Testimony of Olli Heinonen, Belfer Center for Science and International Affairs, John F. Kennedy School of Government, Harvard University, on 29 July 2014, before the United States Senate Committee on Foreign Relations

In my testimony, I will focus on the verification aspects of elements needed in a comprehensive nuclear agreement with Iran, which is being negotiated as a next stage to the Joint Plan of Action (JPOA) concluded in Geneva on 24 November 2013[1]. I base my remarks on the implementation of the comprehensive safeguards agreement (CSA) and relevant UN Security Council resolutions on Iran, recent experiences from the implementation of the JPOA, and complemented with personal experience drawn additionally and in particular, from the IAEA verification activities in South Africa after its dismantlement of its nuclear weapons program, Libya, Syria and North Korea.

When we look at the lessons learned on nuclear proliferation cases of the last couple of decades, states have chosen to use undeclared nuclear materials at undeclared locations or facilities at declared sites to which the IAEA had not had full access. Proliferators also took advantage of weaknesses at the front end of the nuclear fuel cycle by exploiting the use of yellow cake for uranium conversion at undeclared facilities. In order to achieve their objectives, states often, in addition to secrecy, stalled, misled or obfuscated to buy time and delay the IAEA in its verification mission. Since 2002, we have experienced many of these adverse actions taken by Iran. Iran has not heeded to the resolutions of the United Nations Security Council[2], which have asked it, inter alia, to suspend all enrichment-related and heavy water-related activities, and to cooperate with the IAEA on all outstanding issues, particularly with those which raise concerns on the military dimension of Iran's nuclear program[3]. Both the implementation of the JPOA and the

[1] Communication dated 27 November 2013 received from the EU High Representative Concerning the text of the Joint Plan of Action, IAEA, INFCIRC/855, 27 November 2013.

[2] United Nations Security Council Resolution 1929, 9 June 2010.

[3] The involvement of military institutes includes support to the acquisition of nuclear technology, building the nuclear infrastructure, and work related to acquisition of nuclear

Framework on Cooperation[4] have generally proceeded well, but negotiations have also seen headwinds as reflected in Secretary Kerry's op-ed on 1 July 2014 in the Washington Post on where Iran needs to be. Moreover, as the Iranian Ambassador's recent letter to the IAEA demonstrates[5], Iran continues to challenge, inter alia, the Agency's right and obligation to verify the correctness and completeness of Iran's declarations under the CSA, the legality of the IAEA Board resolutions, and the IAEA Secretariat's practices in reporting its findings in its reports to the IAEA Board and the UN Security Council.

Due to the fact that Iran has been running parts of its nuclear first clandestinely and then without satisfactorily fulfilling its reporting obligations to the IAEA and disregarding UN Security Council resolutions, the onus of proof bears heavily on Iran to show that its nuclear program is entirely peaceful.

I have recently published with David Albright and Andrea Stricker[6] an analysis on principles, which the negotiators crafting the comprehensive final agreement should follow. Five fundamental principles are:

1. stable provisions;
2. a nuclear program meeting Iran's practical needs;
3. effective verification;
4. adequate irreversibility of constrains, and
5. sufficient response time in case of violations.

In the following I will highlight some details that should be included to a final agreement negotiated. I will note a need for possible additional UN Security Council resolutions, and points to bear in mind on future reporting of the IAEA on safeguards implementation in Iran.

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materials, nuclear source materials, and key raw materials, and production of single use nuclear equipment. Of concern is also work by these organizations related to neutron physics, neutron sources, high explosives, missile re-entry vehicle, which appear to have the characteristic of nuclear weapon development.

[4] Joint Statement on a Framework for Cooperation, GOV/INF/2013/14, IAEA,11 November 2013.

[5] Communication dated 4 June 2014 received from the Permanent Mission of the Islamic Republic of Iran to the Agency regarding the Report of the Director General on the Implementation of Safeguards in Iran, IAEA, INFCIRC/866, 13 June 2014.

[6] D. Albright, O. Heinonen, and A. Stricker, "The Six's" Guiding Principles in Negotiating with Iran, ISIS, 3 June 2014.

Stable Provisions

It is important for the credibility and durability of an agreement that it is crafted to minimize opportunities for violations and delays to achieve compliance.

The first requirement is that Iran provides a complete declaration of its past and current nuclear program as it did partially in 2003 when it started to implement the suspension agreement with the EU3. Such a declaration forms a clear-cut and essential baseline for the verification and monitoring activities by the IAEA.

