VIEWPOINT:
NUCLEAR SAFEGUARDS AS AN EVOLUTIONARY SYSTEM

by John Carlson, Victor Bragin, John Bardsley, and John Hill

Nuclear safeguards are a key element in international action against the spread of nuclear weapons. Safeguards are directed at the verification of peaceful use commitments: commitments given by states through international agreements to use nuclear materials and facilities for exclusively peaceful purposes. Through inspections and evaluations, conducted principally by the International Atomic Energy Agency (IAEA), safeguards serve to verify states' peaceful use declarations. Although the current safeguards system is generally limited to verifying that states' declarations are *correct*, new safeguards aim to verify that these declarations are *complete* as well. This reflects recognition that, in addition to deterring the diversion of nuclear materials from declared facilities, it is becoming more important to identify potential proliferation that is not based on diversion from known facilities. This viewpoint seeks to highlight some key areas in which the safeguards system is evolving in response to this new challenge.

Currently, safeguards comprise technical verification measures to:

- provide *assurance* to the international community that states are honoring their peaceful use commitments; and
- *deter* the possible diversion of nuclear material from safeguarded activities by the risk of early detection.

It should be emphasized that the task of safeguards is not *prevention*, except insofar as risk of discovery may act as a deterrent to a would-be proliferator. The IAEA is not an international policeman. Rather, the political objective of safeguards can be described as *assurance*: to verify that states are complying with their peaceful use commitments, and to assist states that recognize giving such assurance as being in their own interest to demonstrate their compliance to others. Thus the safeguards system plays an important role in confidence-building, and the evolution of the system to meet new challenges should take place in a way that maintains and enhances this confidence-building function.

The current safeguards system is an international regime based on cooperation and regulation that works to control the use of nuclear energy in order to meet the security interests of both individual states and the international community as a whole. Under this regime, access to the benefits of nuclear technology is conditional upon a verified peaceful use commitment. Verification initially relied upon bilateral agreements between nuclear suppliers and recipients, each applying to specific facilities. Beginning in 1957, verification responsibilities under these agreements were progressively transferred to the newly established International Atomic Energy Agency. The IAEA safeguards system assumed a fully multilateral character with the conclusion of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) in 1968.

Safeguards applied under the NPT, often referred to as "classical" safeguards, retain a strong emphasis on nuclear materials accountancy and are primarily concerned with verifying the correctness of states' declarations on their nuclear activities to the IAEA. Classical safeguards are directed primarily at the detection of diversion, i.e., the undeclared removal of nuclear material from safeguards coverage. The IAEA was not expected to look for undeclared nuclear activities, except as revealed through diversion. Prior to the 1991 Gulf War, it was thought that the establishment of a self-contained capability to produce nuclear weapons material entirely separate from a state's declared nuclear program would be too large and difficult an undertaking for most would-be proliferators. It was also thought that any attempt to

Mr. John Carlson is Director General of the Australian Safeguards and Non-Proliferation Office (ASNO). Dr. Victor Bragin is Safeguards Adviser at ASNO. Mr. John Bardsley is Assistant Secretary of ASNO. Mr. John Hill is Head of the International Safeguards Section at ASNO. This paper reflects the personal views of the authors and does not necessarily represent Australian government policy.

establish military-capable facilities (either plutonium production reactors and reprocessing plants or uranium enrichment plants) independent of declared activities would be readily detected by national intelligence efforts. Diversion of nuclear material from facilities under safeguards was therefore considered the most plausible scenario, and safeguards thus reflected the belief that detection of diversion would reveal the existence of any clandestine nuclear activities.

Although classical safeguards have performed well in meeting the expectations of the international community, events this decade have raised new concerns. The failure to address adequately the possibility of undeclared nuclear activities totally separate from safeguarded activities, as revealed in Iraq, has been seen as a major shortcoming, and expectations have changed accordingly. The completeness, as well as the correctness, of states' declarations is now recognized as a major issue for the safeguards system.

Substantial efforts are being made to strengthen the IAEA's capabilities in order to provide credible assurance of the absence of clandestine nuclear activities. In 1997, agreement was reached on a Model Additional Protocol[1] substantially extending the IAEA's authority. Significant progress has been made by the IAEA and its member states in developing new approaches, technologies, and techniques to ensure that this new authority is used effectively.[2]

While the classical safeguards system is commonly considered to be a *quantitative* system, new safeguards approaches have a far greater *qualitative* component. It should be appreciated, however, that classical safeguards also have a substantial qualitative component. Ultimately all safeguards are qualitative, in the sense that they are aimed at a *political* objective and so must satisfy subjective judgments. Safeguards aim to exercise a positive influence on the behavior of states, by providing assurance that reinforces nonproliferation commitments, and by deterring noncompliance through the risk of timely detection. Thus, to be effective, safeguards must be both technically sound and politically credible. Both factors are central to the question of how outcomes are evaluated and, more importantly, how outcomes are presented to the international community.

