IAEA Safeguards Evolution Retrospective

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ABSTRACT

This paper on the evolution of IAEA safeguards was stimulated by Confucius's saying (*1*): "*Study the past, if you would divine the future*," or in more modern terms, "*To decide where to go, it is good to know where you have been*." The author has been involved with the evolution of safeguards since the beginning of his career at IAEA in Vienna in the Office of Deputy Director General for Safeguards Peter Tempus in 1985. Over the period of his involvement in international safeguards, the author has made 32 presentations and publications. Nineteen were at INMM Annual Meetings, six in the INMM Bulletin, three were at ESARDA Annual Meetings, and four were publications and presentations at IAEA. They addressed a wide range of international safeguards topics: safeguarding nuclear fuel cycle facilities, the IAEA Safeguards Criteria, containment and surveillance, termination of safeguards, the New Partnership Approach, compliance under the NPT, transparency and openness in safeguards, safeguards technical parameters, Small Quantities Protocol, timely detection, and, mainly, the continuing evolution of safeguards. This paper is a review of and commentary on the evolution of IAEA safeguards based on those presentations and publications, addressing IAEA safeguards criteria, strengthened IAEA safeguards, integrated safeguards, dealing with compliance, further directions for evolution of IAEA safeguards, state level safeguards, and "*Sixty Years On, Time for Reflection on IAEA Safeguards?"* (*2*). Highlights and the relevance to IAEA safeguards today are presented. The references to all presentations and publications are given for interested persons.

1. *Analects of Confucius*
2. James A. Larrimore, "*Sixty Years On, Time for Reflection on IAEA Safeguards?",* INMM Annual Meeting, July 14-18, 2019, Palm Desert, CA

Introduction

Safeguards '*established and administered'* by the International Atomic Energy Agency (IAEA) have continued to evolve since their beginning in the Atoms for Peace era.
IAEA safeguards has never stood still for any lengthy period. It has continued to evolve to take into account new nuclear facilities under safeguards, new safeguards instrumentation and verification methods, new thinking about how safeguards effectiveness and efficiency could be improved, and modifications to safeguards agreements.

I have been involved with this evolution since I joined the IAEA Safeguards Department in 1985, continuing up to today. Over the course of this period, I made 32 presentation and publications on international safeguards, at INMM Annual Meetings and in the INMM Journal, at ESARDA Meetings and in IAEA publications. The 25 directly related to the evolution of safeguards are listed as References. They can be seen to have covered a wide spectrum of international safeguards with the main topic being the continuing evolution of IAEA safeguards, from the introduction in 1991 of the Safeguards Criteria 1991-1995 through the introduction of integrated safeguards, to the current state-level safeguards. This paper presents a retrospective on the evolution of safeguards based on my publications, with "reflections" on the situation today for international safeguards.

The Safeguards Starting Points

1. The IAEA may "*apply safeguards at the request of the parties, to any bilateral or multilateral arrangement, or at the request of the parties…"* – IAEA Statute III.A.5
2. "*Each [NNWS party] undertakes to accept safeguards as set forth in an agreement to be negotiated and concluded with the [IAEA] … for the exclusive purpose of verification of the fulfillment of its obligations under [the NPT]*…" - NPT Article III.1

Under those two legal bases, by 1985 when I began my involvement with international safeguards, IAEA was applying safeguards under three types of agreement: under the first., so-called item specific safeguards (INFCIRFC/66-type agreements) and so-called Voluntary Offer agreement safeguards with the NPT nuclear weapon states; and under the second., NPT safeguards (INFCIRC/153 agreements). The majority of IAEA safeguards is NPT safeguards.

Over time, NPT safeguards have evolved, so that today one can say that IAEA is applying five cases of safeguards:

1. INFCIRC/66-type safeguards [in three countries],
2. Voluntary Offer safeguards [in five countries],
3. NPT comprehensive safeguards (INFCIRC/153) [in ten countries],
4. NPT comprehensive safeguards with Additional Protocol (INFIRC/540)
5. Fact-based compliance concern cases.

