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Critique of IISS Estimates of the Time Required for Iran to Produce the HEU Metal Core Required for a Nuclear Weapon
Addendum: Time Required to Produce the Non-Nuclear Components Needed For a Nuclear Weapon

Since Iran began using centrifuges to produce enriched uranium in 2007, there have been concerns that Iran could modify its enrichment operation to produce the Highly Enriched Uranium (HEU, typically at least 80% U-235) needed to manufacture nuclear weapons. Recently the International Institute for Strategic Studies (IISS) has produced estimates of the time required for Iran to use its existing enrichment facilities at Natanz in order to produce the HEU for a nuclear weapon.[1] The IISS estimates that it would take Iran one to two years to carry out this process and prefer their estimate of two years. This estimate includes not only the time needed to produce the HEU but also the time required to fashion the HEU into a metal sphere required for a nuclear weapon.

An estimate of two years is far higher than my most recent estimate of the approximately two and one half months.[2] Naturally I was interested in what caused the difference in our estimates. Initially I thought the difference might lie in the arcane calculations related to uranium enrichment but in fact the differences relate to four factors. One, the IISS assumes that Iran would prefer to repipe its cascades at Natanz to produce HEU rather than use the significantly faster batch recycling method. Two, the IISS vastly overestimates the time required to convert uranium hexafluoride (UF6—the chemical form of uranium required for the enrichment process) to a uranium metal sphere required for a nuclear weapon. Three, the IISS assumes that due to processing losses, Iran will have to produce a total of 37.5 kilograms of HEU when only 20 kilograms are necessary. Four, the IISS assumes that Iran uses only 24 cascades (3,936 centrifuges) when Iran has the equivalent of 31 cascades (5,144 centrifuges) in operation. We will discuss each of these factors in turn, after some background on centrifuge enrichment of uranium and Iran's centrifuge enrichment operations.

Iran and Centrifuge Enrichment

Natural uranium contains only 0.7% U-235. For uranium to be used as fuel in light water power reactors, which are the most common type of power reactors in operation today, the percentage of U-235 must be increased (enriched) to 3%-5%. As was indicated above, uranium should contain 80% or more of U-235 to be used in a nuclear weapon.

[1] *Iran's Nuclear, Chemical and Biological Capabilities, A net assessment*, an IISS strategic dossier, The International Institute for Strategic Studies, London, 2011.
[2] Gregory S. Jones, "Iran's Rate of Enriched Uranium Production Continues to Increase: Centrifuge Enrichment and the IAEA November 23, 2010 Update", November 30, 2010, http://www.npolicy.org/files/Irans_Rate_of_Enriched_Uranium_Production.pdf

One method of enriching uranium involves using gas centrifuges. In order to produce meaningful levels of enrichment it is necessary to operate many centrifuges in series—an arrangement known as a cascade. Since the output of a single cascade is limited, many cascades are often operated in parallel.

According to the International Atomic Energy Agency (IAEA), as of November 5, 2010 Iran had 29 cascades (4,816 centrifuges) in operation at its main enrichment facility at Natanz producing 3.5% enriched uranium starting from natural uranium. This enrichment level is suited for use in power reactors, but the only power reactors that Iran possesses receive all of their fuel from Russia. As Iran has no current use for the 3.5% enriched uranium it is producing, the material is being stockpiled. As of October 31, 2010, Iran had produced 2,152 kilograms of 3.5% enriched uranium. At its pilot enrichment facility (also located at Natanz), Iran has the equivalent of two cascades (328 centrifuges) in operation, enriching 3.5% enriched uranium to 20% enriched uranium. As of November 19, 2010, Iran had produced 22 kilograms of 20% enriched uranium.

It has long been known that the technical characteristics of the gas centrifuge are such as to make it fairly easy to produce HEU even when utilizing a centrifuge enrichment plant that was not specifically designed to produce such material. In Iran's case, its stockpiles of enriched uranium further ease this process. Since most enrichment effort is expended at the low concentration end of the process, 3.5% enriched uranium is already more than halfway to becoming HEU and 20% enriched uranium is about 90% of the way to HEU.

Enrichment Plant Repiping vs. Batch Recycle

There are two ways to produce HEU from a centrifuge enrichment plant designed to produce 3.5% enriched uranium.[3] The first method involves repiping the enrichment plant so that the large number of cascades operating in parallel are rearranged to operate in series. The second method is called batch recycling. In this method the original enrichment plant is basically unaltered and the 3.5% enriched uranium is successively reenriched by the enrichment plant until the desired enrichment is achieved. Depending on how this process is carried out, two to three additional enrichment passes are required.