Another important provision is the technical parameters of the nuclear program. An example of what would create an unstable and reversible situation that should be avoided is, for instance, suggestions that involve lowering the amount of enriched uranium Iran has access to while increasing the number of allowed centrifuges to 10,000 or more IR-1 centrifuges in order to increase breakout times. The instability arises from Iran continuing to make enriched uranium and maintaining residual stocks of enriched uranium to fuel research reactors. Keeping enriched uranium stocks exceedingly low would be impossible in practice. Practicalities of operating a centrifuge plant and a uranium conversion and fuel production complex would lead to larger enriched uranium stocks, compromising the original goal of longer breakout times. Such a proposal would require Iran to take actions almost monthly to keep its stocks below the agreed enriched uranium cap, something unlikely to be accomplished easily.

Our experiences from the implementation of the JPOA already demonstrate that stocks of low enriched uranium have grown due to logistical or operational difficulties. Any violation of the cap could be sudden and difficult to respond to. Regulating numbers of centrifuges is a far sounder approach than controlling enriched uranium stocks.

The third aspect to the stability equation is that by establishing a baseline, it also helps determine operating parameters. Experiences in implementing the various agreements with Iran since 2003 clearly demonstrate the importance of establishing unambiguous baselines for monitoring Iran’s undertakings. Ambiguity in parameters (such as enrichment capacity, stocks of nuclear material, access to locations) leads to potential slippage. It is also necessary

to specify explicit parameters for other fuel cycle facilities such as on laser enrichment. And it is important to include to the provisions that proscribed activities should not outsourced to other countries.

Practical Needs of the Iranian Nuclear Program

Limiting Iran's centrifuge program to say 2,000 to 4,000 IR-1 centrifuges is consistent with Iran's actual needs for enriched uranium for many years[7]. This number of centrifuges would provide Iran with sufficient enriched uranium for its existing research reactor programs and account for modest growth in them.

Besides breakout considerations, the simple fact for a smaller number of centrifuges is that Iran does not need to refuel the Bushehr reactor. Indeed, these limits would not allow for the fueling of the Bushehr nuclear power reactor. Recently, Iran's Supreme Leader in essence expressed this demand when he stated Iran requires enough centrifuges to produce about 190,000 kilograms of uranium hexafluoride separative work units per year (kg UF6 swu/year). In more standard units, this number would correspond to almost 130,000 kg U swu/year, which is equivalent to over 130,000 IR-1 centrifuges.

Iran's position of needing to produce its own fuel has to be measured against the realities that demonstrate why it in fact should not. Without extensive outside assistance in the form of key equipment, raw materials and advanced technology, Iran has limited prospect of actually building so many IR-1 centrifuges or an equivalent number of advanced centrifuges to fuel the Bushehr reactor over the next decade or two. It will need to continue relying on importing fuel from Russia or another major supplier. We also need to keep in mind that Iran has not demonstrated an ability to produce fuel of sufficient quality for the Bushehr nuclear power reactor, a key safety issue.

Moreover, Russia has not welcomed the idea of Iranian produced fuel in the Bushehr reactor. Russian concerns arise from the fact that having potentially defective Iranian fuel inserted into the Bushehr reactor, and fears of an

[7] Defining Iranian Nuclear Programs in a Comprehensive Solution under the Joint Plan of Action, ISIS, 15 January 2014.

accident which it, as the reactor supplier, could be held liable for. Such an events will also lead to reputational damage of Russian reactors.

Effective Verification

Effective verification is an important core principle, but there are several challenges to overcome. Timely detection and prevention of the development and acquisition of nuclear weapons or a state's capability to produce them is a complex task. Development of weapons of mass destruction is one of the closest kept secrets of a state. There are things, which we know, and there are aspects of such programs, which we can perhaps to certain degree deduce, but also features, which we do not know.

In addition, Iran has refused to make concessions in this area. The IAEA must provide prompt warning of violations, determine the correctness and completeness of Iran's declarations, establish the total number of centrifuges produced by Iran and the size of its natural and enriched uranium stocks, and establish confidence in the absence of undeclared nuclear activities or facilities, including providing assurances on the absence of nuclear weapons related activities in Iran.