The paper reviews how IAEA safeguards has evolved into these five cases. An initial word about the fifth case. Regrettably, there have been five such cases: Iraq, DPRK, South Africa, Libya, Iran. Without question, these have been the most important challenges for IAEA safeguards.

IAEA Safeguards Criteria

When Jon Jennekens became Deputy Director General for Safeguards in 1987, he recognized the need to bring more consistency to NPT safeguards implementation around the world. He established a project to develop safeguards criteria to be applied uniformly throughout the Safeguards Department. He appointed Dimitri Perricos to head the project. and me as project Technical Secretary. In 1987 I was still learning the business, so initially my principal contribution was in developing the detailed structure and language of the criteria. We took three years to do the job and the product proved itself to be well done, if I say so myself.

Under the IAEA Safeguards Criteria, comprehensive, non-discriminatory facility level safeguards were formalized in 1991. The safeguards criteria were designed to cover cases 1, 2 and 3 safeguards agreements – NPT, but also INFCIRC/66 and Voluntary Offer. The Safeguards Criteria specified the activities that the Agency considered necessary to meet its obligations under those safeguards agreements and to draw safeguards conclusions.

Having served as the Technical Secretary for the development of the IAEA Safeguards Criteria 1991-1995, and then as Chair of the Criteria Working Group up to 1999, I presented five papers on the safeguards criteria, in 1993, 1996, 1997, 2011 and finally in 2023.

In 1993 I published an article in the INMM Journal titled "*Experience with the IAEA Safeguards Criteria*," [23], which described the scope, structure and use of the criteria, the

general principles behind IAEA verification requirements, and the first two years of implementation experience, in particular the positive experience with the use of certain procedures (e.g., zone approach, dual C/S) but the slower-than-anticipated implementation of other procedures (e.g., randomization of domestic transfer verification).

In a presentation at the 1996 INMM Annual Meeting titled "*IAEA Safeguards Criteria 1991-1995: Where Do They Stand in 1996*." [19] I reported that the Criteria had been serving their functions well as both implementation and evaluation criteria, and that the period of their application had been extended through 1997. Some refinements had been made in the Criteria to take account of the experience and of new developments in the areas of light water reactors, dual C/S, zone approaches and safeguards at small facilities. And plans for a further evolution of the criteria in 1997 were presented.

Member States continued to exert pressure to increase the efficiency of IAEA safeguards, especially NPT states with large nuclear programs that felt they were being over inspected. From the IAEA side there was a continuing push to increase effectiveness. There was particular attention to safeguards in the countries in EURATOM. Euratom safeguards had begun before IAEA safeguards and a competition between inspectorates had developed. The focus was on how to implement INFCIRC/153 paragraph 7 that states: "…*the Agency to verify…findings of the State's system. The Agency's verification shall include, inter alia, independent measurements and observations*…" Happily, good will prevailed and led to introduction of a more efficient "*New Partnership Approach*." One can say that, to the NPT safeguards "species" (Case 3), this added an important "subspecies," *NPT safeguards in the EU*. At the 1997 INMM Annual Meeting, I made a presentation focused on that evolution in IAEA safeguards implementation in the Euratom countries and suggested its possible application elsewhere, titled "*Directions for Improving IAEA Safeguards Cost Effectiveness: Wider Application of Procedures Developed for the New Partnership Approach*." [17]

In November 2010, the new Deputy Director General for Safeguards in his opening statement at the IAEA Symposium on International Safeguards presented "information driven" as the direction for the further evolution of IAEA safeguards. In response, I presented a paper titled "*The IAEA Safeguards Criteria: Historical perspective on moving to more information driven safeguards*", [6], at the 2011 INMM Annual Meeting. The paper provided historical perspective on IAEA safeguards under the Safeguards Criteria on which IAEA safeguards implementation had been based for two decades, and addressed the criticisms of over-prescription and inflexibility. The aim was to assist the international safeguards community in understanding and evaluating the development of what the DDG-SG had termed "information driven" safeguards.