Both repiping the enrichment plant as well as using batch recycling are considered to be valid ways to produce HEU.[4] Which of these two methods is used depends on a country's specific situation as well as the strengths and weaknesses of each method. A key disadvantage of the repiping method is the time needed to replumb the plant, during which time no enrichment can be carried out. The IISS estimates that it would take 12 weeks (close to three months) to carry out the replumbing. A key strength of this method is that once the replumbing is completed, the plant can carry out sustained operation. Iran's main enrichment plant at Natanz could be reconfigured so as to take natural uranium and enrich it all of the way to the 90% U-235 concentration needed for a nuclear

[3] *Nuclear Material Safeguards for Enrichment Plants, Safeguards Training Course, Part 4. Gas Centrifuge Enrichment Plant: Diversion Scenarios and IAEA Safeguards Activities*, K/ITP-156/P4/R1, Martin Marietta Energy Systems, Inc., Oak Ridge, Tennessee, October 1988, p.163.
[4] *Ibid.*, p.187.

weapon. The output of HEU would be about 20 to 25 kilograms of HEU per year, which is approximately the amount needed for one weapon.

However, repiping the plant to use natural uranium as feed means that Iran could not take advantage of its large stockpile of 3.5% enriched uranium (2,152 kilograms) to produce HEU. The IISS realizes this problem and instead assumes that Iran would repipe its main enrichment plant so as to produce HEU using 3.5% enriched uranium as feed. Once the plant had been repiped, Iran could produce enough HEU for one weapon in about 16 months (based on the IISS's assumptions). But there would be several disadvantages. The plant in this configuration could only run for as long Iran's stockpile of 3.5% enriched uranium lasted. Once the supply of this enriched uranium ran out (after producing roughly 40 to 50 kilograms of HEU), Iran would have to repipe the enrichment plant yet again so that natural uranium could be used as feed. Additionally Iran could not utilize its stockpile of 20% enriched uranium.

The IISS recognizes that in a breakout scenario, "time is of the essence." Yet it does not think Iran would use the batch recycling method at the main enrichment facility at Natanz even though this method would produce the HEU for a weapon in only six months, (according to the IISS assumptions). The IISS says that batch recycling is untested and points out that Pakistan gave the design for a repiped enrichment plant to Libya rather than proposing that batch recycling be used. However, the enrichment plant that Pakistan was to have provided was to going to be clandestine and not under IAEA safeguards. Therefore time was not of the essence and there was no pressure to produce HEU as quickly as possible before such activity could be discovered and counter-measures taken. Nor did Libya have preexisting stockpiles of enriched uranium which would have shortened the time needed to produce HEU. Pakistan configured the design for the enrichment plant it was offering so as to provide for the sustained production of HEU using natural uranium as feed which made perfect sense given the circumstances.

However, given Iran's need for speed and having stockpiles of enriched uranium, using batch recycling makes more sense. Further, it is untrue that batch recycling is untested, as Iran already has experience with this process. The first step of the batch recycling process involves enriching 3.5% uranium to 20% uranium which is the step that takes the most time. Iran already has experience with this operation since in February 2010 it began using a standard cascade at its pilot enrichment plant at Natanz to enrich 3.5% uranium to 20% enriched uranium. Iran has encountered no problems with this process and has maintained steady production of 20% enriched uranium, though, since it is using only one cascade, the rate is low.

In the long-run it would make sense for Iran is to produce one or more weapons quickly using batch recycling. Once Iran's stockpiles of enriched uranium are exhausted, it could then repipe its enrichment plant to provide for sustained HEU production using natural uranium feed.

The IISS estimates that if Iran were to use batch recycling, then it could produce the metal core of HEU needed for a nuclear weapon in about one year. While this is significantly shorter than its estimate that two years would be required if Iran were to use the repiping method instead, one year is still a long time for a country that would need to produce a nuclear weapon as quickly as possible.

Converting UF6 into a Weapon's Metal Core

The IISS's one year estimate consists of two components: (1) six months for batch recycling to produce sufficient HEU in the form of UF6 and (2) six months to convert the UF6 into the uranium metal sphere required for a nuclear weapon. This six month estimate for converting UF6 into uranium metal is very high compared to Chinese and U.S. experiences and is also quite at variance with expert estimates.

