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# The IAEA's Safeguards System as the Non-Proliferation Treaty's Verification Mechanism

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## SUMMARY

The Treaty on the Non-Proliferation of Nuclear Weapons (NPT) is the cornerstone of international efforts to stop the proliferation of nuclear weapons. The International Atomic Energy Agency (IAEA) safeguards system fulfills a vital role underpinning the NPT, reinforcing commitments to the non-proliferation of nuclear weapons and providing confidence that nuclear energy is used for exclusively peaceful purposes. Effective safeguards also are essential for achieving a nuclear-weapon-free world. This paper explores how the IAEA safeguards system was created, its accomplishments and challenges, issues remaining in flux, and possible future directions.

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*We dedicate this paper to the memories of our dear colleagues Roland Timerbaev and George Bunn. They made enormous contributions to non-proliferation and arms control, especially in the negotiation of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT); it is very much due to their efforts that the NPT assigns the International Atomic Energy Agency explicit verification responsibilities. Bunn and Timerbaev set an outstanding example of what can be achieved in this area when Russia and the United States are able to work together. Reducing the risk of nuclear war is absolutely crucial to humanity's future. The example of Bunn and Timerbaev should inspire all of us to do our utmost in support of constructive engagement on these issues.*

### **About the Nuclear Threat Initiative**

NTI is a nonprofit global security organization focused on the reducing nuclear and biological threats imperiling humanity. [www.nti.org](http://www.nti.org)

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Safeguards analysts combine multiple sources of information, including satellite imagery, on a data wall, to guide inspectors in searching for potential undeclared nuclear activities. Photo: D. Calma, IAEA.

## Introduction

This year marks the 50th anniversary of the entry into force of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and the 63rd anniversary of the founding of the International Atomic Energy Agency (IAEA). The NPT is the cornerstone of international efforts to stop the proliferation of nuclear weapons. This treaty provides assurance that nuclear energy is being used for peaceful purposes and requires parties to pursue the elimination of nuclear weapons. The treaty gives the IAEA the responsibility of verifying the commitments made by treaty parties with respect to nuclear material. Non-nuclear-weapon states parties are required to conclude safeguards agreements with the IAEA for this purpose. The IAEA safeguards system has a vital role in supporting the NPT and, through the treaty, international peace and security.

In this paper, we explore how the IAEA safeguards system was created, its accomplishments and challenges, issues that remain in flux, and possible future directions. We write as independent experts—from Australia, Russia, and the United States respectively—and the views we express are our own. Together, we have a century of collective experience, both from outside the IAEA, ensuring that the safeguards system meets the wishes and intentions of the international community, and from inside, helping to shape the inner workings of the safeguards system. We write as a joint undertaking, reflecting our personal perspectives and recollections.

The term *safeguards* is not defined in the IAEA Statute, nor in the NPT, nor in the safeguards agreements concluded between the IAEA and its member states. As noted in this paper, an IAEA information circular

(INFCIRC/26) contains a definition referring to “measures pursuant to the Statute to prevent loss or diversion of materials,” and so forth.<sup>1</sup> Since then, safeguards have come to mean the system of legal, organizational, and technical measures applied to verify political commitments made by states, principally pursuant to the NPT, not to use nuclear energy to produce nuclear weapons. This is commonly referred to as a *peaceful use commitment*, though as will be discussed, the NPT does not proscribe military use provided that it is non-explosive (such as for naval propulsion). These peaceful use commitments are given legal expression through international agreements, the principal such agreement today being the NPT.<sup>2</sup>

At a technical level, safeguards comprise measures to detect, identify, characterize, and quantify nuclear material and to assess the peaceful nature of nuclear activities. In the case of IAEA safeguards, these measures are applied by the IAEA as a multilateral inspectorate, in cooperation with national authorities. Today, routine verification of safeguards agreements concluded pursuant to the NPT represents the IAEA's main verification effort.

## Origins of Safeguards

The first international expression of the concept of nuclear safeguards is found in the Agreed Declaration Relating to Atomic Energy<sup>3</sup> issued by the leaders of the United States, United Kingdom, and Canada in November 1945. Following the destruction of Hiroshima and Nagasaki in 1945, the need for effective control over the future development of nuclear energy for civilian use became a subject of the highest priority, prompting this declaration.

The declaration referred to collaboration in developing applications of atomic energy for peaceful and humanitarian purposes but emphasized the need to devise “effective enforceable safeguards against its use for destructive purposes.” To this end, the declaration called for the establishment of an Atomic Energy Commission to make proposals, *inter alia*, for “effective safeguards by way of inspection and other means to protect complying states against the hazards of violations and evasions.”

At the same time the declaration recognized that:

the only complete protection for the civilized world from the destructive use of scientific knowledge lies in the prevention of war. *No system of safeguards that can be devised will of itself provide an effective guarantee against production of atomic weapons by a nation bent on aggression.* (emphasis added)

When the United Nations first met in January 1946, one of the first issues it considered was how to ensure the effective control of nuclear energy. However, political differences at that time were such that it was not possible to reach agreement on an international organization for this purpose. Accordingly, the practical development of safeguards began on a bilateral basis, through states exporting nuclear materials and technology—research reactors and other facilities, nuclear components, and so on—requiring importing states to declare that the imported items were intended for exclusively peaceful use. Some exporters sent national inspectors to confirm that the supplied items were indeed being used for peaceful purposes.<sup>4</sup>

From their beginnings with inspector visits, bilateral safeguards evolved to include (a) nuclear material accountancy procedures and findings and (b) verification by inspectors of the amounts and characteristics

of the nuclear materials through sampling for analysis at a laboratory in the exporting state and through measurements the inspectors were able to carry out at the facilities. These early practices thus laid the foundations for the future IAEA safeguards system.

## Establishment of the IAEA

The IAEA was created as a result of U.S. President Dwight Eisenhower's "Atoms for Peace" speech to the United Nations General Assembly on December 8, 1953, calling for promotion of peaceful uses of atomic energy and the creation of an international atomic energy agency to oversee such uses.<sup>5</sup> The IAEA was established in 1957.

The IAEA was given a dual mission—to promote and to control the atom. On the latter aspect, the IAEA Statute authorizes the agency

To establish and administer safeguards designed to ensure that special fissionable and other materials, services, equipment, facilities, and information made available by the Agency or at its request or under its supervision or control are not used in such a way as to further any military purpose; and to apply safeguards, at the request of the parties, to any bilateral or multilateral arrangement, or at the request of a State, to any of that State's activities in the field of atomic energy.<sup>6</sup>

As the IAEA began to develop its safeguards system, the states involved in bilateral inspection arrangements began to transfer those activities to the agency.

## Adopting IAEA Safeguards as the NPT Verification Mechanism

Negotiations on the NPT began in 1965.<sup>7</sup> During the negotiations the IAEA agreed to accept the verification responsibilities envisaged under the treaty. The NPT was concluded in 1968 and entered into force in 1970.<sup>8</sup> Following the NPT's entry into force, the IAEA embarked on a process of extending and adapting the agency's safeguards system to meet the new responsibilities required by the treaty.

The safeguards system predating the NPT continues in force, although most of the pre-NPT safeguards agreements have been subsumed under new NPT safeguards agreements. Since its inception, the agency's safeguards system has evolved to meet the growing demands placed on it by the international community. Many changes grew organically out of implementation as the nuclear industry evolved and as safeguards verification technologies expanded in scope and effectiveness.

# The IAEA Safeguards System Prior to the NPT from 1959 to 1972

Almost immediately after the establishment of the IAEA and its secretariat in 1957, the secretariat commenced activities “to establish and administer safeguards,” as authorized by the IAEA Statute.<sup>9</sup>

The first ad hoc safeguards procedures were adopted in 1959 for the JRR-3 research reactor in Japan, which was fueled with Canadian uranium supplied through the IAEA.<sup>10</sup> These procedures specified the reports and inspections required until the JRR-3 reached criticality. This was the first practical application of IAEA safeguards procedures.

Based on this experience the secretariat prepared a draft of general principles and procedures for IAEA safeguards that was provisionally approved by the IAEA Board of Governors, also in 1959.<sup>11</sup> The draft document defined, among other things, the types of technical assistance and nuclear and other material to which IAEA safeguards should be applied. At that time, the agency had initiated research work on non-destructive measurement of irradiated nuclear fuel for the purpose for maintaining accurate safeguards records.

Finally, on January 31, 1961, the Board of Governors approved the IAEA's safeguards system. This was published for the information of all IAEA member states in INFCIRC/26. INFCIRC/26 described the first version of the IAEA safeguards system developed to meet the requirements specified in the IAEA Statute.

These safeguards were to apply to nuclear material and nuclear facilities as well as non-nuclear material and equipment (referred to as “items”) and technological information, supplied to a state by or with the assistance of the agency under “project agreements.” The IAEA Statute also provided for safeguards to apply at the request of the parties to a bilateral or multilateral arrangement or at the request of a state.

The state concerned was required to conclude an agreement with the IAEA setting out the state's obligation not to use nuclear material or items to which safeguards apply in such a way as to further any military purpose, the agency's responsibility to verify the state's compliance in this undertaking, and the procedures for enabling the agency to do this.

INFCIRC/26 did not contain a model safeguards agreement; the document sets out the general principles and procedures that were to be further detailed in individual safeguards agreements.

This first version of the safeguards system was developed for nuclear reactors with less than 100 megawatts thermal (MWth) output and the nuclear materials used and produced in these reactors.<sup>12</sup>

We will now discuss the most important definitions, principles, and procedures of the first version of the safeguards system that influenced its further development and evolution.

**Agency safeguards:** *Agency safeguards* as defined in INFCIRC/26 were

the measures pursuant to the Statute to prevent loss or diversion of materials, specialized equipment or principal nuclear facilities.<sup>13</sup>



INFCIRC/26 also distinguished between *attachment of safeguards*, meaning a safeguards obligation would “attach” to supplied items (which later evolved into the term *subject to safeguards*) and *application of safeguards*, which meant implementation of the relevant safeguards procedures.

**Principal nuclear facility:** The term *principal nuclear facility* was used to refer to reactor facilities, reprocessing and fuel fabrication plants, isotope separation plants, and other facilities designated by the Board of Governors. (This term evolved into the term *facility*, as used in safeguards agreements based on INFCIRC/153, which is discussed later.)

**Diversion:** *Diversion* was defined as

the use by a recipient State of fissionable or other materials, facilities or equipment supplied by the Agency so as to further any military purpose or in violation of any other condition prescribed in the agreement between the Agency and the State concerning the use of such materials, facilities or equipment.<sup>14</sup>

Those definitions allow us to discuss the system's operation. IAEA inspectors should be able to detect misuse of the items to which safeguards are attached (i.e., the items subject to safeguards). Those items were, at that time, mostly reactors and reactor fuel. As regards detection of possible misuse of reactor fuel, as long as inspectors can confirm that the fuel remains within the reactor facility, they can conclude that the nuclear material contained in the fuel has not been diverted from peaceful use in the reactor. Detecting undeclared removal of the fuel would mean possible diversion—that is, non-compliance of the state with its undertakings under the agreement.

As regards detection of possible misuse of the reactor, if the reactor is used to produce plutonium by inserting undeclared uranium into or around the reactor core, then this misuse would also constitute an act of diversion according to the definition of that term, and the state would be acting in non-compliance with its agreement.

## Non-Compliance

The IAEA Statute gives inspectors the responsibility of determining whether there is compliance with the undertaking not to further any military purpose with safeguards and with other conditions of the relevant agreement.<sup>15</sup> The director general is to report any non-compliance to the Board of Governors. If the Board finds that there has been non-compliance, it is to call upon the state concerned to remedy such non-compliance forthwith. The Board is also required to report the non-compliance to all member states, the United Nations General Assembly, and the United Nations Security Council. The IAEA may undertake measures to prevent further misuse, including terminating the applicable project agreement and calling for the return of the supplied materials or items. The Security Council may, under the authority of Chapter VII of the United Nations Charter, apply sanctions and, if it deems necessary, order military intervention to remedy the non-compliance.

## Safeguards Procedures

The safeguards procedures for fulfilling the obligations of the state and the IAEA, to be specified in the agreement, included (a) review and approval by the IAEA of nuclear reactor projects, (b) maintenance by the state concerned of an agreed nuclear material accounting system, (c) submission of regular and special reports to the IAEA, and (d) IAEA inspections.<sup>16</sup>

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**As states expanded their peaceful nuclear energy programs, it became necessary to extend the safeguards system to conversion plants, enrichment plants, nuclear fuel fabrication plants, power reactors, reprocessing plants, and associated storage facilities.**

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In 1962, the secretariat started practical implementation of this system in Japan, Finland, and the Congo as well as at four reactors in the United States. In the first three cases, safeguards agreements were required to cover the transfer of nuclear material or items or the provision of technical assistance. The U.S. agreement was a case of voluntary submission of reactors to IAEA safeguards.

