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The Strengthened Safeguards System and the Front-end of the Nuclear Fuel Cycle

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Article IV of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) encourages the “fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy.” While Article IV is simply an ambition, it is compliance with the international nuclear safeguards requirements of Article III that provides the main basis for commercial nuclear trade and the free intercourse of ideas and information on peaceful nuclear activities. The confidence of the international community in the international safeguards system as administered by the International Atomic Energy Agency (IAEA) is crucial to these continued activities.

This confidence was, however, severely shaken in the aftermath of the Gulf War at the beginning of the 1990s. The post Gulf War inspections of Iraq by both the IAEA and the United Nations Special Commission (UNSCOM) determined that Iraq had managed to hide the development of a complex weapons programme from the international community. The inspections also revealed that a state party to the NPT could develop and nurture a clandestine nuclear weapons programme in spite of periodic international inspections and the separate efforts of national intelligence agencies to expose such illicit activities. Iraq became to nuclear non-proliferation what Chernobyl is to nuclear safety: a warning that repetition of the event would bring dire consequences to the objectives purported by Article IV of the NPT.

This paper proceeds through five sections. First, the shortcomings of international safeguards as demonstrated by Iraq in the early 1990s are reviewed. Second, initial reform efforts are recapped. Third, the Additional Protocol is briefly described. Fourth, the relationship between the Additional Protocol and the front-end of the nuclear fuel cycle is explored. Finally, some next steps are proposed.

Shortcomings in Safeguards as Demonstrated by Iraq

According to Article III of the NPT, every state party is required to conclude a comprehensive safeguards agreement with the IAEA. Every comprehensive safeguards agreement is based on a model (INFCIRC/153) entitled “The Structure and Content of Agreements Between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons”, which was concluded in 1972 by an open committee of all member states to the IAEA.

The model allows for the implementation of international safeguards in non-nuclear weapons states in a non-discriminatory, objective and universal manner. The model allows for the creation of a verification system that works toward providing assurances that all nuclear material in peaceful nuclear activities is safeguarded and thereby not diverted to nuclear weapons or other nuclear explosive devices. It requires all state parties to set up a state system of accounting and control (SSAC) to facilitate accounting and reporting of nuclear material inventories to the IAEA. It also obliges state parties to conclude subsidiary arrangements and facility attachments that contain the specific details for safeguards implementation at the state and facility levels, respectively. Most important, the model arrangement grounds comprehensive safeguards implementation in quantitative nuclear material accountancy measures at declared locations, leaving the issue of undeclared nuclear activities for IAEA member states to address through other means.

Once a state has concluded a comprehensive safeguards agreement and its associated subsidiary arrangements and facility attachments with the IAEA, the SSAC is obligated to account for and control all nuclear material subject to safeguards. The nuclear material is declared to the IAEA and is subject to verification and re-verification to ensure that it is not diverted from declared peaceful uses to proscribed military activities. This is accomplished, under the auspices of comprehensive safeguards agreements, by allowing the IAEA to monitor the flow of safeguarded nuclear material at and between designated "material balance areas", to perform measurements and to apply containment and surveillance measures at specific "strategic points". This has the effect of concentrating the IAEA's verification activities on declared nuclear materials at specific physical locations within the state's declared nuclear facilities.

The revelations by international inspection teams of a mature clandestine nuclear weapons programme in Iraq highlighted three primary shortcomings of comprehensive safeguards implementation. First, the implementation of IAEA safeguards, as embodied in INFCIRC/153, dictated that verification activities be applied only to declared nuclear material and that it was up to the state to declare all relevant material to the IAEA. The political climate of the Cold War, under which the IAEA was born and comprehensive safeguards developed, sought to minimise the intrusion of the international inspection regime into the state's sovereignty. In doing so, it later allowed Iraq the conditions necessary to produce indigenously (e.g. via an undeclared uranium conversion plant in Jesira capable of producing UO_2 from yellowcake and UCl_4 from UO_2) and to acquire clandestinely (e.g. via unreported UO_2 imports from a third party) stocks of undeclared nuclear material that should have been declared and, consequently, should have been subject to IAEA safeguards.