The Chinese produced the HEU for its first nuclear test by constructing a gaseous diffusion enrichment plant at Lanzhou. On January 14, 1964 this plant produced its first 90% enriched uranium.[5] Yet only three and one half months later, on April 30, a man named Yuan Gongfu was given the task of machining the uranium metal into the core for a nuclear weapon. The man had an attack of nerves and initially could not carry out his task but after a break and a glass of milk he was able to proceed. By May 1 "the nuclear core for the bomb was ready."[6]

At most, then, it took the Chinese only three and one half months to convert their UF6 into the core for their first nuclear test. The actual time would have been less, since some of that three and one half month period would have been used for the Lanzhou enrichment plant to produce sufficient HEU for a weapon. The production rate of the enrichment plant is unknown but best estimates are that it could produce 60 to 300 kilograms of HEU per year[7] which implies that the plant would have had to operate for one to three months before it had produced enough HEU for a weapon.[8] Therefore it took the Chinese somewhere between a half a month and two and one half months to convert their UF6 into the required uranium metal core.[9] Though this estimate is already far less than the IISS's six month estimate, it is clear that the Chinese were in no particular hurry to test a nuclear weapon and this estimate is not the minimum time required.[10] To gain a better idea of what the minimum time might be, it is necessary to look at the U.S. experience in World War II.

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[5] John Wilson Lewis and Xue Litai, *China Builds the Bomb*, Stanford University Press, 1988, p.136.
[6] *Ibid.* pp. 167-168.
[7] David Albright and Corey Hinderstein, "Chinese Military Plutonium and Highly Enriched Uranium Inventories", Institute for Science and International Security, June 30, 2005, http://isis-online.org/uploads/isis-reports/documents/chinese_military_inventories.pdf
[8] The high end of this estimate is more likely since the plant would not yet have reached equilibrium and therefore would be producing HEU at a lower rate. Enrichment plants are not at equilibrium when they first begin producing product. See: Stelio Villani, *Isotope Separation*, American Nuclear Society, 1976, p.134.
[9] The low end of this time range is more likely since as was discussed in the prior footnote, the enrichment plant was not operating at equilibrium and therefore most of the three and one half month interval would likely have been needed to produce the HEU.
[10] For example, the Chinese produced a fully completed test device on August 19, 1964 but did not test it until October 16, 1964.

As part of the Manhattan Project, the U.S. used several different methods to produce HEU. This was the first time that the large scale production of HEU had been attempted and there were various technical difficulties. Though significant HEU production began in the summer of 1944, the production rate was low—only about 1 kilogram of U-235 per month.[11] In the first part of 1945, the rate significantly increased to 5 to 7 kilograms of U-235 per month.

The HEU was to be used for a gun type nuclear weapon, in which a subcritical projectile of HEU is fired into a subcritical target of HEU. When combined the two pieces of HEU produce a supercritical mass and a large scale nuclear explosion. This weapon would be exploded over the city of Hiroshima.

Since large amounts of HEU had never existed before, as the material was produced it was distributed to various groups so that its properties could be studied. But starting on June 4, 1945, this HEU was collected and began to be fashioned into the components needed for the weapon.[12] By early July, all of the weapon's non-nuclear components as well as the HEU projectile were completed. These parts were transported to San Francisco and loaded onto the cruiser Indianapolis. After the successful nuclear test at Alamogordo on July 16, the cruiser made a high-speed run to the island of Tinian. It arrived on July 26.

But there was not yet enough HEU to make the weapon's HEU target and production was continuing. On June 27 workers at the Y-12 facility were exhorted to increase their efforts. Production records imply that it was only July 15 before sufficient HEU was received at Los Alamos.[13] Only nine days later on July 24, the HEU target was ready.[14] This component was transported by air to Tinian and arrived during the night of July 28-29. By July 31 the weapon was ready but due to poor weather, it was not dropped on Hiroshima until August 6.

The U.S. experience shows how quickly a weapon can be prepared. Based on this experience, the conversion of UF6 to HEU metal components should only take about one week, not the six months suggested by the IISS. This view is reinforced by expert judgment derived from two different sources.

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[11] The HEU production is reported as the number of kilograms of U-235 produced per month. The enrichment of this material was variable, ranging from 63% to 89%. See: David Hawkins, *Manhattan District History, Project Y, The Los Alamos Project*, LAMS-2532, Volume I, report written in 1946, report distributed in December 1961, p.308.

[12] Richard G. Hewlett and Oscar E. Anderson, *The New World*, A History of the Atomic Energy Commission, Volume I, 1939/1946, WASH 1214, Atomic Energy Commission, 1962, pp. 374-375.