The essential feature of this first version of the agency's safeguards system was that it was facility oriented and item specific. The emphasis was on research reactors, associated nuclear material, and other items supplied by the IAEA under a project agreement. INFCIRC/26 called for the principles and procedures of the safeguards system to be reviewed after two years in light of the actual experience gained by the agency and the technological development that would have taken place meanwhile.

During this period, the number of states establishing nuclear programs continued to grow. These states typically started with research reactors; most were imported but some were indigenously designed. Later, states began to use power reactors for electricity generation. Some states started to import or develop indigenous capabilities for fabricating reactor fuel and a few did so for reprocessing spent fuel. These trends required the IAEA to further develop the safeguards system to include the new types of facilities being deployed and other situations requiring the conclusion of safeguards agreements. Increasingly, safeguards were to be applied at the behest of supplier states to materials or items supplied under bilateral agreements. This involved application of safeguards not only at supplied facilities but also at indigenously designed facilities where nuclear materials (or other materials such as heavy water) supplied or produced under safeguards were processed or used.

As states expanded their peaceful nuclear energy programs, it became necessary to extend the safeguards system to conversion plants, enrichment plants, nuclear fuel fabrication plants, power reactors, reprocessing plants, and associated storage facilities. The main principles and procedures for reactor facilities were completed in 1965 and were published in INFCIRC/66.<sup>17</sup> Procedures for reprocessing and fuel fabrication plants were added in 1966 and 1968 in INFCIRC/66. Rev.1 and Rev.2 respectively.<sup>18</sup>

The stated purpose of INFCIRC/66 was to inform member states and enable them to determine in advance the circumstances and manner in which the agency would administer safeguards. Additionally, INFCIRC/66 provided guidance to the agency to enable it to determine readily what provisions should be included in safeguards agreements and how to interpret such provisions.<sup>19</sup>

In INFCIRC/66 and the subsequent revisions, it was reaffirmed that the agency would apply safeguards in a member state only pursuant to a safeguards agreement to which that state was a party and under one of the following three circumstances:

- (a) The Agency has concluded with the State a *project agreement* under which materials, services, equipment, facilities, or information are supplied, and such agreement provides for the application of safeguards; or
- (b) The State is a party to a bilateral or multilateral arrangement under which materials, services, equipment, facilities, or information were supplied or otherwise transferred, and;
  - (i) All the parties to the arrangement have requested the Agency to administer safeguards; and
  - (ii) The Agency had concluded the necessary *safeguards agreement* with the state; or
- (c) The Agency has been requested by the State to safeguard certain nuclear activities under the latter's jurisdiction, and the Agency had concluded the necessary *safeguards agreement* with the State.<sup>20</sup>

A state could have more than one safeguards agreement based on INFCIRC/66, concluded at different times to cover different facilities or different materials within a given facility.

Agreements based on INFCIRC/66 are commonly known as *item-specific safeguards agreements*. However, INFCIRC/66 is not a model safeguards agreement, but rather it is the description of the IAEA safeguards system for these applications that can be used as the basis for various types of agreements. Safeguards agreements pursuant to circumstances (a) and (b) above are item-specific by their nature, but agreements pursuant to circumstance (c) could be comprehensive in scope: in principle, a state could request the agency to cover all nuclear activities in the state (as Mexico did in 1967).

Regarding nuclear material, it was determined that, except in certain cases specified in paragraphs 21–28 of INFCIRC/66/Rev.2 (exemption from safeguards, termination and suspension of safeguards, and transfer of safeguarded material out of the state), such material should be subject to agency safeguards if it met one of the following criteria:

- (a) Supplied under a project agreement involving the agency
- (b) Submitted to safeguards under a safeguards agreement by the parties to a bilateral or multilateral arrangement
- (c) Unilaterally submitted to safeguards under a safeguards agreement
- (d) Produced, processed, or used in a principal facility<sup>21</sup> meeting the terms of (a), (b) or (c) above
- (e) Produced in or by the use of safeguarded nuclear material
- (f) Substituted for safeguarded material as permitted under the safeguards agreement.<sup>22</sup>

Following the publication of INFCIRC/66, detailed procedures were developed for the application of safeguards at each type of nuclear facility, including

- (a) IAEA review of the facility design to ensure that it would be able to apply effective safeguards at the facility
- (b) Specification of operating records and nuclear material accounting records to be maintained by the facility operator at each facility and examination of these records
- (c) Specification of the contents and reporting requirements for official reports from the state to the IAEA that would be based on these operating and accounting records
- (d) Provisions for the IAEA to carry out various kinds of inspections.

The purpose of the inspections pursuant to safeguards agreements concluded on the basis of INFCIRC/66/Rev.2 is specified in paragraph 46 of the INFCIRC. The inspections are to verify compliance with the safeguards agreement, assist states in complying with such agreements, and resolve any questions arising out of the implementation of safeguards. Mainly, this was done through routine inspections that included, as appropriate, the following:

- (a) Audits of records and reports
- (b) Verification of the category and quantity of safeguarded nuclear material by physical inspection, measurement, and sampling
- (c) Examination of nuclear facilities, including a check of their measuring instruments and operating characteristics
- (d) Check of operations carried out at nuclear facilities and at research and development facilities containing safeguarded nuclear material.

Each INFCIRC/66-type agreement might introduce new measures that would then be adopted in subsequent agreements—the introduction of containment and surveillance measures being a case in point.

Along with the development of these principles and procedures, the technologies for their implementation were under continuous development in this period with assistance provided by a number of member states. These included, *inter alia*

- (a) Methods of determining the power output of a reactor
- (b) Methods for verifying the nuclear material contained in fuel elements and assemblies by item at each facility by means of item counting and identification in order to confirm that such items had not been diverted
- (c) Non-destructive assay of fresh nuclear fuel as a means of quickly checking whether it contained the amount of fissile material declared
- (d) Observation of Cherenkov glow and photographic identification and non-destructive measurements for spent nuclear fuel
- (e) Monitoring charge/discharge machines in continuous refueling-type reactors.

The secretariat organized expert panels and symposia to advance its capabilities for the application of safeguards.

In summary, 1962–69 can be seen as the major formative period for the establishment and implementation of the IAEA's safeguards system, pursuant to Article III.A.5 of the IAEA Statute. The basis of the system is the conclusion of a safeguards agreement between the state (or group of states) and the IAEA. This agreement specifies the state's undertakings concerning peaceful (non-military) use of nuclear material, items, and technology and the responsibility of the IAEA to verify the state's compliance with its undertakings. Both parties have obligations under the agreement. The procedures for fulfilling these obligations are specified in the agreement.

Over this period, a firm foundation for the application of IAEA safeguards was laid, providing growing confidence on the part of IAEA member states, some of which had questioned the feasibility of such a system during the initial stages of its creation. The safeguards system had responded to the concern that increasing international cooperation in the peaceful use of nuclear energy, and the expanding use of nuclear material and equipment and non-nuclear material transferred through bilateral or multilateral cooperation, might be used for military (i.e., nuclear weapons) purposes. It is noteworthy that at the same time the IAEA was developing the safeguards system, it was charged with encouraging and assisting research on and development and practical application of atomic energy for peaceful use throughout the world.<sup>23</sup>

Without international cooperation in nuclear energy, the opportunity to establish safeguards would not have arisen, and without safeguards, the IAEA might never have been created.



IAEA laboratory analysts use a secondary ion mass spectrometer to examine safeguards environmental samples to detect unreported activities or undeclared nuclear materials. Photo: D. Calma, IAEA.

## Conclusion of the NPT and the Introduction of Comprehensive Safeguards

The adoption of nuclear technology by a growing number of states in the 1960s led to increasing concern in the international community about the possibility that some of those states might use their ostensibly peaceful nuclear programs as a means of producing—or enhancing their ability to produce—nuclear weapons. Such a development could lead to an increase in the number of states possessing nuclear weapons—that is, to the further proliferation of nuclear weapons.

Ireland took the initiative of putting the problem of preventing further proliferation of nuclear weapons before the United Nations. In October 1958, at the 13th session of the United Nations General Assembly, Ireland proposed what became known as the “Irish Resolution,” which recognized

that the danger now exists that an increase in the number of states possessing nuclear weapons may occur, aggravating international tension and the difficulty of maintaining world peace . . .

The Irish resolution was finally adopted unanimously in 1961 after a three-year discussion, reflecting that a consensus had begun to emerge within the United Nations and in the global community against the further spread of nuclear weapons and in favor of a treaty on the non-proliferation of nuclear weapons.<sup>24</sup>

The Eighteen Nation Disarmament Committee (ENDC) in Geneva took up this negotiating mandate in 1964. A first draft of a treaty to prevent the spread of nuclear weapons was presented to the ENDC by the United States in August 1965, followed by a draft from the Soviet Union the following month. In August 1967, the United States and the Soviet Union introduced identical drafts (indicating that substantial negotiations had taken place meanwhile). However, in this draft, the crucial Article III on the control of nuclear energy was left blank.<sup>25</sup> Intensive negotiations followed, culminating in a complete and final draft of the Treaty on the Non-Proliferation of Nuclear Weapons being adopted by the United Nations General Assembly on June 12, 1968. The depositary governments (the United Kingdom, the United States, and the Soviet Union) opened the treaty for signature, and the NPT entered into force on March 5, 1970, following ratification by 43 states, including the depositaries.

In parallel with the process of developing the NPT, an important step in the same direction was taken by 21 Latin American states when, in February 1967, they signed the Treaty for the Prohibition of Nuclear Weapons in Latin America, or the Treaty of Tlatelolco. This treaty created the first internationally controlled nuclear-free zone in a populated area.<sup>26</sup> In the framework of this treaty, Mexico asked the IAEA to apply safeguards to its all nuclear activities. The resulting safeguards agreement, the first to cover all present and future nuclear activities in a state, entered into force on September 6, 1968. However, the content of this agreement was based on INFCIRC/66. This agreement was suspended in 1973 when Mexico's comprehensive safeguards agreement pursuant to the NPT entered into force.

Without diminishing the importance of other articles of the NPT in ensuring the non-proliferation of nuclear weapons, for the purposes of this paper the focus will be placed on the provisions of Articles II and III of the treaty.

Article II is the basic non-proliferation undertaking accepted by non-nuclear-weapon states (NNWS) parties to the NPT. In Article II, each NNWS undertakes

not to receive the transfer from any transferor whatsoever of nuclear weapons or other nuclear explosive devices or of control over such weapons or explosive devices directly, or indirectly; not to manufacture or otherwise acquire nuclear weapons or other nuclear explosive devices; and not to seek or receive any assistance in the manufacture of nuclear weapons or other nuclear explosive devices.

Article III.1 sets out two requirements applicable to each NNWS party to the treaty. The first requirement is an undertaking to accept IAEA safeguards and to conclude a safeguards agreement for this purpose:

[T]o accept safeguards, as set forth in an agreement to be negotiated and concluded with the [IAEA] in accordance with the Statute . . . and the Agency's safeguards system, for the exclusive purpose of verification of the fulfilment of its obligations assumed under this Treaty with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices.

The second requirement is for IAEA safeguards to apply to all the nuclear material in peaceful use in the state:

Procedures for the safeguards required by this Article shall be followed with respect to source or special fissionable material whether it is being produced, processed or used in

any principal nuclear facility or is outside any such facility. The safeguards required by this Article shall be applied on all source or special fissionable material in all peaceful nuclear activities within the territory of such State, under its jurisdiction, or carried out under its control anywhere.

The purpose of IAEA safeguards under the NPT is to verify the fulfilment of a state party's obligations under the treaty with a view to

preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices . . . .

This purpose is very similar to the IAEA safeguards objective specified in the IAEA Statute:

to ensure that special fissionable and other materials, services, equipment, facilities, and information made available by the Agency or at its request or under its supervision or control are not used in such a way as to further any military purpose . . . .<sup>27</sup>

Although verification is stated to have the purpose of preventing diversion of nuclear energy, Article III.1 sets out the focus of the IAEA safeguards system as being on nuclear materials. There is no indication as to why the NPT refers to diversion broadly (nuclear energy) but provides for safeguards in more specific terms (application to nuclear material). It is reasonable to assume that the specific language on nuclear material reflects what was considered verifiable by the IAEA's safeguards system at that time—and, of course, a nuclear weapon cannot be produced without nuclear material.