Second, and closely related to the first, physical access via on-site inspections by IAEA inspectors was limited to designated "strategic points" to apply containment and surveillance measures and to perform activities related to quantitative accountancy on declared nuclear material. After a state concludes a comprehensive safeguards agreement with the IAEA, it submits design information on all facilities relevant to the application of safeguards. The design information, which contains a basic description of the relevant

processes and activities, is used by the IAEA to develop a safeguards approach to verify the non-diversion of nuclear material from the facility to undeclared activities. The approach, including the material to be subject to safeguards and the scope and intensity of inspections, is reflected in part in the facility attachment.

In fusing the frequency of inspection to the type of nuclear material and its location at the facility, access to perform on-site verification activities under comprehensive safeguards agreements was limited. Not only did this prohibit the IAEA from venturing beyond areas that contained declared nuclear material, it also had the effect of severely constraining the IAEA's ability to investigate areas that might have contained undeclared nuclear materials and clandestine activities. These limitations were later made starkly evident in Iraq's ability to mask successfully a parallel nuclear weapons programme under its declared peaceful nuclear activities by co-locating some of its illicit activities on the same sites (e.g. Al Tuwaittha) as the IAEA performed its routine verification activities, as well as by operating wholly separate clandestine facilities elsewhere in Iraq.

Third, the safeguards system as implemented pursuant to INFCIRC/153 defined the "starting point of safeguards", and thereby nuclear material accountancy, as "nuclear material of a composition and purity suitable for fuel fabrication or for being isotopically enriched". Theoretically, there is a magical line at a conversion facility where this occurs. Practically, in Canada, this translates into IAEA safeguards starting on finished drums of UO_2 powder, finished UF_6 cylinders and uranium metal. While INFCIRC/153 contains some import and export reporting obligations on material before the starting point of safeguards, comprehensive safeguards agreements contain no obligation for the state to report, for safeguards purposes, to the IAEA on its indigenous production of pre-safeguards material (i.e. source material, including uranium concentrate and yellowcake, as well as uranium ores and ore residue). Again, Iraq used this to the advantage of its nuclear weapons programme by indigenously producing (e.g. producing yellowcake at an undeclared uranium concentration plant at Al Qaim) and acquiring safeguarded material (e.g. via improperly disclosed imports of yellowcake from third parties).

In 1990 and 1991, in the aftermath of the Gulf War and the onset of intrusive international inspections in Iraq, the international community through its representatives in both the General Conference and the Board of Governors of the IAEA voiced their concern over these shortcomings and vowed to strengthen international safeguards to prevent further Iraqi-style violations of the NPT. At a special session of the IAEA Board of Governors on 18 July 1991, the IAEA declared that Iraq had violated its comprehensive safeguards agreement. It strongly condemned Iraq for not correctly and completely declaring all the nuclear material and facilities of its nuclear programme for IAEA inspection. Moreover, throughout and following the special session of the Board meetings, the international community demanded that, if international safeguards were to retain any credibility, there would have to be some changes to the implementation of IAEA safeguards to make them more effective.

In response, the then IAEA Director General Hans Blix affirmed his commitment to reform and indicated that the safeguards system should undergo a three-way strengthening — increased access to information on national nuclear programmes, unrestricted access to any safeguards-relevant location, and strong enforcement support from the international community via the United Nations Security Council.

The Reform Process

These commitments to reform started initially with piecemeal efforts in the early 1990s which culminated in five key decisions taken at the February 1992 Board meeting. First and foremost, the IAEA Board re-affirmed the requirement that the IAEA provide assurances regarding the “correctness and completeness” of nuclear material declarations with comprehensive safeguards agreements. Although the scope of INFCIRC/153 was not limited to verification of declared nuclear material, political considerations during its implementation tended to make it so. The Board, in reacting to the shortcomings mentioned above, sought to restore the obligation to apply safeguards to all relevant nuclear material under comprehensive safeguards agreements. The effect of this decision was to support a more active role by the IAEA Secretariat in investigating any indications that a country might have undeclared nuclear material or activities on its territory.