[13] A total of 50 kilograms of U-235 had been produced by July 15, 1945. The amount and enrichment of HEU used in the Hiroshima weapon remains classified (though based on the production data, the enrichment had to be less than 89%). However the South Africans produced HEU nuclear weapons of the gun-type that had a yield of 14 kt ± 4 kt which is similar to that of the Hiroshima weapon (16 kt ± 2 kt). The South African weapon used 55 kilograms of 90% enriched HEU which contains 49.5 kilograms of U-235. See: David Albright, "South Africa and the Affordable Bomb", *Bulletin of the Atomic Scientists*, July/August 1994, pp.37-47.

[14] David Hawkins, *Manhattan District History, Project Y, The Los Alamos Project*, LAMS-2532, Volume I, report written in 1946, report distributed in December 1961, p. 253.

In the 1970s, I worked on various project related to nuclear proliferation for Albert Wohlstetter at his company Pan Heuristics. This company was part of SAIC which employed a number of nuclear weapon and nuclear industry experts. An important issue in our research was this very question of how quickly materials such as HEU in the form of UF6 or plutonium in the form of a nitrate or oxide could be converted into the metal cores needed for a nuclear weapon. After consulting with SAIC's experts, I reached the judgment that the time involved would be "days to weeks." This conclusion was published over 30 years ago.[15]

The IAEA has made a similar estimate.[16] It has estimated "conversion times" which are "The time required to convert different forms of nuclear material to the metallic components of a nuclear explosive device." For a variety of uranium and plutonium compounds in various degrees of purity, the IAEA estimates the conversion time as 1 to 3 weeks. The IAEA also states that for pure uranium or plutonium compounds [such as we are talking about here], the conversion time would be "at the lower end of the range" i.e. one week. Thus, the estimates produced by the IAEA, the ones I made in the 1970s and the U.S. World War II experience consistently demonstrate that the conversion time would be approximately one week and not the six months estimated by the IISS.

Amount of HEU Required

The IISS estimates using batch recycling at Natanz would take six months to produce 37.5 kilograms of HEU in the form of uranium hexafluoride. It determined that 37.5 kilograms of HEU was needed by starting with the IAEA's "significant quantity" for HEU which is 25 kilograms. The IISS then says that due to "wastage" during the fabrication of the HEU metal core, the required amount needs to be increased by 50% (25 x 1.5 = 37.5).

However, the IAEA says, "Significant quantities take into account unavoidable losses due to conversion and manufacturing processes…"[17] In other words the IAEA already has included a wastage factor into its estimate of "significant quantities." The IISS does not need to add another wastage factor.

Further as the IISS notes, the material lost in conversion and manufacturing is not permanently lost but rather can be recovered. This is not surprising since the HEU is more valuable than gold. However, since as we saw above, the IISS believes that the conversion of uranium chemical compounds into metal is a long and laborious process, it thinks that "lost" uranium cannot be recovered quickly. As we have shown, this belief is untrue and given the actual speed with which uranium metal can be produced from chemical compounds, it should be possible to expeditiously recover this material and still use it for the nuclear weapon. This fact applies to the IAEA's "significant quantity" as

[15] Albert Wohlstetter, Thomas Brown, Gregory Jones, David C. McGarvey, Henry Rowen, Vince Taylor and Roberta Wohlstetter, *Sword from Plowshares*, The University of Chicago Press, Chicago, 1979, p. 153.
[16] *IAEA Safeguards Glossary*, 2001 Edition, International Atomic Energy Agency, Vienna, 2002, pp.18-19.
[17] *Ibid.*, p.19.

well, which I estimate is still too large. In the U.S. experience discussed above, it appears that the amount of wastage in the production of the Hiroshima weapon was minimal.[18] Therefore I use only 20 kilograms as the required amount of HEU needed for to produce a nuclear weapon.

Since the time required for the production of HEU by batch recycling is roughly inversely proportional to the amount of HEU required, adjusting the IISS's time estimate reduces it to a little more than 3 months. (6 months x [20/37.5] = 3.2 months).

Number of Centrifuges

As we stated earlier, at the last IAEA inspection (November 5, 2010), Iran had 29 cascades (4,816 centrifuges) in operation at its main enrichment facility at Natanz and the equivalent of two more cascades (328 centrifuges) in operation at its pilot enrichment facility at Natanz for a total of 5,144 centrifuges. Yet the IISS assumes in its estimate that Iran uses only 24 cascades (3,936 centrifuges) to produce HEU. If one assumes that Iran uses all of the cascades that it has in operation then the IISS estimate becomes about two and one half months which is the same as my own estimate. (3.2 months x [24/31] = 2.5 months).