Most recently, at the 2023 Joint INMM/ESARDA Annual Meeting in Vienna, I presented a paper titled "*The IAEA Safeguards Criteria: Everything you might like to know but didn't know who to ask*." [1] I noted that the Safeguards Criteria continue in use, e.g., in States with INFIRC/66-type safeguards agreements. The paper once again countered the criticism of the safeguards criteria. It pointed out that the Iraq, DPRK and Iran earthquakes in the nonproliferation world had made clear that the Safeguards Criteria were suited to NPT States that wanted to and were abiding by their NPT obligations but were not enough for fact-based compliance concern cases. Nevertheless, the paper suggested how the safeguards criteria can be relevant for todays and future safeguards, in particular for the case of Iran.

Strengthened IAEA Safeguards

Discovery of a clandestine nuclear weapon program in Iraq resulted in a major evolution of the IAEA safeguards system. Programme 93+2 defined safeguards measures that could strengthen the effectiveness while improving the efficiency of IAEA safeguards. The IAEA Board of Governors in 1995 approved new strengthening measures under existing legal authority, and the IAEA began to implement a "*Strengthened Safeguards System,*" applicable to NPT States.

The Board in 1997 approved a new legal instrument, the "*Model Additional Protocol to Safeguards Agreements*" (AP), published as INFCIRC/540. This improved the IAEA's ability to detect undeclared nuclear material or activities associated with a nuclear weapon program. The AP provides the legal basis for important strengthening measures. However, adoption of the AP by States is voluntary.

I presented a paper at the 1999 INMM Annual Meeting, [16], reflecting on how IAEA safeguards had gone through a major new phase since the discovery of a clandestine nuclear weapon program in Iraq in 1991. The paper presented views on the evolution of IAEA safeguards to effective implementation of a Strengthened Safeguards System, with continued integration of new technology into safeguards and adaptation of safeguards to a "State" orientation with consequent optimization of resource utilization.

Those views were expanded upon in a paper reflecting on the start of a new millenium presented at the 2000 INMM Annual Meeting [14]. Objectives and responsibilities for the improvement of international safeguards for the next decade were elaborated. Key issues were: the IAEA safeguards system should evolve to meet the expectations of States; what States expect from IAEA safeguards must be balanced by what States do for IAEA safeguards; the new safeguards responsibilities of the IAEA are to be balanced by its commitment to contain the cost of safeguards; and the IAEA must strengthen and optimize safeguards with the cooperation and assistance of States. Discussed were several fundamentals of the effective implementation of a Strengthened Safeguards System and its optimization through the integration of safeguards measures. This paper also suggested the establishment of a general structure for IAEA safeguards goals in the new millennium, which would cover the different types of safeguards obligations undertaken by States under their safeguards agreements.

Integrated safeguards

The adoption in 1997 of the AP had major consequences. States that had put an AP in force expected that the Agency would make an annual statement that such States were in full compliance with their obligations, i.e., they were not conducting nuclear weapon activities. The Agency established a process to support such an annual statement that there were no undeclared nuclear material or activities in a State. This was the so-called "broader conclusion." It was an addition to the conclusion that diversion of declared nuclear material had not occurred, which was the safeguards conclusion drawn for NPT States without an AP in force.

After the IAEA had drown for the first time a broader safeguards conclusion that there was no evidence of undeclared nuclear activities, the State moved into a new category in which the Agency implemented "*integrated safeguards*". This, in effect, established a new non-proliferation goal for NPT non-nuclear weapon States: *getting to integrated safeguards*. And that introduced the fourth type of IAEA safeguards, the combined implementation of INFCIRC/153 and INFCIRC/540.

At the end of 1999, my status in the IAEA Department of Safeguards changed from IAEA staff member to Consultant to the Director, Concepts and Planning Division, where I was directly involved in the conceptual planning of the evolution of safeguards during the following decade. One of the early accomplishments was the introduction of the phrase "*differentiation without discrimination*" as a guiding principle.