Article III.1 refers to the agency's safeguards system. The safeguards system in existence during the negotiation of the NPT was based on INFCIRC/66, and in fact, the two annexes to INFCIRC/66 were added while the NPT negotiations were under way. But the parties realized that the NPT obligations under Article III.1, requiring the application of safeguards to all the nuclear material in a state, was a new concept and that a new adaptation of the safeguards system would be needed. This requirement is reflected in the first two paragraphs of the model comprehensive safeguards agreement, INFCIRC/153 (discussed in the next section), the first paragraph stipulating the obligations of each NNWS, and the second stipulating the corresponding verification obligations of the IAEA.<sup>28</sup>

## Comprehensive Safeguards

Initially the concept of applying safeguards to all the nuclear material in a state was called *full scope safeguards*; later it became known as *comprehensive safeguards*. This was a major change from existing safeguards, which applied only to specified nuclear material, facilities, or items, with the state legitimately having any other nuclear material outside safeguards. Under INFCIRC/66 agreements, a state could voluntarily submit all its nuclear material to safeguards, as Mexico did for the Treaty of Tlatelolco. However, to support the effective operation of the NPT, a new kind of agreement was considered necessary, together with the necessary safeguards procedures, that would meet the NPT requirements in a version of the IAEA safeguards system specifically designed for implementing full scope or comprehensive safeguards.



The NPT set out some guiding principles for the development of the IAEA's safeguards system pursuant to the treaty:

- (a) The system should apply the principle of safeguarding effectively the flow of source and special fissionable materials by use of instruments and other techniques at certain strategic points.<sup>29</sup>
- (d) Safeguards measures should be implemented in a manner designed to avoid hampering the economic or technological development of the parties.<sup>30</sup>

In April 1970, the Board of Governors set up a committee (the Safeguards Committee) open to all IAEA member states to advise it as a matter of priority on the content of the safeguards agreement required by Article III of the NPT. Later, the Board also asked the committee to study the question of meeting the cost of safeguards. The Safeguards Committee began its work in June 1970, and nearly 50 member states participated.

The Safeguards Committee faced a rather difficult task as major adaptations of the existing system were necessary to meet the new requirements. The committee completed its work on March 10, 1971, after 82 meetings. The committee's recommendations were adopted by the Board of Governors and were set out in INFCIRC/153 (corrected), *The Structure and Content of Agreements between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons*, published by the IAEA in June 1972. This document is not legally binding, but it is used as the basis for negotiating individual safeguards agreements. For convenience, the term *INFCIRC/153* will be used in this paper rather than the more formal *INFCIRC/153 (corrected)*.

INFCIRC/153 consists of two parts: Part I contains principles or general provisions, including the obligations of the state and the IAEA under the agreement, while Part II contains the procedures for implementing the general provisions.

The first paragraph of Part I sets out the obligation of the state to accept, in accordance with Article III.1 of the NPT,

safeguards, in accordance with the terms of the Agreement, on all source or special fissionable material in all peaceful nuclear activities within its territory, under its jurisdiction or carried out under its control anywhere, for the exclusive purpose of verifying that such material is not diverted to nuclear weapons or other nuclear explosive devices.

The second paragraph sets out the IAEA's "right and obligation"

to ensure that safeguards will be applied, in accordance with the terms of the Agreement, on all source or special fissionable material in all peaceful nuclear activities within the territory of [the state], under its jurisdiction or carried out under its control anywhere, for the exclusive purpose of verifying that such material is not diverted to nuclear weapons or other nuclear explosive devices.

Indirectly, this second paragraph defines the non-proliferation objective of IAEA safeguards pursuant to the NPT, recognizing that all nuclear activities in a non-nuclear-weapon state, except non-proscribed military activity, must be peaceful, and all nuclear material in the state must be declared and placed under safeguards.

Failure to do so could place a state in non-compliance with its safeguards agreement. As discussed in the next section, nuclear material in non-proscribed military uses must be covered by appropriate arrangements between the state and the IAEA.

## The Safeguards Objective

To paraphrase NPT Article III.1, the IAEA has the right and obligation to ensure that safeguards are applied on all nuclear material in all peaceful nuclear activities in the state to verify that such material is not diverted to nuclear weapons. In general, this can be considered as the definition of the safeguards objective. At the same time, paragraph 28 of INFCIRC/153 describes the objective of safeguards in slightly different terms:

the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or of other nuclear explosive devices or for purposes unknown, and deterrence of such diversion by the risk of early detection.

Considering that paragraph 28 is in Part II of INFCIRC/153, which specifies the procedures to be applied for the implementation of the safeguards provisions set out in Part I, this definition of the objective of safeguards is actually defining the objectives of safeguards procedures. The wording of comprehensive safeguards agreements makes this point clear.<sup>31</sup>

As discussed earlier, the term *diversion* was first introduced in INFCIRC/26. There, *diversion* meant the use of items subject to safeguards “to further any military purpose.” There was no list of proscribed military purposes because any military use was prohibited. The definition of the items subject to safeguards (meaning subject to the state’s peaceful use undertaking) was straightforward, and each item was specified in an inventory that was part of each agreement, which could include fuel assemblies or heavy water that had been supplied under the agreement. This meaning of diversion also applied under INFCIRC/66 agreements.<sup>32</sup> Following the introduction of the concept of non-proscribed military uses under the NPT, however, the meaning of *diversion* became “diversion to nuclear weapons or for purposes unknown.”

## Non-Proscribed Military Uses

A key point of difference between the IAEA Statute and the NPT is that the NPT does not proscribe all military uses of nuclear material. The NPT prohibits acquisition or manufacture of nuclear weapons or other nuclear explosive devices by non-nuclear-weapon states, but it does not proscribe non-explosive military uses of nuclear material (which might include, for example, naval propulsion, powering of military satellites, or use of depleted uranium in armor piercing munitions or ballast).

Because of the NPT’s provision for non-explosive military uses, some nuclear material in an NNWS may not be subject to full scope safeguards procedures. INFCIRC/153 agreements provide for safeguards to be suspended for nuclear material in non-proscribed military use, in accordance with arrangements to be made between the state and the IAEA.<sup>33</sup> Any such suspension, however, does not relieve the state of the basic undertaking in the NPT—namely, that all the nuclear material in the state, including any material in non-proscribed military use, is subject to the undertaking not to use the material for nuclear weapons.

If an NNWS plans to use nuclear material in a non-proscribed military activity, the state is required to make clear to the Agency that

- (a) The nuclear material to be used is not subject to a “peaceful use only” obligation (nuclear material supplied through the Agency and most nuclear material supplied under bilateral agreements cannot be used for any military purpose).
- (b) During the period of non-application of safeguards, the nuclear material will not be used for the production of nuclear weapons or other nuclear explosive devices.

The state is required to make an arrangement with the IAEA identifying the period or circumstances in which safeguards will not be applied, informing the agency of the total quantity and composition of such material and providing for reapplication of safeguards when the material is reintroduced into a peaceful nuclear activity. To date, these provisions have not been used, and there are no approved models for the arrangements that would be required.<sup>34</sup>

## Completeness

Under comprehensive safeguards, the IAEA was given a new responsibility—to ensure that the state had placed all its nuclear material under safeguards,<sup>35</sup> or what later became known as the issue of “completeness.” In analyzing possible diversion scenarios, the IAEA considered that if a state had decided to manufacture nuclear weapons, it would have unsafeguarded (that is, undeclared) facilities,<sup>36</sup> and diversion paths might lead from facilities containing safeguarded material to unsafeguarded facilities and vice versa. Safeguards procedures were designed on this basis to detect anomalies at safeguarded facilities, such as the undeclared removal of nuclear material or the presence of undeclared nuclear material.

It was also recognized that a state might have a wholly undeclared nuclear program, with no flows of nuclear material to or from safeguarded facilities. In the period under discussion here, the IAEA considered that practical and political constraints applied to its ability to address this issue. On the practical side, it was considered there would be no “observables” or indicators that inspectors could detect using methods available to them at that time. Politically, it was considered that

a kind of international police organization with inspectors roaming around in sovereign States in the search of possible clandestine nuclear facilities or material is universally unacceptable and has not been suggested by anyone.<sup>37</sup>

A further consideration was that

the reports and conclusions of the IAEA are not the only source of information available to Member States. They may have their own national means for detecting unsafeguarded nuclear activities.<sup>38</sup>

It was thought that if a state, through national means, found indications of a possible safeguards violation by another state, it would inform the IAEA to enable inspectors to investigate.

As will be discussed later, in the 1990s developing approaches for verifying completeness became the greatest challenge facing the IAEA safeguards system.

## Non-Compliance

The safeguards objective cannot be considered in isolation but must be linked to the consideration of non-compliance and how major safeguards violations should be dealt with. INFCIRC/153 elaborated on the concept of non-compliance that was set out in the IAEA Statute (and was applicable under INFCIRC/66 agreements). INFCIRC/153 agreements provide that

if the Board upon examination of relevant information reported to it by the Director General finds that the Agency is not able to verify that there has been no diversion of nuclear material required to be safeguarded under the agreement to nuclear weapons . . . the Board may make the reports provided for in paragraph C of Article XII of the Statute. . . .<sup>39</sup>

This provision is complemented by the reference in the safeguards objective set out in INFCIRC/153 to

detection of diversion of . . . nuclear material . . . to the manufacture of nuclear weapons or . . . for purposes unknown. . . .<sup>40</sup>

The reference to “purposes unknown” is especially important: its effect is to relieve the IAEA of the need to prove that diverted nuclear material has gone to the manufacture of nuclear weapons, a burden of proof likely to be impracticable.<sup>41</sup>

It would not be very realistic to consider scenarios in which an inspector detects the specific act of diversion: that is, catches an operator red-handed removing material from authorized uses. It is therefore the purpose of the diversion analysis to identify anomalies, that is to say “observables”, that might be indicative of acts of diversion. Safeguards approaches are then designed to ensure that verification activities focus on anomalies and provide an adequate detection probability.<sup>42</sup>

If the agency does all that is reasonable to investigate apparent diversion, the state fails to provide a reasonable explanation, and a nuclear weapons purpose is plausible in the circumstances, a report should be made to the Board to enable it to consider action under the IAEA Statute. Article XII.C of the IAEA Statute sets out a number of actions, including reporting non-compliance to the United Nations Security Council and the United Nations General Assembly.

## Conceptual Basis for Safeguards Implementation

The practical implementation of the general provisions of Part I of INFCIRC/153 agreements is addressed in Part II of each agreement. The conceptual basis for this implementation was taken, with some modifications, from experience gained under INFCIRC/26 and INFCIRC/66 agreements. Some aspects, such as the definitions of *facility*, *exemption from safeguards*, and *termination of safeguards*, were taken from INFCIRC/66. Other terms, such as *nuclear material flow*, *starting point of safeguards*, and *material balance area* (MBA) were new, reflecting the new situation: safeguards now applied to a state's entire nuclear fuel cycle and the flow of nuclear material moving through the facilities in the fuel cycle.

Nuclear material “subject to safeguards”—that is, nuclear material that must be placed under safeguards—must be declared by the state to the IAEA through its national system of accounting and control of nuclear

material (referred to as the SSAC), based on a system of measurements, records, and reports. The state is required to provide information on facilities and locations outside of facilities (LOFs) where nuclear material, which is subject to safeguards, will be stored, processed, or used. The state is also required to provide information on nuclear material inventories and inventory changes with respect to each facility or LOF.

States are required to submit a design information questionnaire (DIQ) for each facility. Each DIQ is examined and becomes the foundation for the safeguards approach to be applied at that facility. Inspectors verify the DIQ for each facility to confirm that the information is complete and accurate. The state is obligated to notify the IAEA of any modifications that could render the DIQ invalid for the purposes of applying safeguards, and inspectors are authorized to verify any such changes to determine whether the safeguards approach remains valid.

INFCIRC/153 stipulates that nuclear material accountancy is a safeguards measure of fundamental importance, with containment and surveillance as important complementary measures.<sup>43</sup> The technical conclusions of the IAEA's verification activities are to be a statement, with respect to each MBA, of the amount of material unaccounted for (MUF) over a specific period.<sup>44</sup> All nuclear material records and reports are to be created in relation to agreed MBAs in facilities and LOFs, and all nuclear material moving into or out of each MBA is to be made available for visual examination; nondestructive assay, weighing, or volume measurement; and sample taking for analytical analysis. Such measurements are taken at agreed key measurement points or other strategic points. Containment and surveillance measures complement nuclear material accountancy, providing a means to preserve the integrity of IAEA verification equipment and providing assurance that access to nuclear materials will proceed only according to agreed arrangements.<sup>45</sup>

Comprehensive safeguards agreements provide for three types of inspections:

- (a) *Ad hoc inspections*—for example, to check the initial report that the state submits to the Agency, or before the export or after the import of nuclear material.<sup>46</sup>
- (b) *Routine inspections*, which are limited to strategic points, including key measurement points, strategic points for the application of containment and surveillance measures, and “other strategic points.”<sup>47</sup> A safeguards approach for a particular facility is agreed by the state, the agency, and the facility operator; this approach contains the procedures to be followed by a facility operator and IAEA inspectors.
- (c) *Special inspections* to verify information contained in special reports, provide additional inspection time in facilities where the agreed actual routine inspection effort (ARIE) value stipulated in the Facility Attachment has been exhausted. Special inspections also take place if the agency considers that information received from the state and obtained in routine inspections is not adequate for the agency to fulfill its responsibilities. In the latter case, inspector access to locations that are not declared by the state is permissible, subject to consultations between the IAEA and the state.

