockpile before detection.

Iranian Production of Plutonium

The IAEA has also reported that Iran has made significant progress on its construction of its plutonium production reactor (the IR-40 at Arak). The installation of the reactor's cooling and moderator circuit piping is almost complete. Iran has produced a test fuel assembly for this reactor that it is irradiating in the Tehran Research Reactor. Iran has also produced over nine metric tons of uranium dioxide (using natural uranium) which is probably enough for the first core of this reactor. Iran has transferred nearly four metric tons of this material to its Fuel Manufacturing Plant. Iran has stated that it plans to begin to operate this reactor in the first quarter of 2014. This schedule may slip and even if Iran can meet this scheduled startup, it would still take about another year before Iran would be able to produce and separate enough plutonium for a nuclear weapon. Still Iran's steady progress on this reactor shows that in a few years it will have the ability to produce plutonium as well as HEU for nuclear weapons.

Appendix 2

Limiting Iran to Producing and Stockpiling Less Than 5% Enriched Uranium Does Not Prevent Easy Access to HEU

As was discussed in the text, many who propose a diplomatic solution with Iran have suggested that Iran should be allowed to continue to enrich uranium as long as this activity is subject to "proper" controls. In particular, they propose that Iran should not enrich uranium to more than 5% and that Iran's current stockpile of near 20% enriched uranium should be removed from Iran. Further, they propose that the size of Iran's enrichment effort be determined by the needs of Iran's peaceful nuclear program.

But as was shown in Appendix 1 (Table 4), even if Iran were to give up its current stockpile of 19.7% enriched uranium, Iran could still produce the HEU required for a nuclear weapon in just under three months (twelve and one half weeks). The problem is Iran's growing enrichment capacity. Furthermore, Iran's current enrichment effort is quite small compared to that needed for most peaceful nuclear activities such as providing fuel for a single nuclear power reactor. A diplomatic solution could provide Iran with the justification for greatly expanding its current enrichment facilities as well as removing sanctions. Under these circumstances, Iran might receive assistance to expand its enrichment facilities (from say China or Pakistan) as part of normal nuclear commerce. These greatly expanded facilities would provide Iran easy access to the HEU needed for nuclear weapons.

For example, even if Iran produced only 4.1% enriched uranium[39] and expanded its enrichment capacity by about a factor of 12 (100,000 SWU/yr), it would only produce about 15 metric tons of enriched uranium per year. This amount would still be less than that needed to fuel a single large power reactor yet, using batch recycling, these enrichment facilities could produce enough HEU for a nuclear weapon in just two weeks. This process is shown in Table 8.

In the first step, 4.1% enriched uranium is processed into 20.2% enriched uranium. In the second step, this uranium is processed into 60.2% enriched uranium and the third step completes the process by producing the 20 kilograms of 90% enriched uranium needed for a nuclear weapon. Each step produces not only the material needed to be processed in the next step but the material needed for the plant inventory which in this case is 30 kilograms per step.

Instead of just producing enough HEU for one nuclear weapon, Iran could produce enough HEU for five nuclear weapons (100 kilograms) in a single batch recycling campaign. This process would take about five weeks and is shown in Table 9. This process would require starting with 6,090 kilograms of 4.1% enriched uranium but since the plant will be producing about 15,000 kilograms per year, it would not be hard for Iran to stockpile this quantity of enriched uranium.

Though Iran's expansion of its 19.7% enriched uranium stockpile contributes to the shrinking time required for Iran to produce the HEU needed for a nuclear weapon, unless restrictions are placed on the size of Iran's overall enrichment effort, Iran's growing centrifuge enrichment capacity will allow Iran to quickly produce the HEU required for a nuclear weapon.

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[39] With tails of 0.2%.

Table 8

Time, Product and Feed Requirements for the Production of 20 kg of HEU by Batch Recycling at a Centrifuge Enrichment Plant Designed to Produce 4.1% Enriched Uranium (100,000 SWU per year total)

Cycle	Product Enrichment and Quantity	Feed Enrichment and Quantity	Time for Cycle (Days)
First	20.2% 304 kg	4.1% 1,990 kg	7.5
Second	60.2% 69.5 kg	20.2% 274 kg	1.7
Third	90.0% 20 kg	60.2% 39.5 kg	0.5
Total			16*

*Includes six days to account for equilibrium and cascade fill time.

Table 9

Time, Product and Feed Requirements for the Production of 100 kg of HEU by Batch Recycling at a Centrifuge Enrichment Plant Designed to Produce 4.1% Enriched Uranium (100,000 SWU per year total)

Cycle	Product Enrichment and Quantity	Feed Enrichment and Quantity	Time for Cycle (Days)
First	20.2% 929 kg	4.1% 6,090 kg	23
Second	60.2% 228 kg	20.2% 899 kg	5.6
Third	90.0% 100 kg	60.2% 198 kg	2.5
Total			37*

*Includes six days to account for equilibrium and cascade fill time.