A major theme in the current safeguards debate is *integration*, the rationalization of classical safeguards with the new safeguards strengthening measures. As part of this rationalization process, it is timely to reassess traditional safeguards implementation practices. One concern is uniformity in the way safeguards activities are implemented in different states. Another is whether the traditional concept of safeguards confidentiality is consistent with the increasing importance of transparency. The safeguards system cannot fulfill its vital confidence-building role unless all states clearly understand how the IAEA conducts its new tasks and reaches its conclusions about the absence of undeclared activities. With the extension of safeguards into the area of assurance against undeclared nuclear activities, it is natural to anticipate that the safeguards system will start to evolve in new directions. This paper identifies and discusses four key aspect of this transition:

- a shift in emphasis from a classical, facility-based approach to a holistic, state-level approach;
- a move from mechanistic uniformity in safeguards implementation to a more flexible approach, which takes account of the differences between states' nuclear fuel cycles;
- a balance between classical and new safeguards measures, achieved by integration of the two, with the exact balance likely to vary with the circumstances of each state; and
- a greater emphasis on transparency, in contrast to the currently prevailing approach of maintaining confidentiality of the IAEA's activities in each state.

CLASSICAL IAEA SAFEGUARDS: INFCIRC/153

The NPT and its associated IAEA safeguards system are the centerpiece of the nuclear nonproliferation regime. States with comprehensive safeguards agreements —which comprise the non-nuclear weapon states party to the NPT[3]—agree to accept IAEA safeguards on all nuclear material within their territory or under their jurisdiction or control. The safeguards applied are set out in an agreement concluded with the IAEA, based upon the IAEA document Information Circular (INFCIRC)/153.[4]

The classical safeguards system relies upon the relative ease by which nuclear material can be measured and material balances calculated and verified. It is a basic requirement of IAEA safeguards that the operators of safeguarded nuclear facilities maintain, under the supervision of each country's national safeguards authority, detailed accounting records of all movements and other physical transactions involving nuclear material.[5]

IAEA inspectors regularly visit nuclear facilities to verify the completeness and accuracy of this documentation through activities such as checking inventories, sampling, and other analytical procedures. Nuclear material accountancy[6] is complemented by other techniques, such as containment and surveillance,[7] to maintain continuity of knowledge about nuclear material between inspections.

The classical safeguards system has the following general characteristics:

- although the NPT commitment to accept safeguards is expressed in terms of all the nuclear material in a state, in practice classical safeguards are facility-based, applying measures at the facility level;
- routine inspections are restricted to agreed "strategic points" within declared nuclear sites;[8]
- the technical objective of safeguards is the detection of diversion of nuclear material from declared facilities to nuclear weapons or to purposes unknown;
- the IAEA has not been expected to look for undeclared nuclear facilities or material, although safeguards approaches take into account the possibility that undeclared facilities may exist;
- classical safeguards, notwithstanding increasing use of containment and surveillance, are primarily based on nuclear material accountancy, and are hence seen as a quantitative system; and
- quantitative inspection goals underlie the criteria used by the IAEA in the evaluation of safeguards performance.[9]

The role of quantitative methods in the system may have given a semblance of certainty to the results of applying safeguards, perhaps contributing to a false sense of security about the extent of the assurance that classical safeguards can provide. The discovery of an advanced, clandestine nuclear weapons program in Iraq revealed the limitations of the classical system. Not only is diversion of safeguarded material unattractive because of the likelihood of early detection, but the opportunities to divert weapons-grade materials from a declared civil nuclear fuel cycle are limited. Thus a state pursuing a weapons program has an incentive to establish clandestine uranium enrichment or spent-fuel reprocessing capabilities. If a state is able to do this, it is unlikely it will jeopardize its weapons program by risking detection as a consequence of diversion from declared stocks of material.

ENHANCED SAFEGUARDS AGAINST UNDECLARED ACTIVITIES: INFCIRC/540

Events in Iraq have shown that for safeguards to continue their key confidence-building role, it is essential to address the issue of detection of undeclared nuclear activities. At the same time, safeguards must become more efficient in order to manage an expanding workload within budget constraints. New techniques, such as remote monitoring (closed-circuit television and other systems that transmit encrypted data to the IAEA by phone or satellite) and environmental analysis, offer both improved efficiency (through reducing inspection time) and greater effectiveness.