In the safeguards concept outlined here, it was assumed that diversion of nuclear material from peaceful use at a safeguarded facility would give rise to indications that could be detected by inspections, such as significant discrepancies or anomalies in nuclear material accountancy. If no such indications were found, the agency can reach the safeguards conclusion that the nuclear material placed under safeguards remained in peaceful nuclear activities or was otherwise adequately accounted for.

## Voluntary Offer Safeguards Agreements

Also, during this period, the nuclear-weapon states parties to the NPT concluded so-called voluntary offer safeguards agreements (VOAs) with the IAEA. VOAs were created to allow the agency to gain useful experience in applying safeguards at facilities similar to those in non-nuclear-weapon states and to enable the nuclear-weapon states to appreciate—at least to a limited extent—the burdens that IAEA inspections were creating in non-nuclear-weapon states. Under the VOAs, each nuclear-weapon state is free to choose which facilities it is prepared to offer to the IAEA to be safeguarded, free to add or remove nuclear material as it decides, and free to withdraw such facilities from safeguards should it so decide. The extent to which the IAEA carries out inspections under VOAs has depended on availability of funding. When funds have been limited by the principle of zero growth budget, safeguards under VOAs have usually been the first place where cuts were implemented.

In summary, following the introduction of agreements based on INFCIRC/153, the IAEA safeguards system was adapted and extended to meet challenges associated with verification of all nuclear material in non-nuclear-weapon states parties to the NPT. This required tremendous effort from both the IAEA and its member states.

With finalization of work on INFCIRC/153 and the conclusion of the first safeguards agreements based on it, by 1972 the IAEA was operating three types of safeguards agreements:

- (a) Safeguards agreements based on INFCIRC/66, known as *item-specific safeguards agreements*.
- (b) Safeguards agreements required by NPT Article III for non-nuclear-weapon states, based on INFCIRC/153, known as *comprehensive safeguards agreements*, or CSAs.<sup>48</sup>
- (c) VOAs concluded by the IAEA with the five NPT nuclear-weapon states to apply safeguards to nuclear material in selected nuclear facilities.

# Implementation of the Safeguards System from 1972 to 1991

This period begins with the publication of the model comprehensive safeguards agreement, INFCIRC/153, in June 1972. It ends with the discovery in 1991 that Iraq was pursuing a nuclear weapon program in violation of the NPT and its safeguards agreement.

As more and more states joined the NPT and concluded CSAs, the IAEA's safeguards workload increased exponentially. A major task for the IAEA was to establish the technical arrangements and capabilities needed to meet its new and expanded responsibilities. As states brought their NPT safeguards agreements into force, most existing safeguards agreements concluded under INFCIRC/26 and INFCIRC/66 were terminated; however, some remained in force in NPT states, including agreements applying "flagging" requirements to supplied uranium<sup>49</sup> and agreements involving arrangements for the storage of spent fuel and reprocessing in nuclear-weapon states.

Paragraph 3 of INFCIRC/153 calls for cooperation between the state and the IAEA in implementing the safeguards agreement. Indeed, such cooperation was very important not only for the implementation of these agreements but also for the development of safeguards procedures during this period. In the cases of Euratom (the European Atomic Energy Community), ABACC (the Argentine-Brazilian Agency for Accounting and Control of Nuclear Materials), and Japan, arrangements for cooperation were elaborated under the respective safeguards agreements, establishing principles and procedures for cooperation and coordination between the IAEA inspectorate and national, multinational, or regional inspectorates.

A small quantities protocol (SQP) was developed for states with CSAs requiring accounting and inspection procedures. For such states, most of the provisions of Part II of their agreements were held in abeyance.

Safeguards agreements concluded pursuant to INFCIRC/66 and INFCIRC/66 Rev.1 and Rev.2 remained in force in states that were not parties to the NPT, and new agreements continued to be concluded between the IAEA and those states based on INFCIRC/66/Rev.2, during and after this period.<sup>50</sup>

Initially, the state's undertakings in INFCIRC/66 agreements were formulated in accordance with the wording of the IAEA Statute: the items specified in the agreement were "not used in such a way as to further any military purpose." India's detonation of a "peaceful nuclear explosive" in 1974, made with plutonium

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**As more and more states joined the NPT and concluded CSAs, the IAEA's safeguards workload increased exponentially. A major task for the IAEA was to establish the technical arrangements and capabilities needed to meet its new and expanded responsibilities.**

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produced in the Canadian-supplied CIRUS reactor,<sup>51</sup> prompted a revision of the state's obligation under INFCIRC/66 agreements. A revised formula, reflecting the language of the NPT, was introduced:

[None of the materials or items subject to the agreement] shall be used for the manufacture of any nuclear weapon or to further any other military purpose and . . . such items shall be used exclusively for peaceful purposes and shall not be used for the manufacture of any nuclear explosive device.<sup>52</sup>

## National Legislation and the SSAC

In the process of bringing safeguards agreements into force, states had to enact laws and regulations and establish national authorities to implement the responsibilities and obligations under their agreements. NPT states had to establish (or adjust) their national nuclear material accountancy capabilities according to requirements promulgated by the IAEA for SSACs. The SSACs included the necessary procedures for establishing quantities of nuclear material subject to accounting procedures and for the recording and reporting procedures necessary for declaring nuclear material inventories and flows to the IAEA. Design information for each facility was to be provided to the IAEA to enable it to design effective safeguards approaches.

## Subsidiary Arrangements

INFCIRC/153 provides for subsidiary arrangements to be agreed to between each state and the IAEA. These arrangements comprise a “General Part” and a separate “Facility Attachment” for each facility placed under safeguards. Subsidiary arrangements contain the technical and administrative procedures for specifying how the provisions of the safeguards agreement are to be applied in the state.

## Inspection Goals

Inspection procedures to be applied at a safeguarded facility were developed on the basis of the analysis of plausible scenarios of undeclared physical removal of nuclear material from the facility, including consideration of various concealment methods. The goal of the procedures—the so-called inspection goal—was to be able to detect diversion of a minimum of one significant quantity (SQ) of nuclear material from the facility within the timeliness interval corresponding to the given category of nuclear material (see Table 1).

An SQ is the quantity of nuclear material from which the ability to produce one nuclear weapon could not be excluded. The SQ values allow for unavoidable losses caused by conversion and manufacturing processes and should not be confused with critical masses.<sup>53</sup> The timeliness goal has been established on the assumption that the state may have unsafeguarded nuclear facilities that could be used for further processing of nuclear material diverted from peaceful activities at a safeguarded facility. The timeliness goal reflects the time required to convert material diverted from a given facility into a weapons-usable quality. The guidance on establishing actual parameters for SQs and timeliness goals (see Table 1) was provided by the Standing Advisory Group on Safeguards Implementation (SAGSI).<sup>54</sup>



**Table 1: Verification Parameters for Safeguards Implementation**

Material Category	Significant Quantity (SQ)	Timeliness Goal
<b>Plutonium</b>	8 kg plutonium (for all plutonium containing less than 80% Pu-238)	Separated Pu: 1 month Spent fuel: 3 months
<b>HEU (<math>\geq</math> 20% U-235)</b>	25 kg U-235	Separated HEU: 1 month Spent fuel: 3 months
<b>U-233</b>	8 kg U-233	Separated U-233: 1 month Spent fuel: 3 months
<b>LEU (<math>&lt;</math> 20% U-235)</b>	75 kg U-235	1 year
<b>Natural uranium</b>	10 tons	1 year
<b>Depleted uranium</b>	20 tons	1 year
<b>Thorium</b>	20 tons thorium	1 year

Note: HEU = highly enriched uranium; LEU = low enriched uranium.

The inspection procedures developed for a given type of nuclear facility—for example, a power reactor—were applicable, with small modifications, to any such facilities under the three existing types of safeguards agreements.

The inspection procedures were based on nuclear material accounting supported by containment and surveillance measures (such as application of IAEA seals and surveillance). Radiation monitoring was used either as a separate containment measure or as a complementary measure for surveillance, in order to facilitate the evaluation of the surveillance results. In accordance with paragraph 30 of INFCIRC/153, the technical conclusion for each MBA (each facility contains one or several MBAs) is the statement on MUF over the material balance period, which is the period between two consecutive physical inventory takings by the facility operator. Evaluation of the MUF value enables the inspector to conclude on the absence of a protracted diversion.<sup>55</sup> Evaluation of the results of each inspection carried out for timeliness purpose enables the inspector to conclude on the absence of abrupt diversion.<sup>56</sup>

A very important role in the development and implementation of nuclear material accountancy verification procedures was played by non-destructive assay methods and methods of radiochemical analysis. Aided by member state support programs, the IAEA implemented analytical chemistry procedures in a dedicated laboratory,<sup>57</sup> where nuclear material samples taken by the inspectors in the field were analyzed. The IAEA organized an international network of national analytical laboratories to support its work in chemical analysis of samples taken during IAEA inspections. This network served three purposes:

- (a) It provided a means to enhance measurement performance in the national laboratories of participating states.
- (b) It provided a means to expand the analytical capabilities of the IAEA's laboratory.
- (c) It provided states with a means to ensure against biased analyses in safeguards conclusions.

During this period, the IAEA convened groups of experts to explore many technical aspects of safeguards implementation. For sensitive facilities, groups of states took responsibility for establishing safeguards approaches for centrifuge enrichment plants and large-scale reprocessing plants and, together with the IAEA, developed guidelines for agency safeguards at reprocessing plants where the anticipated plutonium throughput would be so great as to make nuclear material accountancy unable to detect the diversion of one SQ of plutonium over a one-year period.

In complex plants placed under safeguards (both existing and newly built), the IAEA often had to use instruments owned and operated by facility operators and often shared measurement and containment and surveillance systems with national and regional safeguards inspectorates. This required the IAEA to devise authentication methods and procedures to ensure that it could derive independent conclusions. The IAEA increasingly installed and maintained its own equipment in facilities placed under safeguards and established two regional offices (in Toronto and Tokyo) to gain inspection efficiency and effectiveness.

## Performance Standards: The SIR, Safeguards Criteria, and Effectiveness Evaluation

In the second half of the 1970s, the secretariat, at the request of the Board of Governors, set out to establish standardized implementation requirements. SAGSI advised on the issuance of an annual *Safeguards Implementation Report* (SIR) to inform the Board about the safeguards operations and the problems encountered. The SIR also contained the Safeguards Statement on the results of safeguards operation over the year.

By the beginning of the 1980s, the secretariat developed the methodology for evaluating the effectiveness of implementation of the safeguards approaches applied at facilities placed under safeguards. Evaluation was based on the extent to which the objective of inspection procedures (timely detection of diversion of a minimum of one SQ of nuclear material) was attained for the facility evaluated. The performance targets used in the evaluation were the parameters of inspection procedures, such as detection probability, the completeness of nuclear material coverage by the verification method required, inspection frequency, and so forth. The evaluation results for all the facilities under safeguards, in terms of the inspection goal attainment, were reported in each SIR. The set of performance targets used for evaluation was called the evaluation criteria.

The efforts to establish standardized implementation requirements continued at the end of the 1980s with development of the set of implementation and evaluation criteria, referred to in safeguards literature as the *Safeguards Criteria*. This document was developed on the basis of the previous set of evaluation criteria and on the safeguards approaches developed for all types of facilities under IAEA safeguards. The Safeguards Criteria were introduced for initial implementation in the period 1991–95; later, the implementation period was extended. The Safeguards Criteria represented the culmination of safeguards implementation under the three existing types of agreements in accordance with the facility-level concept.

Although the majority of verification procedures listed in the Safeguards Criteria focused on the individual facility, there were also several procedures that were coordinated over the entire state. These state-level procedures included comparing reports on nuclear material transfers (transit matching) and measures to take into account the possibility of “borrowing” nuclear material from another facility to hide diversion

from the facility being inspected. In addition, the IAEA formulated safeguards conclusions for the state as a whole and published those conclusions in the SIR in the form of the Safeguards Statement.