Summary

To summarize, the difference between my estimate of how long it would take Iran to produce the HEU metal core needed for a nuclear weapon and the estimate of the IISS relate to four factors. First, the IISS assumes that Iran would employ the time-consuming process of repiping its enrichment plant rather than using the significantly faster batch recycling method. Second, the IISS estimates that it would take Iran six months to convert UF6 HEU into the metal core needed for a nuclear weapon. This is a vast overestimate. One week seems to be a more accurate estimate based on U.S. experience in World War II as well as expert opinions including that of the IAEA. Third, the IISS assumes that Iran needs 37.5 kilograms of HEU to produce a weapon, saying that the IAEA's "significant quantity" of 25 kilograms of HEU should be increased by 50% to account for "wastage." This is a mistake since the IAEA's estimate of a "significant quantity" already takes wastage into account. Further, since the actual amount of wastage experienced by the U.S. in producing the Hiroshima weapon seems to have been minimal, 20 kilograms of HEU is a more appropriate amount. Fourth, the IISS assumes that Iran would use only 24 cascades to produce HEU, when as of the last IAEA inspection it had 31 cascades in operation.

[18] By July 15, 1945, 50 kilograms of U-235 had been produced but it is likely that somewhere close to 50 kilograms of U-235 was used in the Hiroshima weapon (the manufacture of which was completed on July 24, 1945).

Addendum: Time Required to Produce the Non-Nuclear Components Needed For a Nuclear Weapon

On March 4, 2011, Mark Fitzpatrick, who is the Director of the Non-Proliferation and Disarmament Programme for the IISS, responded by email to the original posting of my paper. He stated that my second point discussed above, i.e. the six months required for the conversion of UF6 to the HEU metal core, misinterpreted his report. In particular he stated that the six month interval represented not only the time to produce the HEU metal core but also the time required to produce the non-nuclear components.

However, the report seems to say something different: "Whatever method were [sic] used, [to produce the HEU, i.e. the 17 month repiping method or the six month batch recycling method] at least six more months would be required to convert the gasified HEU into metal and fashion it into a weapon."[19] The "it" clearly refers to the HEU and as written the report says that six months will be needed to convert the HEU into a form required for a nuclear weapon. But putting the English aside, if one assumes that the six months now includes not only the time required to produce the HEU metal core but also the non-nuclear weapon components, does this resolve the issue? The answer is no.

As the quotation from the prior paragraph shows, the IISS envisions the six months to be additive to the time required to produce the HEU in the form of UF6. This implies that the IISS sees this as a sequential process, where first the HEU in the form of UF6 is produced and only then can the final production of the non-nuclear weapon components take place. But this is a fundamental misunderstanding of how nuclear weapons are developed. The production of the fissile material for a nuclear weapon and the production of the non-nuclear components needed to detonate the fissile material can be carried out in parallel. This essential fact has been known since the beginning of the nuclear era.

One of the clearest statements of how nuclear weapons are developed can be found in the official British history of its nuclear weapons program. In a memo dated November 1, 1946, William Penney who was to lead the British effort, outlined how the task could be accomplished. According to the British history:

> "He said that the manufacture of an atomic bomb of present design fell naturally into two parts: firstly the production of the active material and secondly the ordnance part, that is, the manufacture and assembly of the components causing the explosion of the active material. The second part of the work could be begun and completed without the need to use fissile material at any stage."[20]

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[19] *Iran's Nuclear, Chemical and Biological Capabilities, A net assessment*, an IISS strategic dossier, The International Institute for Strategic Studies, London, 2011, p.120. Page 83 of this report similarly states that after the production of the HEU metal core, it must be "assembled into a weapon."

[20] At the time the memo was so highly classified that Penney had to type it himself. See: Margaret Gowing, assisted by Lorna Arnold, *Independence and Deterrence: Britain and Atomic Energy, 1945-1952*, Volume I, Policy Making, St. Martin's Press, New York, 1974, p.180.

The U.S. manufacture of the Hiroshima nuclear weapon, described above, also illustrates that production of a nuclear weapon is not a sequential operation where first the HEU must be produced and only then can the non-nuclear components of the weapon be developed. Rather the non-nuclear components for this weapon were already completed and sailing across the Pacific Ocean when the HEU components were still being manufactured.