The strength of the IAEA verification system is access to nuclear material, facilities, equipment and people. To this end, the IAEA has, under its Comprehensive Safeguards Agreement (CSA) and Additional Protocol (AP), significant tools available if fully implemented and utilized. Iran argues that ratifying the Additional Protocol is enough but while such a step is welcome, it is not sufficient. The long-term agreement must also establish a range of other verification provisions, which collectively are often known as Additional Protocol Plus.

Throughout the long history of discussions on the scope and content of its nuclear program, Iran has often offered 'transparency' to build international confidence on its nuclear program. Recently President Rouhani has again publicly stated Iran's readiness for greater transparency. More importantly, such transparency should be understood and implemented in a meaningful and systematic way. Even in the name of 'transparency,' where Iran decides to 'show' a place previously off limits (imposed by Iran), such inspection visits can have meaning only if substantially new information and

discussions take place, and explanations are provided on the scope and content of the nuclear program. Hence openness should be clearly defined and become a legally binding undertaking, and not treated as good will visits to be granted when problems arise.

To minimize further the effects of the unknowns, it is important to understand the historical production and acquisition of uranium and its compounds by Iran. As part of the information obtained from the Iranian mines and milling facilities under the Framework for Cooperation[8], Iran has provided information on uranium production of mines in Gcchine and Ardakan. It is important that the IAEA shares those actual numbers, and whereabouts of those materials with its member states, which may have additional information to complement the statements made by Iran[9]. This would also provide the Member States indications on Iran's compliance with its undertakings. Releasing of such information by the IAEA will not jeopardize its independent assessment of Iran's declarations, but will complement information available.

Going further, according to the provisions of the CSA, a state has to declare all nuclear material in its territory. Thus military sites do not form sanctuaries, but the IAEA has right to conduct inspections on those under a CSA and complementary access under an AP, when appropriate. Iran has to provide the IAEA with unconditional and unrestricted access [10] to any and all areas, facilities, equipment, records, people, materials including source materials, which are deemed necessary by the IAEA to fulfill its requirements under the safeguards agreement, and to verify the correctness and completeness of Iran's declarations. These are needed both to understand the scope of the nuclear program as well as address the possible military dimensions (or PMD) aspects.

Accomplishing adequate verification, including the IAEA establishing that Iran's program is exclusively peaceful, will take many years. Just as an example, it took to the IAEA for medium size nuclear programs in European

[8] Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council Resolutions in the Islamic Republic Iran, GOV/2014/28, paras 7-8, IAEA, 23 May 2014.

[9] Recent IAEA reports have acknowledged the receipt of such information, but no quantities have been shared with the member states in written reports.

[10] Due to the nature of the verification and monitoring such access should be done in short notice at, inter alia, centrifuge assembly and component manufacturing plants and at enrichment facilities.

countries with CSA and AP implemented, about five years to conclude that all nuclear material in these countries was in peaceful use. Duration of an agreement for twenty years is reasonable in light of the two decades of Iran's non-compliance with its safeguards obligations and non-cooperation with the IAEA.

A comprehensive agreement should also take the opportunity to assess the usefulness of strengthening certain linkages. For instance, the Sanctions Committee on Iran that was established under UNSC's resolution 1737[11] is a separately run mechanism from the IAEA verification process. At a minimum, these two bodies could be allowed to share information. It might also be reasonable to consider whether monitoring the implementation of sanctions should be assigned to a special unit to be established within the IAEA.

Adequate verification also requires Iran to verifiably stop its efforts to procure key proliferation-sensitive goods illegally for its nuclear programs. If not stopped, Iran could secretly purchase the wherewithal for secret nuclear sites or activities. This requires a continuation of national and United Nation Security Council sanctions on proliferation sensitive goods for the long term. However, an agreement will need to eventually allow for monitored Iranian purchases for its legitimate nuclear programs and civilian industries while ensuring that Iran is not buying goods illegally for banned activities.

Another important factor are the financial and human resources of the IAEA. In order to meet the verification requirements, the IAEA needs additional expertise on sensitive technologies. The arrangements have to be made that this staff has also access to Iranian facilities and can participate to discussions with Iranian expertise. Such arrangements worked well in South Africa, and Libya, where the IAEA used its additional experts in addition to inspectors designated under the CSA.

To ensure that the IAEA gets the necessary legally binding authorities to conduct the additional verification work indicated in my statement, it is recommended that the UN Security Council endorse the agreement between P5+1 and Iran.

[11] United Nations Security Council Resolution 1737, 23 December 2006.