I presented a paper at the 2002 INMM Annual Meeting [13] which reviewed the conceptual basis for implementing strengthened safeguards and integrated safeguards as effectively and efficiently as possible with constrained resources, addressing facility focus and State focus, and detection goals. The paper concluded with reflections, a decade after Iraq, on the major evolution that was taking place in international safeguards.

A paper presented at the 2004 INMM Annual Meeting was titled "*Getting to integrated safeguards: The new nonproliferation compliance standard*" [11]. NPT States with significant nuclear activities and good non-proliferation credentials would be going through the transition to integrated safeguards. To solidify the new compliance standard in the non-proliferation regime, it was important that this transition proceeded well and in a timely manner. Completing that transition had been found to be complex, both for the Agency and the State. That paper focused on what was involved for a State and for the Agency in getting to integrated safeguards. It was noted that the Agency considered it important to be very careful, after the revelations of undeclared nuclear activities in NPT States Iran and Libya in 2003 and 2004,

Fact-based Compliance Concern Cases

The Iraq and North Korea cases brought to the fore the most important situations that IAEA safeguards had to deal with – noncompliance with safeguards (and NPT) obligations. Those cases raised media and public awareness of the IAEA inspection process for verification under the NPT and concerns about further States developing nuclear weapons. Then, questions arose about Iran's compliance with its NPT obligations. That introduced the fifth case of IAEA safeguards, when there are fact-based concerns about the compliance of a State. A paper I presented at the 2003 INMM Annual Meeting [12] stated that "it is timely and important to hold a broad and full discussion of international safeguards and compliance under the NPT, addressing the interests and expectations of the large majority of States that are in full compliance with their NPT obligations and the effectiveness of procedures for handling suspicions about compliance." The paper proposed that "strengthening of the non-proliferation regime should include explicit recognition of the necessity for IAEA to deal with fact-based compliance concern cases. "Establishing the ability of IAEA to handle such cases competently and firmly but legally would enhance the confidence of governments in international verification, while it discouraged non-compliance and provided for better long-term assurances." Two decades later, this call for action remains valid.

The 2003 paper dealt in detail with the unfolding compliance concern with Iran. In response to Agency inquiries, the People's Republic of China had confirmed in late 2002 its supply in 1991 of natural uranium to Iran. The IAEA Director General reported to the Board in early June 2003 Iran's failure to report the import of 1800 kilograms of uranium, its subsequent processing and use, and to declare the facilities where the material was stored and processed. Further, he gave details about the two uranium enrichment facilities under construction. In its June 2003 meeting, the Board, as a confidence-building measure, encouraged Iran not to introduce nuclear material at the pilot enrichment plant. The Board urged Iran to promptly and unconditionally conclude and implement an Additional Protocol to its Safeguards Agreement. The Board called on Iran to

cooperate fully with the IAEA. The Board did not at that time declare Iran in non-compliance with its NPT obligations.

The 2003 paper [12] stated "the case of Iran has highlighted the central significance of the Additional Protocol. On the one hand, the protocol helps the IAEA to provide better assurances of compliance; on the other hand, it offers the State a very convincing opportunity to demonstrate its non-proliferation credentials. In this respect, the Additional Protocol should as soon as possible be embedded in the export regime, and indeed become a condition for the supply of nuclear materials and equipment." The 2003 paper also stated "Iran raises a fundamental issue: whether a country may under the NPT engage in advanced nuclear activities, including uranium enrichment and nuclear technologies relevant to plutonium production, as long as these are under IAEA safeguards and not intended to make weapons. Stated more directly, "can a country *'keep within NPT rules, while developing all the skills and expertise it needs for a sudden breakout?'* New ground is being broken, and careful consideration is needed of the interacting technical, economical, legal and political facets of this conundrum." All of that rings true two decades later.