In 1990, the Safeguards Criteria were distributed to member states in order to facilitate their assessment of the credibility of the agency's verification procedures and to contribute to cooperation between states and the agency in the application of safeguards.

## Introduction of Computerized Data Processing

Widespread computer usage was adopted during this period by national authorities, facility operators, and the IAEA. This provided transformational improvements in all aspects of nuclear material management and in the verification of states' obligations. New facilities were brought on stream that employed automated operations and measurements for controlling nuclear material operations and for facilitating the flow of information reported by states to the IAEA. Several ways were developed for IAEA inspectors to receive and process nuclear material accountancy information from operator computers directly into IAEA portable computers with greater accuracy and requiring less effort by facility operators and agency inspectors. Computer-based information processing was developed inside the agency, including the introduction of computerized inspection reports.

IAEA measurement and containment and surveillance (C/S) systems were increasingly computerized, and such measurement systems and C/S systems were increasingly used to carry out the agency's verification activities. Some were integrated into plant operations to provide automated nuclear material assay or monitoring without the need for IAEA inspectors to be present (unattended assay or monitoring). Some of these systems were connected to secure communications systems to provide remote monitoring capabilities.

In summary, the period from 1972 to 1991 was challenging, but the IAEA was able to meet the expanded workloads and the technical challenges presented. In retrospect, it is fortunate that the agency had this combination of a range of challenges and the time needed to address these (some 20 years). This enabled the agency to establish a substantial foundation to address issues revealed by the violations of CSAs that were found during the next period.



Inspectors installing a video surveillance system to monitor a nuclear power reactor to confirm that any access to the reactor is in agreement with declarations. The light blue object is the reactor cover, which must be removed for access to the reactor fuel. Photo: D. Calma, IAEA.

## The Challenge of Completeness and Further Development of the IAEA Safeguards System

### Discovery of Iraq's Nuclear Weapon Program

In 1991, following the First Gulf War, it was discovered that Iraq was developing a clandestine nuclear weapon program. Iraq was an NPT party with a comprehensive safeguards agreement. Safeguards inspections in Iraq prior to the war had not detected undeclared nuclear materials and activities because at that time the IAEA did not have procedures for detection of a wholly undeclared nuclear program that had no obvious links to declared facilities. While, in principle, the agency could have used special inspections, it lacked actionable, location-specific information on which to base such inspections. As the subsequent work on Programme 93+2 showed, both legal and technical aspects of the special inspection mechanism needed further development.

Following the war, the United Nations Security Council gave the IAEA extensive access rights throughout Iraq to investigate Iraq's nuclear capabilities.<sup>58</sup> The IAEA found that Iraq had undeclared nuclear material and activities, including development of uranium enrichment technologies, reprocessing experiments, and development of a nuclear weapon design. The Board of Governors concluded that Iraq was clearly in non-compliance with its safeguards agreement.

The discovery of Iraq's nuclear weapon program was a major shock to the international community and the IAEA:

[It] forcefully underlined the fact that the safeguards assurances presently provided by the IAEA through nuclear material accountancy verification activities at declared facilities alone are insufficient. They must be complemented and strengthened by activities providing equivalent assurances that undeclared nuclear material and nuclear facilities do not exist in states which have entered into comprehensive safeguards agreements with the IAEA.<sup>59</sup>

It was clear that the IAEA should not rely on unverified information provided by an inspected state and should not limit itself to verifying correctness (that is, confirming the accuracy of accounts of nuclear material at declared facilities). The IAEA had to develop the capability of determining whether a state's declarations were not only accurate but also complete—that is, included all the nuclear material in the state, an objective described as *completeness*.

As the IAEA and member state experts considered how to address completeness, it became evident that collection and analysis of all safeguards-related information would be central. An ability to detect indicators of undeclared nuclear programs would require a much wider range of information than used in safeguards at that time. Some of this information could be obtained through additional safeguards reporting requirements, some could be collected through the IAEA's own efforts, and some might be provided by other states or commercial organizations. The IAEA needed to develop a system for identifying and analyzing the information required, using it in planning and implementing inspection activities, and drawing appropriate conclusions.

In February 1992, a number of proposals were put to the Board of Governors for consideration. These proposals involved greater access rights for inspectors and greater use of information reporting, collection, and analysis. Specific proposals included

- (a) Use of special inspections
- (b) A requirement for states to provide design information for new nuclear facilities as early as possible
- (c) Reporting and verification of nuclear exports and imports.

The Board reaffirmed the IAEA's rights to obtain additional information and have access to additional locations in accordance with the IAEA Statute and CSAs. In particular, the Board reaffirmed the IAEA's right to undertake special inspections at any location in a state having a comprehensive safeguards agreement if the agency had reason to believe the state was carrying out unreported nuclear activities.

## Programme 93+2

In 1993, the IAEA initiated Programme 93+2 to “strengthen the effectiveness and improve the efficiency of safeguards.” It was named Programme 93+2 because it was launched in 1993 with the plan of completion in time for the 1995 NPT review conference. While this program was initially prompted by the discoveries in Iraq, a further important influence was the situation unfolding at that time in the Democratic People's Republic of Korea (DPRK). The IAEA had found evidence of undeclared plutonium production and sought

additional information and access to apparent nuclear waste stores. The DPRK refused access, and in February 1993, the IAEA invoked the special inspection procedure under the DPRK's safeguards agreement. The DPRK refused to cooperate, and the Board determined that the DPRK was in non-compliance with its safeguards agreement.<sup>60</sup>

Programme 93+2 was developed in two parts. Part I comprised safeguards measures that the IAEA had the authority to implement within the framework of existing comprehensive agreements. Part II comprised those safeguards measures for which it was considered preferable or necessary for the IAEA to be given additional specific legal authority.

The measures that could be implemented within existing legal authority (Part I) were

- (a) The enhanced analysis of all safeguards-related information about a state
- (b) Early provision of facility design information and the reverification of design information as a means of detecting facility misuse
- (c) Environmental sampling at declared facilities
- (d) Unannounced inspections.

These measures did not require additional legal authority as either they did not require access to the state territory at all (measure a) or they related to safeguarded facilities to which the IAEA had access under existing safeguards agreements (measures b, c, and d).

Part II measures, principally requiring extended declarations by a state about its nuclear activities and giving IAEA inspectors access to nuclear-related locations in the state beyond declared facilities (which became known as *complementary access*), presented an additional degree of safeguards intrusiveness. One consequence was that states needed to ensure that their domestic legislation provided the authority necessary to meet their obligations arising from these new measures.

## Model Additional Protocol

In developing proposals for Part I and Part II measures, the IAEA continued to work closely with member states and SAGSI. This work led to the establishment of a special committee of the Board in 1996 to negotiate a new instrument for the Part II measures. Rather than requiring a new safeguards agreement, it was decided this instrument should take the form of a protocol additional to each state's existing safeguards agreement. The new instrument, the Model Additional Protocol, was approved by the Board in 1997 and issued as INFCIRC/540.<sup>61</sup>

The purpose of the Model Additional Protocol was formulated in a general way:

to strengthen the effectiveness and improve the efficiency of the safeguards system as a contribution to global nuclear non-proliferation objectives.<sup>62</sup>

The Model Additional Protocol was to be used as a standard for additional protocols (APs) to be concluded by states with CSAs. States with other types of safeguards agreements could also conclude APs on an individual basis, negotiating with the IAEA on the measures they were prepared to accept.

The first AP with a CSA state was concluded in December 1997. Today,<sup>63</sup> there are APs in force with 136 states, including 130 non-nuclear-weapon states that are parties to the NPT (CSA states), 5 nuclear-weapon states that are parties to the NPT, and India. Of the 63 CSA states with nuclear facilities, 54 have APs in force, and 1 is applying the AP provisionally.<sup>64</sup> Three such states<sup>65</sup> have signed an AP but not yet ratified it. Five CSA states with nuclear facilities have yet to negotiate an AP.<sup>66</sup> While the failure of a handful of CSA states to conclude APs is regrettable, the AP is now firmly established as part of the agency's safeguards system.

By enabling the IAEA to obtain a much fuller picture of a state's current and planned nuclear activities, nuclear material holdings, and nuclear-related manufacture and trade, the AP increases the IAEA's ability to provide greater assurance on the absence of undeclared nuclear material and activities in the state. The IAEA has emphasized on many occasions that it is unable to conclude that all nuclear material in a state has remained in peaceful activities unless the state has an AP in force.

## The Concept of Integrated Safeguards

To introduce the AP procedures into safeguards implementation practice and to integrate them with the existing CSA-based procedures as described in the Safeguards Criteria, the IAEA developed the concept of *integrated safeguards*. This concept was described in the director general's report to the Board of Governors in March 2000.<sup>67</sup> In this report, *integrated safeguards* were defined as:

the optimum combination of all safeguards measures available to the Agency under comprehensive safeguards agreements and Additional Protocols which achieves the maximum effectiveness and efficiency within available resources in fulfilling the Agency's right and obligation in paragraph 2 of INFCIRC/153 (Corrected).

Integrated safeguards were intended to become more effective and efficient safeguards as compared to the so-called traditional safeguards based on the implementation of the Safeguards Criteria. The design of integrated safeguards followed the guideline given in an information paper prepared for the Board in November 2000:<sup>68</sup>

[T]he safeguards system for implementing comprehensive safeguards agreements should be designed to provide for verification by the Agency of the correctness and completeness of States' declarations so that there is credible assurance of the non-diversion of nuclear material from declared nuclear activities and of the absence of undeclared nuclear material and activities. The predominant focus of the Model Additional Protocol is to strengthen the Agency's capability to detect undeclared nuclear material and activities, in order to provide credible assurance of their absence. The Agency's capability to detect the diversion of declared nuclear material and thus provide credible assurance of the absence of diversion continues to be based primarily on the measures provided for in comprehensive safeguards agreements.

For a state with both a CSA and an AP, integrated safeguards are implemented in two steps. During the first step, which may take from one year to several years, the IAEA implements the CSA procedures described in the Safeguards Criteria and the AP procedures described in IAEA internal guidelines. The goal is to achieve conclusions on the absence of diversion of declared nuclear material and on the absence of undeclared nuclear material and activities in the state. These are the two conditions for drawing what the IAEA calls the “broader conclusion,” that all nuclear material in the state remained in peaceful activities.

Upon completion of the first step, having achieved greater assurance of the absence of undeclared nuclear material and activities, the IAEA develops and implements a state-level approach (SLA). The purpose of the SLA is to maintain the broader conclusion, applying the optimized set of CSA and AP procedures. The CSA procedures are applied at a reduced level as compared with the Safeguards Criteria. This results in improved efficiency under integrated safeguards as compared with simply implementing CSA and AP procedures cumulatively.

## The State-Level Concept

The new objective to ensure the completeness of state's declarations under CSAs has highlighted the fact that states' undertakings under the three types of safeguards agreement are different. This fact was not taken into account in traditional safeguards, which applied what we (the authors) call a *facility-level concept*. Under the facility-level concept, the same verification objective and nearly the same verification procedures were applied to verify non-diversion of declared nuclear material from a facility placed under safeguards, irrespective of the type of agreement. This lack of differentiation is reflected in the IAEA's statements of safeguards conclusions published in the SIR in the period before 2003. A typical example is the Safeguards Statement published in the SIR for 1986:

In 1986, as in previous years, the Secretariat, in carrying out the safeguards obligations of the Agency, did not detect any anomaly which would indicate the diversion of a significant amount of safeguarded nuclear material—or the misuse of facilities, equipment or non-nuclear material subject to safeguards under certain agreements—for the manufacture of any nuclear weapon, or for any other military purpose, or for the manufacture of any other nuclear explosive device, or for purposes unknown. It is considered reasonable to conclude that nuclear material under Agency safeguards in 1986 remained in peaceful nuclear activities or was otherwise adequately accounted for.

From 2003, the IAEA started to use a new format for the Safeguards Statement based on an evaluation of all the information available to the Agency in exercising its rights and fulfilling its safeguards obligations for that year. The essential feature of the new format was that the statement distinguished between the different undertakings by states under the different types of safeguards agreements. The 2003 Safeguards Statement and the statements issued in subsequent years distinguished between the following:

- (a) States with a CSA and an AP, where the IAEA had completed sufficient activities and evaluation and had drawn the “broader conclusion”
- (b) States with a CSA and an AP, where the IAEA found no indication of the diversion of nuclear material placed under safeguards, but where evaluations aimed at drawing a conclusion regarding



the absence of undeclared nuclear material and activities (the broader conclusion) remained in progress

- (c) States with a CSA but no AP, where the IAEA found no indication of the diversion of nuclear material placed under safeguards
- (d) States with item-specific agreements, where the IAEA found no indication of the diversion of nuclear material placed under safeguards and no misuse of facilities and other items placed under safeguards
- (e) States with voluntary offer agreements, where the Agency found no indication of the withdrawal of nuclear material in the selected facilities otherwise than in accordance with the terms of the agreement
- (f) States that were found to be in breach with their respective safeguards agreements.