Possible Military Dimensions

Iran's most serious verification shortcoming remains its unwillingness to address the IAEA's concerns about the past and possibly on-going military dimensions of its nuclear programs. For the IAEA to conclude that all nuclear material is in peaceful use, this is not possible unless Iran satisfies the IAEA in this key area.

There are reports that much of the nuclear weapons related work by the military institutions came to halt in 2003. On the other hand, the IAEA has assessed in its reports that some of this R&D has continued since. It is important to understand the status of Iran's PMD efforts, noting that one of the last duties of Iranian personnel and organizations involved was to document work done. One plausible reason for such effort could have been to save information for further use. Unless properly addressed, it would be difficult to create a meaningful and robust verification regime for Iran. Such additional long term monitoring took place in South Africa from 1993 until 2010 until the IAEA was able to conclude that all nuclear material in South Africa is in peaceful use. Otherwise, it would also render difficult for the IAEA to determine with confidence that any nuclear weapons activities are not ongoing – a necessary ingredient for a long term deal.

The list of IAEA questions on the PMD is long. While the recent Framework for Cooperation agreements between Iran and the IAEA are welcome, the process is far from over. Many of the issues on the list above are interconnected, and they cannot be solved in isolation and not through the step-by-step process. In other words, there should be an understanding and actions provided by Iran that allows the IAEA to address the whole picture of the military dimension concerns. That should be an unambiguous condition to achieving a final accord that is meaningful in safeguards terms.

The agreement should also have provisions to ensure that Iran will decommission, dismantle or convert to non-nuclear or peaceful use in a verifiable and irreversible manner nuclear related equipment, materials, facilities and sites that contradict the provisions of the safeguards agreement or the spirit of Article III of the NPT. Such installations will be subject to a long-term monitoring by the IAEA.

Finally, limiting nuclear capabilities at known sites does not make sense if at the same time the deal makes it easier for Iran to make weapon-grade

uranium at military sites. The comprehensive agreement must focus on both potential pathways as necessary for adequate verification to be carried out.

Irreversibility

Irreversibility is understood as accepting that perfect irreversibility may not be possible but in practice recognizes that the restoration of the previous, unconstrained situation should take a long time—on order of years and not months. In the case of Iran, a long-term agreement would have little lasting value if Iran can reverse the constraints in a matter of days or months. The case of North Korea contains many examples where nuclear constraints imposed on reprocessing and the operation of the 5 MWe reactor were quickly undone and Pyongyang resumed its production of nuclear materials for nuclear weapons. This case also contains important examples of North Korea being unable to establish previous levels of plutonium production when an agreement ended. North Korea shut down its large gas-graphite reactors, ending their ability to make large amounts of weapon-grade plutonium, as a result of the 1994 US/DPRK Agreed Framework. When this agreement ended suddenly in 2002, North Korea was able to reestablish its small plutonium production capability. After 2009, North has put the reactor again in operation after reconstruction of the cooling system for the reactor.

Irreversibility is at the heart of the dispute about Iran limiting plutonium production in the Arak nuclear reactor. As a heavy water reactor Arak with its design can relatively easily make weapon-grade plutonium at a production rate sufficient to make enough weapon-grade plutonium up to two nuclear weapons per year. Iran has suggested reducing plutonium production in this reactor by using enriched uranium rather than natural uranium; other analysts have suggested in addition lowering the power of the reactor. It is true that combined, these proposals would reduce plutonium production to a fraction of the current value. However, both of these steps are reversible and Iran could in a straightforward, quick manner turn back the clock to a reactor able to make significant amounts of weapon-grade plutonium. The simple fix is for Iran to remove the currently installed core and replace it with a smaller one not able to hold enough natural uranium for the reactor to work. Iran so far resists this proposal.

With the above changes to the Arak reactor, there would also be no need for heavy water production—regular, “light” water could be used instead in this

reactor. The heavy water could be shipped out and sold on the international market. This step would further make the Arak reactor changes reasonably irreversible.

Iran has also resisted making concessions about what to do with the centrifuges that would exceed a cap on the total agreed upon number of installed centrifuges. If the cap is say 4,000 IR-1 centrifuges, Iran would need to remove and render harmless almost 15,000 centrifuges installed in its Natanz and Fordow enrichment plants. If left installed, Iran could within months reconstitute operations and create a sizeable breakout capability. Thus, any proposal to keep excess centrifuges at the centrifuge plants is highly reversible and allows a quick reconstitution of dangerously unstable breakout times.