At the 2008 INMM Annual Meeting, the fact-based compliance concern with Iran was again addressed in a paper titled "*Compliance and Transparency Revisited: Iran and the IAEA.*" [10] It was noted that Iran stood out as the longest unresolved compliance case of an NPT signatory State - then extending over two decades. The paper reviewed how the Iran case had been handled. Based on reports by the Director General, the IAEA Board of Governors issued seven resolutions on Iran between 2003 and 2006. In 2005 the Board declared Iran to be in non-compliance. That was automatically reported to the UN Security council, which issued two resolutions in 2006 and one in 2007. The IAEA and UNSC resolutions requested Iran to go beyond its obligations under its safeguards agreement and undertake confidence building measures. That eventually led to negotiations between the P5, Germany, the EU and Iran and to the Joint Comprehensive Plan of Action (JCPOA in 2015, which the UN Security Council mandated IAEA to implement through its resolution 2231 (2015). Following the U.S. withdrawal from JCPOA in 2019, there has been an increasing lack of cooperation by Iran with the IAEA that remains to be overcome.

Further directions for evolution of IAEA safeguards

With the strengthened safeguards assurances for States having in force an NPT safeguards agreement with an Additional Protocol, a reasonable question to ask was whether further differentiation in how States are treated in safeguards implementation could be introduced without discrimination. What reorientation of safeguards implementation might be done and how?

A paper titled "*Safeguards Technical Parameters: Directions for Evolution*", [8], was presented at the 2009 INMM Annual Meeting and published in the Summer 2009 INMM Journal. Noting that safeguards implementation was largely determined by the basic safeguards technical parameters, which include significant quantities, detection probabilities, timeliness goals and nuclear material types, the paper explored possible directions for the evolution of safeguards technical parameters to be applied in future state-level safeguards, focusing on NPT States under integrated safeguards while taking account of implementation under the other types of safeguards agreement. A reformulation of the technical objective of safeguards for NPT States under integrated safeguards was suggested. A modification of the timeliness goal for low

enriched uranium was suggested for NPT States not under integrated safeguards and for non-NPT States. Redefinitions of natural uranium and plutonium nuclear material types were suggested for NPT States under integrated safeguards. The objective of these suggestions was to stimulate consideration of introducing further differentiation in safeguards implementation for different safeguards situations without discrimination. Those suggestions could still be taken up.

A paper at the 2011 INMM Annual Meeting [5] presented the results of a meeting in November 2010 organized by the INMM International Safeguards Division to review the results of the 2010 IAEA Symposium on International Safeguards. Building stakeholder confidence in IAEA safeguards was considered to be an important challenge, for which communication with all involved parties was important. There was a wish to see quick progress in the further development of the state-level concept, which should be intertwined with making safeguards more information driven and improving cooperation between the IAEA and States and State and regional safeguards systems (EURATOM, ABACC). Improving capability to detect undeclared nuclear activities was a priority area, including enhancing environmental sampling and developing new technologies. To assist the development of IAEA safeguards for complex nuclear facilities and new nuclear technologies, emphasis should be placed on promoting Safeguards by Design.

State level safeguards

INFCIRC/153 states the "*objective of safeguards*" as "*the timely detection of diversion of significant quantities*" of nuclear material. The principal goal of safeguards should be for IAEA inspectors to provide "*early warning*" to the IAEA Board of Governors, to give governments time to act "*with a view to preventing diversion*" and possible "*breakout*" to produce a nuclear explosive device. As the transformation of integrated safeguards into "state level safeguards" was starting. I presented my views on timely detection in a paper at the 2013 INMM Annual Meeting titled "T*imely Detection Under the State-Level Concept*." [4] I believed that external stakeholders would like to understand and perhaps provide input on how timely detection, a major factor in inspection frequency, would be implemented under the state level concept. The paper made proposals for how to include timely detection in the state-level concept, considering both safeguards objectives of detection of undeclared nuclear activities and detection of diversion.