Second, and closely related, the IAEA Board also re-affirmed the IAEA’s right to conduct “special inspections”, as allowed for under INFCIRC/153, “when necessary and to ensure that all nuclear materials in peaceful activities are under safeguards”. The Board qualified the affirmation by stating that the special inspections, which could be conducted under comprehensive safeguards agreements when the IAEA considers the information contained in reports from the state is not adequate to fulfil its responsibilities under the agreement, would only occur on rare occasions.

Third, the IAEA instituted new measures for the early provision of design information for new and modified plants. The provision of this information by the state to the IAEA maintains appropriate safeguards approaches for the facility, prevents surprises and creates confidence in the peaceful purpose of the facility making it easier to prepare for its safeguarding. Fourth, the IAEA and its member states agreed to a voluntary export/import reporting scheme of certain equipment and non-nuclear materials used in the nuclear industry. Most of the equipment and non-nuclear material covered by the reporting scheme were already subject to various supplier group guidelines (e.g. the Nuclear Suppliers Group and Zangger Committee) and could have been reported as exports to the IAEA.

Fifth, and finally, the Board also took the decision that member states of the IAEA should provide to the IAEA information obtained from “all other sources”, (e.g. open sources, satellites and national technical means) in drawing credible safeguards conclusions. These latter three provisions relating to the supply of information, together with the information provided under the terms and conditions of comprehensive safeguards agreements, was designed to give the IAEA up-to-date knowledge of all aspects of the state’s nuclear fuel cycle activities. Moreover, correlation of this information with

the state's declared nuclear activities and its accounting reports was intended to give the IAEA the basis for investigating the possible existence of undeclared activities.

The IAEA quickly realised, however, that the reforms, which were mostly only on a voluntary basis, were only capable of accomplishing a fraction of what was needed to be done to strengthen and improve the international safeguards system. So in May 1993, the then IAEA Deputy Director General Bruno Pellaud initiated a comprehensive reform of the safeguards system. Dubbed Programme 93+2, the reforms were aimed at improving IAEA safeguards so that verification covered the correctness and completeness of declarations by states in order to provide "credible assurances that no nuclear material is being diverted from declared activities and that no undeclared activities are taking place". Under seven tasks, Programme 93+2 worked toward three general themes, namely broad access to information, increased physical access, and a more optimal use of the existing (INFCIRC/153) measures.

Without going into the details here, the IAEA developed a set of measures to support the stated objectives of Programme 93+2. Following a legal review of the measures in 1995, it was determined that some of the measures contained in the proposal were capable of being implemented within the existing authority of INFCIRC/153 while other measures required extra or complementary legal authority. This marked the partitioning of Programme 93+2 into its constituent parts, namely Part 1 and Part 2 measures.

In June 1995, the IAEA Board recommended that those measures within the existing legal authority of INFCIRC/153, so-called Part 1 measures, be implemented as quickly as possible. Not surprisingly, as INFCIRC/153 focuses on nuclear material, many of the Part 1 measures are also associated with nuclear material, including the provision of information on past production of nuclear materials and a description of nuclear fuel cycle activities involving nuclear material. Part 1 measures also asked for information on and co-operation with the SSAC, simplified inspector designation procedures and multiple-entry visas for inspectors (which show up again later in the Additional Protocol), as well as the use of advanced safeguards technology in implementing existing comprehensive safeguards (including remote transmission of safeguards data). A new and significant technique introduced under Part 1 measures is environmental sampling, whereby swipe or vegetation/water samples are examined for the presence of radionuclides or other trace elements, during inspections at locations restricted under INFCIRC/153-type activities.