Adequate Response Time

An agreement must provide sufficient time to mount an effective response to major violations by Iran. There are two parts to this principle—one involves intrusive and effective IAEA inspections able to promptly detect and report non-compliance and the other recognizes that even the most intrusive inspections are alone inadequate to provide enough response time in the case of Iran. The latter's adequate response time requires significant limitations on content and parameters of Iran's nuclear programs and translates into a need to limit Iran's pathways to making nuclear weapons.

IAEA reports form a key part of the monitoring of compliance from the point of view of P5+1 and the international community. The member states can use these reports to complement their findings from their activities conducted by national means. From a practical point of view, the quarterly reporting on progress and findings by the IAEA should be sufficient. However, the IAEA should consider releasing factual information as it becomes available. Timeliness of conclusions depends on several parameters. This would entail the detection of the event, asking the clarification, additional sampling.

Much of that depends on the cooperation of the inspected party, but also on the event itself. While diversion of declared material is easily detectable, some more sophisticated events may take longer to detect. The IAEA's practice is to review each finding and claim meticulously, spending a fair

amount of time and resources to refute or confirm any claim. Revised explanations provided by the inspected state also slow down the IAEA. This process needs to be re-thought. The IAEA verification system has its technical limitations. One of the tools the IAEA uses is environmental sampling, which has resulted in long in-between lead times. The latest IAEA report to its Board of Governors indicated that the environmental sample analysis results for Natanz FPEP, FEP, and Fordow were 28 January 2014, 5 February 2014, and 28 January 2014, respectively[12]. If additional samples and clarifications are required, the results will in practice take 6 months. The IAEA work process needs to be factored into an overall understanding of timeliness of response.

An effective metric of adequate limits on Iran's main overt pathway to nuclear weapons, its centrifuge program, is breakout time, which measures the length of time Iran would need to produce enough weapon-grade uranium for a single nuclear weapon. This technical breakout value is converted via detailed breakout calculations into an equivalent number of centrifuges that would be installed in Iran, which results in an oft-stated limit of about 2,000-4,000 IR-1 centrifuges remaining in Iran as part of a comprehensive deal.

There are other reasons to make known breakout times longer. In the past, Iran has conducted activities, and concealed them in such ways that were not quickly detected or stalled in letting the IAEA to proceed with its investigations. Achieving the necessary evidence to judge with high confidence that violations have indeed occurred is time consuming and intelligence reliant in key cases, such as the discovery of the once-covert Natanz and Fordow Fuel Enrichment Plants, clandestine centrifuge R&D at Kalaye Electric, black market nuclear related imports including imports of nuclear material, some with possible military uses.

There is also the still unresolved file on the development of nuclear weapons. The IAEA has not yet been able to verify that Iran has submitted all its nuclear material to the IAEA safeguards. We do not also know how many centrifuges Iran has manufactured and where they are today. Moreover, a larger program also makes it easier for Iran to hide illicit foreign procurements, some of which could be slated for a clandestine

[12] IAEA, "Implementation of the NPT Safeguards Agreement and Relevant Provisions of Security Council Resolutions in the Islamic Republic of Iran," GOV/2014/28, 22 May 2014.

program. To this end, it is also important – as mentioned in my testimony on 10 June 2014 - that Iran has to report all imports and manufacturing of single and dual use items regardless whether the end user is the nuclear program and provides the IAEA access to that information and items[13].

While breakout time does not include the total time to produce a nuclear weapon for testing underground or mounting on a missile, the production of the weapon-grade uranium is the more difficult and time consuming portion of making a nuclear weapon. Once Iran has enough weapon-grade uranium for a weapon, the material would ostensibly vanish to covert sites for further weaponization efforts, which could be small in size without visible detectable signatures as it was in the case of South Africa. Additional concerns are the facts that Iran may have received sufficient amount of design information to avoid testing. If a gun-type nuclear device is a goal, it requires more material, but there is no need for testing. Thus, the priority must be to limit Iran's ability to first produce the weapon-grade uranium.

In summary

The actual verification process will be time consuming and will stretch over many years, especially more so for a nuclear program in Iran that had been largely clandestine in nature, broad and complex. Forthcoming and proper cooperation from Iran could set the tone for the country to have in place a limited nuclear program. A meaningful and robust verification system with the requisite elements is needed to support a long-term deal.

[13] Olli Heinonen, Testimony on 'Verifying Iran's Nuclear Compliance', The United States House Committee on Foreign Affairs, 10 June 2014.