This marked the point where the agency started the development and implementation of the *state-level concept* (SLC). The SLC was initially introduced in the SIR for 2004, as the extension of the integrated safeguards concept to all other states with CSAs in force. The SIR for 2005, in the background to the Safeguards Statement, contained important clarification concerning the legal ground of the objective to verify the completeness of state declarations under comprehensive agreements. It stated:

While the Agency's authority to verify the correctness and completeness of a State's declarations under its comprehensive safeguards agreement derives from the agreement itself, the tools available to the Agency to do so under such an agreement are limited. The Model Additional Protocol . . . equips the Agency with important supplementary tools which address these limitations by providing the Agency with broader access to information and locations.

This new SLC is characterized by its three fundamental properties:

- (a) The objectives of safeguards implementation are formulated at the state level, recognizing the fact that the application of safeguards means verification of the state's compliance with its obligations under its safeguards agreement.
- (b) The development of verification procedures is carried out using a top-down approach: from state-to facility-level; for states with comprehensive agreements, this is based on the IAEA's analysis of plausible nuclear weapon acquisition paths available to each state, producing what the agency considers is the strategy a state might adopt for acquiring weapons-usable material through an undeclared chain of activities involving declared or undeclared nuclear material and declared or undeclared facilities.

The verification procedures reflect verification activities allowed under the scope of each CSA, and for states having an AP in force, the additional procedures allowed under an AP and the annual verification plan for optimizing both CSA Part II activities and AP activities.

- (c) The safeguards conclusion is drawn for each state on the basis of safeguards implementation results obtained following the annual verification plan for each state in accordance with the provisions of its safeguards agreement.

The formulation of the objectives of safeguards procedures under a comprehensive safeguards agreement, which were called the *generic state-level objectives*, was

- (a) To detect undeclared nuclear material and activities in a state
- (b) To detect undeclared production or processing of nuclear material at declared facilities
- (c) To detect diversion of declared nuclear material (diversion is understood here as undeclared removal of declared nuclear material from declared facilities)
- (d) To resolve anomalies, questions, and inconsistencies.<sup>69</sup>

Objective (c) here corresponds to the objective of paragraph 28 of INFCIRC/153 and is formulated at the state level.

In 2012, the SLC was questioned by several states, reflecting their concern that the concept was not properly described and that the secretariat had not sought the Board of Governors' formal approval. Some states considered that the practical implementation of the SLC could potentially result in subjective and politically motivated safeguards conclusions. The issues were considered by the IAEA Board and General Conference over a two-year period, which concluded in a 2014 General Conference resolution requiring that the implementation of the SLC would be carried out strictly in conformance with existing safeguards agreements, and the development and implementation of SLAs would be performed in consultation with the states involved.

The 2012–14 discussion was useful for further development and implementation of the SLC. It demonstrated that the IAEA safeguards system was a joint venture of the IAEA and its member states. It was agreed that such discussions between the secretariat and the member states should continue in future.

In summary, the period from 1991 has seen very substantial development of the agency's safeguards system. The focus of the first decades on the correctness of states' declarations was shown to be inadequate, and the IAEA, with considerable help from member states, has had to address the challenge of verifying completeness.

While the NPT clearly sets *completeness* as an obligation for non-nuclear-weapon states, in the first two decades of safeguards under the NPT no one had fully grasped what would be involved in verifying this. Since the 1990s, the complexity of this challenge has been reflected in the development of new concepts, such as integrated safeguards and the SLC. At the same time, the agency has had to develop major new capabilities in information collection and analysis and new verification technologies. A further challenge is developing methodologies for evaluating safeguards effectiveness regarding detection of undeclared activities. In addition to all these technical challenges, the increasingly qualitative content of the safeguards mission has inevitably led to greater political challenges.

# IAEA Safeguards System Today: Issues and Further Development

## Current Implementation Issues

In accordance with the developments described in the previous sections of this paper, the IAEA now declares that in implementing its safeguards system to verify states' obligations under their respective safeguards agreements, the agency is using the SLC. The IAEA reports in the 2018 SIR that safeguards were applied for 182 states with safeguards agreements in force. In those states, there were a total of 721 facilities under safeguards and 593 MBAs containing locations outside facilities where nuclear material was customarily used (LOFs). At the end of 2018, there were 212,814 significant quantities of nuclear material under IAEA safeguards.

Among the 182 states with safeguards agreements in force in 2018, 129 states had both CSAs and APs in force, 45 states had only CSAs, 3 states had safeguards agreements based on INFCIRC/66, and the 5 nuclear-weapon states had voluntary offer agreements and APs.

There were still 11 states parties to the NPT that had yet to bring into force CSAs as required by Article III of the treaty, so the IAEA did not apply any safeguards in these states. While there is no reason to believe there is any nuclear activity in those states, continuing failure to meet the requirements of the NPT cannot be considered satisfactory, and NPT parties in a position to encourage and assist these states to conclude their CSAs should do so.

These overall figures showing the number of states, facilities, quantities of nuclear material, and other items under safeguards serve to illustrate the diversity of objects with which the secretariat has to deal currently in implementing IAEA safeguards. At the same time, these figures cannot serve as a direct measure of the amount of work carried out by the agency in the implementation of safeguards, nor its complexity and effectiveness.

Unfortunately, there is no simple instrument or metric providing an answer to the question of how effective IAEA safeguards are today, because this effectiveness has at least two components: (a) the ability to detect a breach by a state of its obligations under its safeguards agreement and (b) the deterrent effect against such violations established by this detection capability. It is obvious that if the ability to detect any non-compliance is high, then the deterrence effect is also high.

In assessing the ability of the agency to detect any non-compliance of a state with the provisions of its safeguards agreement, one must evaluate the current level of implementation of the SLC by the secretariat. The 2018 SIR reports that the IAEA applied safeguards in accordance with the framework of this concept for all states having IAEA safeguards agreements. This has allowed the secretariat to make the Safeguards Statement for four groups of states:

- (a) States with a CSA and an AP in force
- (b) States with a CSA but without an AP in force

- (c) States with item-specific safeguards agreements
- (d) States with voluntary offer safeguards agreements.

In view of the great importance of the application of safeguards in non-nuclear-weapon states parties to the NPT, let us consider this category of states and the issues associated with them. There are issues external to the secretariat as well as internal issues that affect the effectiveness of IAEA safeguards implementation.

The principal external issue is the fact that a number of CSA states, including some states with nuclear facilities, have not concluded an AP. As noted earlier, five CSA states with nuclear facilities have yet to negotiate an AP; three such states have signed an AP but not yet ratified it, and one state is implementing its AP provisionally. Every effort should be made to persuade and assist these states to conclude APs without further delay.

Other external issues include the performance and effectiveness of state and regional systems of accounting for and control of nuclear material (SSACs and RSACs); restrictions on access to locations, material, facility records, and other relevant documentation experienced by IAEA inspectors in a number of states; and some difficulties in relation to customs clearance of IAEA safeguards equipment. These issues, though sometimes complex and having a negative impact on the effectiveness of IAEA safeguards, are outside the secretariat's direct capability, though usually they can be solved with due negotiation and interaction by the IAEA with the states concerned.

At the same time, internal issues totally connected with the secretariat, such as technical capabilities and performance and behavior of staff, also influence the effectiveness and efficiency of IAEA safeguards implementation. Some of these causes might be corrected, if necessary, by the agency's management. Others depend on future technology developments and improved practices undertaken by the state and facility operators.

## Transition from Facility-Level Concept to State-Level Concept Still to Be Completed

From reading the 2018 SIR, one can reach the conclusion that the transition from the facility-level concept to the SLC is still to be completed. The statistics in this SIR show that of the 53 NNWS with (a) CSAs, (b) an AP in force, and (c) nuclear facilities, the broader conclusion had been reached, and integrated safeguards were being implemented in 42 (that is, 79 percent) of these states. For the remaining 11 states with a CSA, an AP, and nuclear facilities, the process of reaching the broader conclusion was still going on and the conclusion that safeguarded material remained in peaceful activity was based on measures under the facility-level concept.

This situation might be explained by the fact that most of the safeguards experience accumulated and the documentation produced in the secretariat are based on the facility-level concept. For example, the Safeguards Criteria document, which continues to some extent to be used today, is based on the facility-level concept.

One of the directions in which the transition from the facility-level concept to the SLC should proceed is connected with the secretariat's definition of the SLC:

The general notion of implementing safeguards in a manner that considers a State's nuclear and nuclear-related activities and capabilities as a whole, within the scope of the State's safeguards agreement.<sup>70</sup>

This definition is not applicable for safeguards implementation under item-specific and voluntary offer agreements. Neither of these agreement types prompts the IAEA to consider a state's nuclear activities as a whole. On the contrary, under such an agreement only part of a state's nuclear activities is subject to IAEA safeguards. Second, this definition is too narrow. It does not include such important aspects of the SLC as the formulation of generic, state-level objectives of verification activities in accordance with the provisions of safeguards agreements, the top-down principle of the development of verification activities, and the drawing safeguards conclusions at state level.

With regard to the implementation of the SLC in states with CSAs, the classical notions used in the Safeguards Criteria—that is, the quantity goal and the timeliness goal (see the associated parameters in Table 1 on page 23)—require reconsideration to adjust them for implementation safeguards in the state as a whole.

There are two aspects of such adjustment. One is connected with verification of the data presented by the SSAC; the second is connected with evaluation of the completeness of a state's declarations. In the first case, the verification of nuclear material accountancy remains of fundamental importance. The SQ parameter is still used in the process of evaluating the correctness of the SSAC findings and setting IAEA verification plans during physical inventory verification at declared facilities. At the same time, this parameter could either be reduced, as in the view of some experts that the quantities of nuclear material in modern nuclear weapons designs is smaller than in the old weapons designs, or be made variable, while the quantity verification is only part of the whole approach, which includes both quantitative and qualitative measures.

In contrast, the SQ parameter is not applicable to the verification activities aimed at detecting undeclared nuclear material and activities. Use of even small quantities of undeclared nuclear material in an undeclared nuclear activity—for instance, the development of enrichment or reprocessing technology—represents a violation by the state of its obligation under the safeguards agreement with regard to the completeness of its declarations. That could mean the state is in non-compliance with its obligations under the NPT. This explains the importance of the evaluation and verification activities aimed at detection of undeclared nuclear material and activities.

The timeliness component of an inspection goal was introduced in the Safeguards Criteria as a time interval between two consecutive inspections required for the IAEA to be able to draw the conclusion that there has been no abrupt diversion of one or more SQ at a facility during a calendar year. An *abrupt diversion* refers to the diversion of one SQ or more of nuclear material in a short time (i.e., within a period that is less than the material balance period).

During the initial implementation period of integrated safeguards, the guidelines for implementing integrated safeguards included a set of so-called Integrated Safeguards criteria. In those criteria, the timeliness component of the inspection goal was increased from 3 months to 12 months for spent fuel and from 1 month to 3 months for fresh MOX fuel.<sup>71</sup> Subsequently, however, the use of the Integrated Safeguards criteria was discontinued, following SAGSI's advice. In the SLC, the frequencies and intensities of verification activities are those specified in the SLA for a given state. These frequencies and intensities are defined on the basis of the acquisition path analyses carried out by the secretariat for each state. In fact,

the timeliness component of the verification activities under the SLC involves not only the frequency of inspecting the declared facilities but also the frequency of the other evaluation and verification activities, including activities aimed at detecting undeclared nuclear material and activities.

Thus, there is a need for a new approach for setting the timeliness requirements for evaluation and verification activities. As a basis for such an approach, one may consider the estimated time required to implement a major acquisition path in a state with a given type of nuclear fuel cycle and with known technical capabilities. The data required to carry out such an analysis come from the state's declaration under its AP, evaluated by the agency with consideration of also all other safeguards-related information available to it.

The approach for establishing the timeliness requirements can be illustrated by the following considerations:

- (a) For any state with a CSA, there should be at least one state evaluation performed during the year in order to draw the annual safeguards conclusion required for the Statement of Conclusion reported in the SIR.
- (b) Not every declared facility in a state needs to be inspected during the year: a facility might be selected for inspection either on the principle of random selection or depending on the importance of the facility and the category of nuclear material it handles for the acquisition path considered.
- (c) The frequency of complementary access depends on the estimated technical capabilities of the state to acquire the technology crucial for implementing the acquisition path considered.