The Additional Protocol

While the IAEA proceeded with the implementation of Part 1 measures, Part 2 measures were deemed to require extra or complementary legal authority. Accordingly, a special open-ended committee, entitled "Committee on Strengthening and Improving the Efficiency of the Safeguards System", or simply "Committee 24" for short, was established by the Board on 14 June 1996 to develop the necessary legal authority for the IAEA to implement the Part 2 measures. The committee held its first set of meetings in July 1996 and

met again in October 1996 and in January and April 1997. Finally, in May 1997 a special session of the IAEA Board approved an Additional Protocol to Safeguards Agreements (INFCIRC/540) that serves as the legal instrument to implement Part 2 measures of Programme 93+2.

The Additional Protocol consists of a preamble, 18 articles and two annexes. While it includes articles relating to inspector designations and visas, as well as articles on communication systems and the protection of confidential information, the focus of the Additional Protocol is the augmentation of information reporting by the member states to the IAEA and expansion of physical access by the IAEA to nuclear-related activities within its member states.

Provision of Information

Articles 2 and 3 of the Additional Protocol describe the provision of information, including the scope of the information being requested and the timetables for submission. Whereas under the existing comprehensive safeguards system the provision of information related mainly to nuclear material, the Additional Protocol requests information on nuclear-related activities not involving nuclear material and greater information on those locations and activities presently under IAEA safeguards. The information from twelve sub-articles under Article 2 will be combined into one declaration for the state and submitted in accordance with the deadlines specified in Article 3. In order to assist member states in preparing the declarations, the IAEA has created a “Guidelines and Format Document for the Preparation and Submission of Information Pursuant to Articles 2 and 3 of the Additional Protocol”. This document promises to help state authorities greatly in preparing their submissions.

An important caveat has been placed on the provision of much of the information under Article 2, namely that verifying its accuracy should not be based on detailed nuclear material accountancy measures. This marks a departure from past practice, where safeguards were driven by quantitative nuclear material accountancy, to a new era where qualitative analysis assumes a greater responsibility.

Complementary Access

While Articles 2 and 3 deal with the provision of information, Articles 4–8 of the Additional Protocol provide the IAEA with enhanced physical access to its member states nuclear fuel cycle activities. In fact, an interesting relationship exists between Article 2 and Article 5 of the Additional Protocol: many locations included in the declarations pursuant to Article 2 become subject to access under Article 5. Article 4 describes the purpose of the access and Article 6 delineates the activities the IAEA may carry out when visiting the location. These provisions are discussed in detail below in regard to front-end activities.

It is important to note that the complementary access prescribed by Articles 4–8 is limited by a commitment not to seek mechanistically or systematically to verify the information included in Article 2.

The Additional Protocol and the Nuclear Fuel Cycle

While the starting point of safeguards as defined by INFCIRC/153, i.e. quantitative nuclear material accountancy, remains unchanged, the IAEA's scope of safeguards activities under the Additional Protocol now covers the whole nuclear fuel cycle, including locations and activities previously not subject to comprehensive safeguards. These include, but are not limited to, Zircaloy tube manufacturing plants, heavy water plants and the front-end of the nuclear fuel cycle. The Additional Protocol bestows extra reporting and access requirements for states with front-end activities.

Specifically, the Additional Protocol requires member states to report to the IAEA on:

- production capacity for each uranium/thorium mine and mill, for both operating and closed-down locations;
- current annual production for the state as a whole;
- upon specific request from the IAEA, actual production of an individual mine or mill.

This reporting requirement does not promise to be especially burdensome on member states, or their respective commercial industries, as the information that is being requested is already provided by many member states to the IAEA and OECD for the purpose of compiling the "Red Book" on uranium resources, production and demand. The difference is that the information will now be used by the IAEA for international safeguards purposes.

The Additional Protocol also requires member states to report to the IAEA on holdings of pre-safeguarded source material (U_3O_8 , UO_3 , etc.) whether in nuclear or non-nuclear use. Declarations on holdings are required for any location holding more than 10 tonnes of pre-safeguarded uranium source material (20 tonnes of thorium source material) or if the location is holding more than one tonne and the state as a whole has more than 10 tonnes of uranium (20 tonnes thorium) source material. While declarations on source material for nuclear uses should be relatively easy to compile, source material used for non-nuclear purposes (ceramics, paints, mantels, filaments, etc.) may require extra effort.