Both of these examples demonstrate that Iran need not possess any HEU before it builds the non-nuclear components of its nuclear weapon. Indeed, Iran could finish these non-nuclear components before it begins any batch recycling at Natanz to produce HEU. Even if one accepted the IISS estimates that it would take Iran six months to produce a weapon's worth of HEU by batch recycling and six months to produce the non-nuclear components for the weapon, these two estimates are not additive. Instead of the one year estimate produced by the IISS, the true estimate would be only six months since both of these operations could be performed in parallel.

It should be recognized that any estimate of the time Iran requires to produce the non-nuclear components for a nuclear weapon will be far more uncertain that an estimate of the time required for Iran to produce HEU. The IAEA inspections in Iran provide solid data on the number of centrifuges that Iran has in operation, their production rate of enriched uranium and the amounts of enriched uranium Iran has stockpiled. This information provides a sound basis for estimating the time required to produce HEU. In contrast, the IAEA inspections provide little information about Iran's work on the non-nuclear components for a nuclear weapon. This is especially so, because Iran has blocked enforcement of the IAEA's Additional Protocol since 2007.

For most nuclear weapons, the implosion method is used to detonate the HEU. In this method the HEU is surrounded by explosives and upon detonation the HEU is compressed to a supercritical mass which then produces a nuclear explosion. As I have written elsewhere, the U.S. was able to develop implosion-type nuclear weapons in only eleven months during 1944-1945.[21] Though today Iran would not have the talent and resources available to the Manhattan Project, it would be starting from a far better position than the U.S. did. In 1944, no one knew whether or how the implosion method could work. Today it is not only well known that such weapons work but also there are general descriptions of such weapons and pictures showing their general construction. Knowledge of explosives as well as computing power are far superior today than they were 67 years ago when the U.S. undertook this effort. Further, Iran would not be starting from scratch. According to the 2007 NIE, Iran was developing nuclear weapons until the fall of 2003.[22] In addition, Iran may have received warhead design details from either Pakistan or North Korea. Since Pakistan is thought to already have a viable missile

[21] Gregory S. Jones, "When Could Iran Have the Bomb? An Analysis of Recent Statements That Iran is 3 to 5 Years Away", April 26, 2010, http://www.npolicy.org/article.php?aid=94&rt=&key=Gregory%20S.%20Jones&sec=article

[22] National Intelligence Estimate, "Iran: Nuclear Intentions and Capabilities," National Intelligence Council, November 2007, p.6, http://www.dni.gov/press_releases/20071203_release.pdf

warhead design (believed to have been provided by the Chinese), such aid would be particularly useful to Iran. Therefore, eleven months should be considered an upper bound of the time it would take Iran to develop such a weapon if it were to decide to undertake an all-out effort. The actual time could be considerably less.

The IISS's estimate of six months for Iran to develop the non-nuclear components of a nuclear weapon is reasonable enough. The problem is that the IISS considers this estimate to be static, since it believes that such further development can not occur until after Iran produces HEU. But since the development of the non-nuclear components does not require any HEU to proceed, such development can, and probably is, taking place even now. The IAEA has expressed repeated concerns about the possibility of current Iranian activities to develop a nuclear payload for a missile.[23] U.S. intelligence has indicated that Iran is continuing to work on the development of the non-nuclear components of a nuclear weapon. For example, in June 2010, CIA Director Leon Panetta, responding to a question about whether Iran's efforts to develop their nuclear capability included "weaponization" said, "I think they continue to work on designs in that area."[24] More recently, in testimony before Congress, the Director of National Intelligence James Clapper said, "Iran is keeping open the option to develop nuclear weapons in part by developing various nuclear capabilities that better position it to produce such weapons, should it choose to do so."[25] Therefore, just as Iran's continuing enrichment efforts are reducing the time required for it to produce HEU should it decide to do so, it also is undertaking work that is reducing the time needed for it to produce the non-nuclear components for a nuclear weapon.

The IISS estimates should reflect that Iran's development of the non-nuclear components for its nuclear weapons need not wait for Iran to first produce HEU but rather Iran can, and probably is, developing these non-nuclear components now.

[23] For example, see: *Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran*, GOV/2010/46, September 6, 2010, p.10.
[24] 'This Week' Transcript: Panetta, June 27, 2010, http://abcnews.go.com/ThisWeek/week-transcript-panetta/story?id=11025299
[25] "U.S. Intelligence: Iran leaders reopened nuke debate", Reuters, February 17, 2011, http://www.reuters.com/article/2011/02/17/iran-usa-nuclear-idUSN1717047120110217