The frequencies referred to are the frequencies for routine evaluation and verification activities; in the case of finding an anomaly or inconsistency, the frequencies and intensities of verification activities would need to be established on a case-by-case basis. As regards complementary access, we note the issue is not so much a question of frequency, but rather the extent of such access; broadly speaking, the locations selected for access will be more important than the frequency of access.

Finally, here we raise an issue of terminology that underlies a major issue of substance. The term *state-level concept* could imply a theoretical or non-definitive status. The international community should be able to look forward to the finalization of this transitional phase, a progression from conceptual development to a *state-level framework*, or other appropriate term, including a process for Board approval of the end result.

## Detection of Undeclared Nuclear Activities

Detection of undeclared nuclear activities remains a considerable challenge, and meeting this challenge continues to be a work in progress. As outlined above, secretariat staff develop a safeguards strategy for each state on the basis of acquisition path analysis, considering the various ways the state could acquire nuclear material; how undeclared nuclear activities, if any, could be linked to declared parts of the fuel cycle; the indicators that might be present if there were undeclared activities; and how such indicators could be detected.

Widening the range of information available to the IAEA to enhance its knowledge and understanding of a state's nuclear activities is a vital part of this process. The IAEA is able to gain the information it needs for

safeguards analysis and planning in a variety of ways. It may gather the information itself—for example, using inspectors in the field or from open sources such as data mining and commercial satellite imagery. The state concerned is obligated to provide certain information in accordance with its safeguards agreement and AP and may be asked to provide additional information for explanatory or transparency purposes. And third parties, including other states, may volunteer useful data such as export approvals and denials or intelligence information.

It is unrealistic to expect the IAEA to detect undeclared nuclear activities without assistance. While the agency is developing considerable skills in information collection and analysis, including techniques such as satellite imagery analysis, it can never hope to match the intelligence capabilities of a major state. A partnership between states and the agency is required. This is anticipated by the IAEA Statute, which provides that each member state should make available such information as would, in the judgment of that state, be helpful to the agency.<sup>72</sup> NPT review conferences have called on states parties that have concerns regarding safeguards non-compliance by other states, to direct such concerns, along with supporting evidence and information, to the IAEA to consider, investigate, draw conclusions, and decide on necessary actions in accordance with its mandate.<sup>73</sup>

In fact, information provided to the IAEA by states has been very important in most, if not all, of the non-compliance cases that have arisen to date.<sup>74</sup> Needless to say, where the IAEA is given third-party information, it should regard all such information as questionable, unless and until it is able to confirm the information through independent means.

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**It is unrealistic to expect the IAEA to detect undeclared nuclear activities without assistance. ... A partnership between states and the agency is required.**

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## Technical Capabilities for SLC Implementation

To implement the SLC, the secretariat needs not only a good understanding of the SLC and related management practice, but also a sufficient technical base for obtaining relevant safeguards information and for the treatment of this information.

To reach the goals for timely detection of diversion of an SQ and detection of misuse of a declared nuclear facility, the secretariat relies on a variety of equipment for measurement and instrumentation for containment and surveillance measures. Currently the IAEA possesses a large number of various instruments and hardware for these purposes. All this equipment requires maintenance and support for use in the field. As indicated in the 2018 SIR, significant financial and human resources were dedicated to performance monitoring to ensure the reliability of the agency's equipment. At present, the reliability of digital surveillance systems, nondestructive assay (NDA) systems, unattended monitoring systems, and electronic seals has exceeded the target goal of 99 percent availability.

In parallel with the use of available equipment, there is active development of new NDA measurement systems. For example, the 2018 SIR reports that, following the completion of field testing, the performance of the fast-neutron coincidence collar (FNCL) for the verification of fresh fuel assemblies containing burnable poison rods was evaluated; results showed the FNCL to be more accurate and four times faster than systems based on thermal neutron detection.

Remote data transmission (RDT), formerly referred to as remote monitoring, gives the agency the capability to receive data at IAEA headquarters in Vienna from unattended safeguards systems installed in facilities. The use of RDT enables greater verification efficiency by relieving inspectors of the task of data collection at facilities and allows early detection of any deterioration in system performance.

To fulfill the objective of detecting any undeclared nuclear material and activity, the secretariat must have tools to identify evidence that indicates the existence of such a possibility. One such tool is environmental sampling. In the application of this tool, both the correct sampling procedure and the sample evaluation process are important. According to the 2018 SIR, the implementation of new modeling tools and the automation of reporting features, including graphics, have enabled the secretariat to improve this activity.

On May 15, 2018, the secretariat completed, on schedule, the planned modernization of safeguards information technology. The work done in the framework of the Modernization of Safeguards Information Technology (MOSAIC) project has enhanced existing tools and software in the safeguards information treatment practice, introduced new information treatment tools and software and strengthened information security. Through the completion of the modernization activities, the secretariat has established an information treatment system that, *inter alia*, provides for effective and efficient collection processing and evaluation of safeguards-relevant information; increased facilitation of the analysis of diversion and acquisition path analysis; greater assistance to inspectors in conducting safeguards activities in the field and at Agency headquarters; better underpinning of the agency's safeguards techniques and technologies; and the continued drawing of soundly based safeguards conclusions.

The analysis of safeguards-relevant information is an essential part of implementing SLC and drawing safeguards conclusions. In drawing its safeguards conclusions, the agency analyzes the consistency of state declarations and compares them with the results of agency verification activities and other safeguards-relevant information available to it, such as commercial satellite imagery, open-source, and trade information. The secretariat continues to identify new relevant open sources of information to improve processes and to enhance methodologies and tools.

## Management and Transparency

During implementation of the facility-level concept, the administrative structure of the IAEA Safeguards Department and the practice of safeguards implementation and evaluation were well matched and understood by IAEA member states. Since the start of SLC implementation, the Safeguards Department has undergone some structural and procedural changes. There is no longer one section responsible for evaluation of safeguards implementation. Instead, there is a state evaluation group to evaluate IAEA safeguards implementation for each state—over 100 state evaluation groups in total. At the same time, according to the 2018 SIR, analysis processes and safeguards activities continued to be performed in a standardized manner. The quality management system within the Safeguards Department is said to provide regular oversight of the key safeguards processes and their results to ensure impartiality, effectiveness, and efficiency in safeguards implementation. Unfortunately, there is insufficient transparency to judge whether this is the case. Further efforts are required to improve the transparency of SLC implementation, including the process of drawing safeguards conclusions.



Under the facility-level concept, for example, the use of the Safeguards Criteria ensured both the transparency and impartiality of safeguards implementation. The frequency and intensity of verification procedures prescribed by the Safeguards Criteria for a given type of facility are the same, irrespective of the state in which the facility of a given type is located. Although the use of the Safeguards Criteria was criticized, with reason, for the lack of flexibility and, in some cases, for causing over-inspection, there were positive outcomes as well. The Safeguards Criteria provided a common base for discussing safeguards implementation in each state among the state authority, facility operators, and IAEA inspectors. The Safeguards Criteria served for the evaluation of the effectiveness of safeguards implementation; the results of such an evaluation were used for identifying implementation problems and for analyzing the root causes of such problems. In the past, such analyses helped to solve a number of generic implementation problems.

With the move from the facility-level concept to implementation of the SLC, the advantages of the Safeguards Criteria were, unfortunately, lost. New possibilities for restoring these safeguards implementation features should be investigated. The involvement of member states in developing such possibilities is crucial.

In summary, progressing the SLC and providing assurance against possible undeclared nuclear activities—together with all the associated processes for implementing, evaluating, and performing quality assurance and ensuring the confidence of member states—remain challenging tasks for the agency. Transparency and consultation are necessary to maintain confidence in the safeguards system. The current status of safeguards implementation provides a good foundation for the future development of the safeguards system, but it is essential for all stakeholders—the IAEA and member states—to ensure close and collaborative engagement.



An IAEA analytical chemist measuring the plutonium content in an inspection sample. The typical accuracy for such measurements is 0.1%. Plutonium toxicity requires that such operations be carried out in glove boxes to prevent contamination. Photo: D. Calma, IAEA.

## Future Implementation of IAEA Safeguards

Here we prognosticate about the broad directions that the IAEA safeguards system could take over the next several decades. We assume that the international consensus on the vital importance of the non-proliferation regime will remain and, hence, that the IAEA will continue with its responsibilities pursuant to the NPT and the various safeguards agreements. We also assume—we hope not too optimistically—that NPT states that have yet to conclude their required comprehensive safeguards agreement will do so, that CSA states still without an AP will conclude one, and the number of states in which the IAEA is able to derive broad conclusions will continue to increase to 100 percent. New nuclear facilities will be constructed and placed under comprehensive safeguards, and aging facilities will be shut down and decommissioned.

Against this background, we believe the future of the safeguards system will be influenced by (a) the future of nuclear power development, including resolution of spent fuel management and disposition, assurances of fresh fuel supply, and further enhancements of nuclear safety and security; (b) whether sensitive nuclear technologies spread to further states or are multilateralized; (c) possible advances in safeguards technology; and (d) possible progress in relation to Article VI of the NPT.

Regarding the future of nuclear power, there are two broad possibilities. The pessimistic vision sees stagnation of world nuclear power up to its total disappearance for various reasons (this might happen by 2100). The optimistic outlook envisions growth of nuclear power, perhaps driven in part by the increasing demands to address climate change. In the first case, the IAEA's safeguards workload would shrink. In the

second case, it would grow, but the extent of this growth would depend on possible multilateralization of the nuclear fuel cycle and advances in safeguards technology.

Regarding sensitive nuclear technologies, it is worth reflecting that the parts of the fuel cycle of greatest relevance for safeguards are those where fissile materials, or direct-use materials (principally highly enriched uranium [HEU] or separated plutonium), can be produced or are used—namely, enrichment and reprocessing. If it were possible to have total assurance that a particular state did not have enrichment or reprocessing capabilities (or no HEU or separated plutonium), then routine safeguards would not be required in that state. At present, total assurance is not achievable, so a certain level of safeguards effort is required to counter the possibility of undeclared enrichment or reprocessing activity. In this regard the SLC is a mechanism by which the IAEA can work toward a rational level of safeguards effort based on state-specific factors.

Conversely, for those states that have enrichment or reprocessing activities, not only is significant safeguards effort required, but there is an issue of effectiveness; it could be difficult to ensure timely warning of major safeguards violations. This is especially the case where states hold inventories of direct-use materials, which can be diverted very quickly. If the number of states with these activities and materials increases, there will be consequences both for safeguards workload and for the level of assurance safeguards can provide. Another factor will be the extent to which proliferation-resistant attributes are incorporated into the fuel cycle. Concerns with sensitive technologies and materials would be reduced if they were controlled on a multilateral rather than a national basis.

Progress in relation to Article VI of the NPT (disarmament) could also have major implications for IAEA safeguards—for example, if safeguards were extended to fissile materials in the NPT nuclear-weapon states and the other nuclear-armed states.

Regarding advances in safeguards technology, a number of ideas have been advanced for monitoring technologies that could enhance the IAEA's detection capabilities and significantly reduce routine safeguards effort. Technologies already being deployed include process monitoring with data transmission and increased digitalization of nuclear material accounting. Concepts under consideration for future use include wide area environmental monitoring (referred to in the AP), antineutrino detection, and satellite-based multispectral analysis.

Technical advances have played a major role in enabling the IAEA to meet an expanding workload without requiring corresponding increases in resources, and no doubt they will continue to do so. However, the importance of inspector presence in a state should not be overlooked. Care must be taken in balancing inspection effort in IAEA headquarters and in the field; the observational skills of inspectors make an essential contribution to safeguards effectiveness.

# Conclusions

The IAEA safeguards system fulfills a vital role underpinning the NPT, reinforcing commitments to the non-proliferation of nuclear weapons, and providing confidence that nuclear energy is used for exclusively peaceful purposes. Effective safeguards are also essential for achieving a world free of nuclear weapons.

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**As the safeguards system develops further, the agency and member states should consider the development of a collaborative safeguards culture that can help ensure that the operation of safeguards as whole ... reflects shared principles and values and provides the best possible outcomes.**

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In this paper, we hope we have given some idea of the challenges faced in the evolution of the IAEA's safeguards system and how the agency, with the support of its member states, has been able to confront these challenges. Developing an inspectorate to verify peaceful use commitments in an area that is technologically complex and of existential importance to the entire international community is a truly remarkable achievement—an achievement recognized by the award of the Nobel Peace Prize in 2005.

The challenge of ensuring timely detection of undeclared nuclear activities is ongoing. So too is the challenge of meeting an expanding workload with limited resources. For the IAEA to have the best chance of meeting these and other challenges, it is essential for safeguards to be seen as a collaborative responsibility. This has a number of aspects. Every state benefits from the contribution to international peace and security that the safeguards system makes. It follows that it is in the national interest of every state to cooperate with the safeguards system. This means full political support for the work of the agency. One aspect of this is acceptance of the most effective, applicable form of safeguards. In other words, states without an AP must not be able to hold safeguards effectiveness hostage to extraneous political goals.