Furthermore, the Additional Protocol requests information on the export and import of pre-safeguarded source material for non-nuclear purposes, when exports/imports of uranium exceed 10 tonnes and when exports/imports of thorium exceed 20 tonnes. Recall that imports and exports of pre-safeguarded source material for nuclear uses are currently covered by INFCIRC/153-type safeguards agreements. Again, much of this information is already compiled by regulatory agencies, but it is now subject to use for international safeguards verification purposes.

Taken together, this information will contribute to the completeness of the IAEA's knowledge of all of the state's holdings of nuclear material and it will be used, in co-operation with the quantitative nuclear material accountancy information already provided to the IAEA, to assess the consistency of these holdings with the state's declared nuclear programme. The information will

also be cross-referenced with open-source material.

While completeness of knowledge is important, enhanced declarations on the front-end of the nuclear fuel cycle also expand the IAEA's physical access. Declarations under the Additional Protocol on the front-end of the fuel cycle as discussed above are subject to IAEA access "on a selective basis in order to assure the absence of undeclared nuclear material and activities". Two points bear mentioning here.

First, although no operational definition of "on a selective basis" has been offered by the IAEA, it can be considered in terms of the IAEA's current timeliness requirements for certain classes of nuclear material. At present, the IAEA uses the following timeliness guidelines:

- one month for unirradiated direct-use material, i.e. fresh fuel containing HEU, Pu or MOX;
- three months for irradiated direct-use material, i.e. spent fuel containing HEU or Pu;
- one year for indirect-use material, i.e. fresh fuel containing natural uranium, LEU or Th, and for direct-use material types with less than one significant quantity in inventory.

These timeliness guidelines translate roughly into the number of verifications required per year such that 12 per year are required for facilities handling the first category of material, four per year for the second category and one per year for the last category of material. Given that only one verification per year is required for facilities handling safeguarded indirect-use material, it is not presumptuous to assume that access under the Additional Protocol to front-end locations will not be guided by timeliness components of the material involved, and be more infrequent than one per year. In fact, it is conceivable that some locations may be subject to access requests once every couple of years and that others may go for three to seven years or longer without becoming subject to IAEA access requests.

Access requests will most likely be made by the IAEA to the state authority responsible for safeguards in the state. The IAEA is required to give 24 hours notice when requesting access under the Additional Protocol, except when it is performing routine/scheduled inspections under comprehensive safeguards agreements whereby the IAEA is required to give only two hours notice under the Additional Protocol before requesting access to another place at the location it is already inspecting. In either case, it is important that state authorities assist all locations that might become subject to access under the Additional Protocol in developing and documenting written procedures to allow for these periodic and infrequent access requests.

Second, the purpose of the access request is, as stated above, "to assure the absence of undeclared nuclear material and activities". This purpose stems from the two main proliferation risks for most front-end locations. The primary risk is that the location could be used to produce materials that could undergo further processing to produce materials for a nuclear explosive device. A secondary risk is that the location could be used to conceal activities and materials related to a clandestine nuclear weapons programme. In order to

interrogate these two risks, the Additional Protocol prescribes activities that may be carried out during IAEA access to front-end locations.

Unlike comprehensive safeguards implementation whereby the IAEA attains confidence in the state's holdings of safeguarded nuclear material stocks by performing systematic and mechanistic quantitative verification, confidence in the production of material at front-end locations will be obtained through means other than detailed material accountancy. An important element in the verification approach will be examination of records, especially those relevant to quantities, origin and disposition, held at the location and some item counting of nuclear material. In order to attain greater confidence in the records and the state's declaration for that location, the Additional Protocol also permits the IAEA to perform non-destructive measurements on material held at the location and to take samples of that material for destructive analysis.

In seeking to assure further that there are no undeclared materials or activities at the location, the Additional Protocol allows IAEA inspectors to use visual observation and to collect environmental samples throughout the location. Visual observation allows inspectors the opportunity to assure that the activities at the location are as declared by the state and that the location is not masking parallel production streams or other nefarious activities. The signatures obtained via environmental sampling are also meant to confirm the declared activities of the location.