The timeliness goals established in the 1970s based on advice from the Director General's Standing Advisory Group on Safeguards Implementation (SAGSI) had been maintained for 40 years, except for a modification made in introducing 'integrated safeguards'. There, the timeliness goal for spent fuel at reactors was increased from 3 months to a year, under the assumption that clandestine preparations for spent fuel reprocessing would likely be detected.

In introducing the state-level concept, timely detection of diversion could be dealt with more flexibly. But, the IAEA was listing timely detection of undeclared nuclear activities as its first state-level safeguards objective. To accomplish that, the IAEA had acquired an impressive toolkit of measures. These included environmental sampling at sites; evaluation of commercial satellite imagery; collection, analysis and evaluation of a wide range of 'open sources' of information, and complementary access and environmental sampling elsewhere in those states with an additional protocol. Tough questions were raised about this shift in focus towards undeclared activities. Was there an equivalent to the '*technical objective of safeguards'* for diversion of declared nuclear material? What basis could be used to establish how frequently

safeguards evaluations regarding undeclared nuclear material and activities should be made, and therefore, how frequently those measures should be employed? Was there a legally justified basis for setting timely detection goals for detection of undeclared activities, which would garner support of governments?

Some principles were proposed for timely detection under the state-level concept. It was suggested that activities in state-specific safeguards approaches should be aimed at providing "*early warning'* of nuclear weapon capability development. Emphasis should be placed on timely detection goals for detection of diversion of plutonium and uranium and "*early warning*" of misuse of a declared facility for nuclear weapon development. In addition, timely detection goals would need to be set for the NPT nuclear weapon States and the non-NPT States if and when the state-level concept was extended to them.

Conclusions

At the 2019 INMM Annual Meeting, a paper titled "*Sixty Years On, Time for Reflection on IAEA Safeguards?" [2] reviewed* how over the sixty years of INMM's existence IAEA safeguards had continually evolved, as described in this paper. As a result, for an NPT state, the desired safeguards conclusion drawn by the IAEA became no longer '*no indications of diversion of declared nuclear material from peaceful activities*." Desired is the additional conclusion for NPT states with an Additional Protocol in force and the 'broader conclusion' drawn that there were '*no indications of undeclared nuclear material or activities*,' which IAEA now expresses as "*all nuclear material is in peaceful uses.*"

A companion presentation at the 2019 ESARDA Symposium titled "*Fifty Years On, Time for a New NPT Standard*?" [3] reviewed how over the fifty years of ESARDA's existence the effectiveness and efficiency of NPT safeguards had increased through technological advances, experience with fact-based compliance concern cases, and through modifications to safeguards agreements

IAEA Director General Blix stated after Iraq's clandestine program came to light that the IAEA needed more information and more access to provide assurance about the State's nuclear activities. In response, IAEA Member States negotiated an Additional Protocol (AP), which does provide IAEA with more information and more access. For NPT States that adopted the AP, the broader safeguards conclusion was introduced.

Of the 174 States with which IAEA has NPT safeguards agreements, one hundred States have limited nuclear activities and therefore initially had a Small Quantities Protocol to their safeguards agreement. As a strengthening measure, a Modified Small Quantities Protocol was introduced and has been adopted by most states.

To codify these two important developments, I proposed in 2019 that it was time to formally recognize a nonproliferation norm - a new "***NPT Safeguards standard***". That standard would include the Additional Protocol as a necessary component for all NPT States, and the Modified Small Quantities Protocol for relevant NPT States. I renew that call today: **A new NPT Safeguards Standard should be formally recognized.** For a State that does not meet that standard, the IAEA should not draw the safeguards conclusion that "*all nuclear material is in peaceful uses*."

To conclude, considering the experience gained with NPT safeguards as well as with safeguards under INFCIRC/66 agreements, under Voluntary Offer Agreements with the NPT

nuclear weapon States, and the experience gained from the compliance concern cases, I repeat my statement of 2019 that IAEA safeguards are robust, mature and tested. Today IAEA continues to face a serious challenge with the long-standing Iran compliance concern case. That case must be resolved to uphold the international nuclear nonproliferation regime.

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