A collaborative approach includes information sharing. Where states have suspicions regarding another state, safeguards provide an impartial mechanism for resolving such suspicions. A collaborative approach also requires a high degree of transparency on how the safeguards system operates, how decisions are made, and how conclusions are reached. Transparency is essential for confidence. It requires constructive dialogue between the agency and member states, including on safeguards approaches and methodologies, with the objective of making the IAEA safeguards system the success we all need.

The final point we will mention here is the need for member states to ensure that outstanding professionals are made available for staffing the agency. Ultimately, the performance of the safeguards system depends on the quality of its staff.

Most of the issues raised here could be brought together under the heading of safeguards culture. As the safeguards system develops further, the agency and member states should consider the development of a collaborative safeguards culture that can help ensure that the operation of safeguards as whole—the IAEA's safeguards system and states' interaction with it—reflects shared principles and values and provides the best possible outcomes.

## About the Authors

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## Endnotes

- <sup>1</sup> IAEA, *The Agency's Safeguards*, INFCIRC/26, para. 18.
- <sup>2</sup> Other agreements setting out peaceful use obligations verified by IAEA safeguards include nuclear weapon-free zone treaties and nuclear cooperation agreements.
- <sup>3</sup> Harry Truman, Clement Attlee, and W. L. MacKenzie King, *Agreed Declaration Relating to Atomic Energy*, Washington, DC, November 15, 1945, <https://iea.uoregon.edu/treaty-text/1945-declarationatomicenergytext>.
- <sup>4</sup> Early efforts at nuclear arms control and safeguards are summarized in James Tape and Joseph Pilat "Nuclear Safeguards and the Security of Nuclear Materials," in *Nuclear Safeguards, Security and Nonproliferation*, ed. James Doyle (Oxford, U.K.: Butterworth-Heinemann Press, 2008).
- <sup>5</sup> Dwight Eisenhower, "Atoms for Peace," address to the 470th Plenary Meeting of the United Nations General Assembly, December 8, 1953, <https://www.iaea.org/about/history/atoms-for-peace-speech>.
- <sup>6</sup> IAEA Statute, Article III.A.5.
- <sup>7</sup> For the most definitive work on the negotiation of the NPT, see Mohamed Shaker, *The Nuclear Non-Proliferation Treaty: Origins and Implementation, 1959–1979* (London: Oceana, 1980).
- <sup>8</sup> As of November 23, 2019, 191 states were parties to the NPT, including 5 nuclear-weapon states. See the website of the United Nations Office for Disarmament Affairs at <http://disarmament.un.org/treaties/t/npt>.
- <sup>9</sup> IAEA Statute, Article III.A.5.
- <sup>10</sup> IAEA, *Report of the International Atomic Energy Agency to the General Assembly of the United Nations Covering the Period 1 July 1958 to 30 June 1959*, INFCIRC/10, para. 213.
- <sup>11</sup> INFCIRC/10, para. 212.
- <sup>12</sup> The safeguards system was extended to reactors above 100 MWth in INFCIRC/26/Add.1, published on April 9, 1964.
- <sup>13</sup> INFCIRC/26, para. 18.
- <sup>14</sup> INFCIRC/26, para. 17. The term *further any military purpose* comes from Article II of the IAEA Statute.
- <sup>15</sup> IAEA Statute, Article XII.C.
- <sup>16</sup> INFCIRC/26, para. 40.
- <sup>17</sup> IAEA, *The Agency's Safeguards System (1965)*, INFCIRC/66.
- <sup>18</sup> See page 1 of INFCIRC/66/Rev.2. For convenience, the term *INFCIRC/66* will be used in this paper for all versions of this INFCIRC unless indicated otherwise.
- <sup>19</sup> INFCIRC/66/Rev.2, para. 3.
- <sup>20</sup> INFCIRC/66/Rev.2, para. 15.
- <sup>21</sup> *Principal nuclear facility* means a reactor, a plant for processing nuclear material irradiated in a reactor, a plant for separating the isotopes of a nuclear material, a plant for processing or fabricating nuclear material (except a mine or ore-processing plant) or a facility or plant of such other type as may be designated by the Board from time to time, including associated storage facilities.
- <sup>22</sup> In accordance with INFCIRC/66/Rev.2, para. 26(d).
- <sup>23</sup> IAEA Statute, Article III.A.1.
- <sup>24</sup> Many books have been written on the NPT. Interested scholars should begin with Mohamed Shaker's *The Nuclear Non-Proliferation Treaty*.
- <sup>25</sup> According to George Bunn, there was a time in the negotiations when the United States was prepared to accept a treaty with no verification obligations. Bunn and Roland Timerbaev developed draft language for Article III by beginning with the provisions of the Tlatelolco Treaty and creating a text that each could support through their personal contacts. (Private communication from George Bunn, now deceased.) See also the memoriam of Roland Timerbaev, written by George Bunn's son, Matthew Bunn, at <https://www.armscontrol.org/act/2019-09/features/roland-timerbaev-1927-2019-vanguard-nuclear-nonproliferation>.
- <sup>26</sup> Previous nuclear-free treaties—the 1959 Antarctic Treaty and the 1967 Outer Space Treaty—applied to unpopulated areas.
- <sup>27</sup> IAEA Statute, Article III.A.5.
- <sup>28</sup> IAEA, *The Structure and Content of Agreements between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons*, INFCIRC/153 (corrected).
- <sup>29</sup> NPT preamble.
- <sup>30</sup> NPT Article III.3.
- <sup>31</sup> See, for example, Article 29 of Australia's comprehensive safeguards agreement (INFCIRC/217).
- <sup>32</sup> IAEA Safeguards Glossary (2001), 2.3(b).
- <sup>33</sup> See INFCIRC/153, para. 14.
- <sup>34</sup> Brazil has had a program underway to develop a nuclear-powered submarine but has not yet approached the IAEA to develop the arrangements that would be needed. For a detailed discussion of this subject see Thomas E. Shea, *The Nonproliferation and Disarmament Challenges of Naval Nuclear Propulsion* (Washington, DC: Federation of American Scientists, 2017), <https://fas.org/pub-reports/the-nonproliferation-and-disarmament-challenges-of-naval-nuclear-propulsion/>.
- <sup>35</sup> Strictly speaking, the state's obligation relates to nuclear material in peaceful use, but as discussed, the state is also obliged to inform the IAEA of any nuclear material proposed for non-proscribed military use and to conclude an appropriate arrangement covering such material.
- <sup>36</sup> It is also conceivable that a state might have assistance from another state, including the possible use of facilities and capabilities owned and operated by a state having nuclear weapons.
- <sup>37</sup> H. Gruemm, "Safeguards Verification—Its Credibility and the Diversion Hypothesis," *IAEA Bulletin* 25, no. 4 (1983): 27–29, <https://www.iaea.org/sites/default/files/publications/magazines/bulletin/bull25-4/25403452729.pdf>.
- <sup>38</sup> Gruemm, "Safeguards Verification," is an excellent discussion of this topic.

- <sup>39</sup> INFCIRC/153, para. 19.
- <sup>40</sup> INFCIRC/153, para. 28.
- <sup>41</sup> It is conceivable that if a state is falsely accused of having a nuclear weapon program, the state might invite the IAEA to carry out inspections at sites that would otherwise not be accessible to IAEA inspectors, with full protection being provided for confidential information. Such an inspection could be organized under the provisions for special inspections (see INFCIRC/153, para. 73(b), for example).
- <sup>42</sup> Gruemm, "Safeguards Verification."
- <sup>43</sup> INFCIRC/153, para 29.
- <sup>44</sup> INFCIRC/153, para 30.
- <sup>45</sup> Containment and surveillance measures include seals, cameras, and equipment such as instruments for radiation detection and flow monitoring.
- <sup>46</sup> Ad hoc inspections are applied during the period when the safeguards equipment and procedures are being developed for a facility just being placed under safeguards. During this period, there are no agreed limits on, for example, inspection effort. Ad hoc inspections can also be applied when changes are made to the design or operational arrangements at a facility placed under safeguards, until the safeguards approach and the corresponding subsidiary arrangements are modified.
- <sup>47</sup> Other strategic points are used, for example, to provide access within facilities processing direct-use nuclear material for the purposes of achieving detection timeliness while the facility remains in operation.
- <sup>48</sup> CSAs, with appropriate adjustment, have been used for non-NPT parties—for example, Albania and Ukraine before they joined the NPT as well as for Taiwan.
- <sup>49</sup> *Flagging* refers to attaching safeguards obligations to specified material or items, usually as a requirement of the supplier.
- <sup>50</sup> While NPT activities were substantially greater than those subject to safeguards under agreements based on INFCIRC/66, demands for non-NPT safeguards also expanded during this period, including on-load power reactors, reprocessing, heavy water production, and possible enrichment under transfer agreements (e.g. from Germany to Brazil).
- <sup>51</sup> India's CIRUS Reactor commenced operations in 1960. The name indicated the suppliers involved: C for Canada (the reactor), I for India, R for reactor, and US for the United States (for the heavy water). While CIRUS was not under IAEA safeguards, having been supplied in 1954 and therefore predating the IAEA safeguards system, both Canada and the United States stipulated that the reactor was to be used for peaceful purposes only.
- <sup>52</sup> See, for example, the India-IAEA agreement of November 17, 1977, covering the supply of heavy water from the Soviet Union (published as INFCIRC/260) and the Cuba-IAEA agreement of May 5, 1980 covering the supply of a nuclear power plant from the Soviet Union (published as INFCIRC/281).
- <sup>53</sup> A *critical mass* is the minimum amount of fissile material needed to maintain a nuclear chain reaction.
- <sup>54</sup> SAGSI comprises a group of experts outside the IAEA established by the IAEA director general to advise on safeguards matters.
- <sup>55</sup> A *protracted diversion* would involve removal of small amounts of nuclear material over an extended period.
- <sup>56</sup> An *abrupt diversion* would involve removal of large amounts of nuclear material between inspections, with the diverter trying to produce one or more nuclear weapons as quickly as possible, preferably before the next inspection.
- <sup>57</sup> The Safeguards Analytical Laboratory in Seibersdorf, Austria.
- <sup>58</sup> By United Nations Security Council Resolution 687 and subsequent resolutions.
- <sup>59</sup> Jon Jennekens, Ray Parsick, and Adolf von Baeckmann, "Strengthening the International Safeguards System," *IAEA Bulletin* 1 (1992): 6–10, <https://www.iaea.org/sites/default/files/34103450610.pdf>.
- <sup>60</sup> The DPRK has since established a uranium enrichment program, tested nuclear weapons, and developed a nuclear arsenal.
- <sup>61</sup> IAEA, *Model Protocol Additional to the Agreement(s) between State(s) and the International Atomic Energy Agency for the Application of Safeguards*, INFCIRC/540.
- <sup>62</sup> INFCIRC/540, Foreword.
- <sup>63</sup> Information is from IAEA AP status report of February 20, 2020, <https://www.iaea.org/sites/default/files/20/01/sg-ap-status.pdf>.
- <sup>64</sup> Iran is applying its AP provisionally.
- <sup>65</sup> Algeria, Belarus, and Malaysia.
- <sup>66</sup> Argentina, Brazil, Egypt, Syria, and Venezuela.
- <sup>67</sup> IAEA, *The Development of Integrated Safeguards*, GOV/INF/2000/4, March 9, 2000.
- <sup>68</sup> IAEA, *The Development of Integrated Safeguards*, GOV/INF/2000/26, November 17, 2000 (not publicly available).
- <sup>69</sup> From the 2005 SIR, p. 99.
- <sup>70</sup> Jill N. Cooley, "Overview of the Development and Discussion on Evolving Safeguards Implementation," presented to the Symposium on International Safeguards: Linking Strategy, Implementation, and People, October 2014, Vienna, Austria.
- <sup>71</sup> MOX refers to mixed oxides of plutonium and uranium.
- <sup>72</sup> IAEA Statute, Article VIII.A.
- <sup>73</sup> This call was made in the final documents of the 1995, 2000, and 2010 review conferences (no final documents were agreed on at the 2005 and 2015 review conferences). See the Final Document of the 2010 Review Conference, Volume I, Part I, paragraph 9, [https://undocs.org/NPT/CONF.2010/50%20\(VOL.I\)](https://undocs.org/NPT/CONF.2010/50%20(VOL.I)).
- <sup>74</sup> To date, the IAEA has reached non-compliance findings with respect to Iraq (1991), Romania (1992), the DPRK (1993), Libya (2004), Iran (2006), and Syria (2011).



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