The IAEA and its member states, including the Atomic Energy Control Board's Canadian Safeguards Support Program, are also investigating the use of commercial satellite imagery in the implementation of strengthened safeguards, including implementation at the front-end of the fuel cycle. Initial considerations are examining the use of commercial satellite imagery as an aid to on-site inspection activities, as a method of detecting changes and undeclared activities and as a means of confirming the declared activities of locations. The results of this analysis may reveal that successive images over successive years will continue to confirm Canada's declaration regarding the status of its front-end locations, particularly those that are closed-down or decommissioned, thus reducing the need for or the number of on-site visits by IAEA inspectors.

These verification activities are not, however, unlimited. The IAEA and its member states recognise the commercial competitiveness and proprietary nature of many of the activities, processes and information at the front-end of the fuel cycle. In this regard, the Additional Protocol contains two important measures, namely managed access and confidentiality provisions.

Article 7 of the Additional Protocol allows the state authorities to make arrangements with the IAEA for managed access "in order to prevent the dissemination of proliferation sensitive information, to meet safety or physical protection requirements, or to protect proprietary or commercially sensitive information". Managed access is not new to safeguards and is used in many other verification environments. Traditionally, it has included:

- shrouding sensitive displays, stores and equipment;
- allowing only limited visibility of sensitive items;
- restricting measurements to those relevant for the purpose of the inspection;

- restricting sampling to that relevant for the purpose of the inspection;
- removing sensitive papers from offices;
- logging off computers;
- restricting access to particular locations/areas.

While these managed access techniques may be used to protect confidential information, they cannot be used to limit the ability to draw proper verification conclusions. Moreover, managed access under the Additional Protocol will work best when the reasons and techniques behind the managed access proposals are properly communicated to the IAEA well in advance of any access request.

Article 15 of the Additional Protocol also places an obligation on the IAEA to maintain “a stringent regime to ensure effective protection against disclosure of commercial, technological and industrial secrets and other confidential information”. Of course, this is not a new obligation. It follows current practice under INFCIRC/153 where the IAEA keeps confidential all of the accounting and inspection reports generated in implementing comprehensive safeguards agreements. The IAEA’s confidentiality regime is, however, being augmented and supplemented to manage the increased scope and quantity of information being submitted by its member states under the Additional Protocol.

Next Steps

The implementation of the Additional Protocol marks the most significant change in international safeguards since the inception of INFCIRC/153 and the onset of comprehensive safeguards in the early 1970s. It marks the beginning of a new era: a consolidation of quantitative and qualitative techniques into one safeguards system.

Many of the activities and locations covered by the Additional Protocol have not previously been subject to international inspection for safeguards purposes. As such, the learning curve will be steep over the next few years for all parties concerned. As the IAEA works toward managing its new responsibilities, the state authorities and affected industries will have to become familiar with their new obligations.

This is particularly true of industries operating at the front-end of the nuclear fuel cycle. Minimally, there will be new reporting obligations and the need to develop access procedures to accommodate complementary access requests under the Additional Protocol. Additionally, there will be opportunities to contribute to the development of this new safeguards system. The nuclear industry should take advantage of this opportunity to share experiences and to suggest methodologies for implementing these new techniques in an effective and efficient manner.

For example, the IAEA Secretariat has indicated its intentions that the new measures provided for by the Additional Protocol should not be implemented in an incremental manner by simply being added on top of the existing INFCIRC/153 measures. The Secretariat, with Board support, has announced a goal of “cost-neutrality” with regard to the expense of implementing the new

“integrated” safeguards system. This implies that certain classical quantitative safeguards measures, particularly on less sensitive nuclear materials, can eventually be relaxed as a result of the greater assurances provided by the new system of the absence of undeclared nuclear activities.

In any event, only by working together on developing and then implementing the new safeguards system — industry, state authority and IAEA — can we fulfil the obligations of Article III of the NPT and thereby the ambition of Article IV: the fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy.

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