Provided that the risk of detection of diversion is set at an appropriate level, it is most likely that a proliferating state will attempt to establish a weapons program entirely outside safeguards coverage. Indeed, a state with uranium resources and clandestine nuclear upgrading capability might not have to contemplate diversion at all. Hence, in the years following the Gulf War, the focus of safeguards development has been enhancing the IAEA's capability to detect undeclared nuclear activities—to verify the *completeness* of states' declarations.

Safeguards efforts in this regard have been at two levels, the technical and the institutional. Technical efforts to develop the technology and methodology to address the risk of undeclared nuclear activities have made considerable progress, but much remains to be done. At the institutional level, efforts to enhance the authority of the IAEA have culminated in agreement on the text of a Model Additional Protocol, INFCIRC/540, to be used as the basis for each state to conclude an individual protocol in addition to its existing safeguards agreement with the IAEA (whether based on INFCIRC/153 or otherwise).

With the conclusion of INFCIRC/540, the IAEA has the task of developing and implementing new measures and integrating them with classical safeguards. The primary objective is to achieve a more effective safeguards system, but this must be done in the most cost-efficient way. Briefly, the new safeguards measures, which are directed specifically at providing assurance of the absence of undeclared nuclear activities, can be outlined as follows:

- *Enhanced data collection and analysis*. The state is to provide an Expanded Declaration[10] detailing its nuclear and nuclear-related activities, and the IAEA will have improved capacity to evaluate this information;

- *"Complementary access."* The IAEA will have rights of access at nuclear sites and nuclear-related locations, and will have access elsewhere to undertake environmental sampling and other measures;[11] and
- *Environmental sampling.* The IAEA will immediately be able to undertake location-specific environmental sampling,[12] with wide-area sampling[13] to be introduced in the future.

The key difference between classical safeguards and these new strengthened safeguards is that classical safeguards are based primarily on quantitative methods, while the strengthened safeguards are seen as qualitative. With strengthened safeguards, both implementation and evaluation will involve an increasing degree of judgment.

Australia played a major role in the negotiation of the Model Protocol, and in September 1997 became the first country to sign a protocol based on this model, reflecting the Australian government's strong support for the strengthening of safeguards. It is essential that the new measures for strengthening safeguards be brought into general application without delay. Indeed, the Model Protocol, together with INFCIRC/153 which it complements, is a consolidated statement of the contemporary IAEA safeguards system, representing the standard that should be applied to all comprehensive safeguards states. Australia is urging other states to conclude their protocols with the IAEA as soon as possible.[14] There seems to be no reason why most states cannot do so by the 2000 NPT Review Conference.

A wide range of new measures—such as remote monitoring, unannounced inspections, environmental analysis, and greater cooperation with national safeguards authorities—offers substantial advances in both the efficiency and the effectiveness of the safeguards system. An important aspect of the new strengthened safeguards measures being developed will be the rationalization and prioritization of routine safeguards inspections.

DEVELOPING A "WHOLE OF STATE" APPROACH

In the negotiation of the Model Additional Protocol, delegations expressed concern that the application of these measures should not simply be a function of the scale of nuclear activities in each state. In the initial development of safeguards, a requirement to avoid discrimination among participating states was met by adopting uniformity in safeguards application. This led to the practice in classical safeguards of basing the incidence of inspections on the quantities of nuclear material declared in each state (regardless of a state's suspected interest in proliferation). This can be seen as a disadvantage of an unduly quantitative approach, as it leaves little room for discretion to target inspection where concern may be greater, but declared material less. The Model Additional Protocol therefore specifies that verification should not occur in a "mechanistic" or "systematic" way.

INFCIRC/153 does actually provide for flexibility to meet the circumstances of each state. In particular, paragraph 81 details a number of criteria to be used for determining the actual number, intensity, duration, timing, and mode of routine inspections. These include the characteristics of the state's nuclear fuel cycle, the extent of international interdependence in that fuel cycle, the form of nuclear material in the state, and the effectiveness of the State's System of Accounting for and Control of nuclear material (SSAC). To date, however, the IAEA has not taken advantage of the flexibility offered by these provisions.

In the case of classical safeguards, which are essentially facility-based, uniformity can work (albeit inefficiently) because similar facilities can be treated alike. The new safeguards measures, however, are to be applied to states as wholes. Since no two states will have identical circumstances, we believe it will be necessary to establish a basis for determining the way safeguards should be applied in each state. Taking account of the differences between states will be essential to achieving the objectives of effectiveness and cost-efficiency. Provided this is done using objective criteria applied in a transparent way, the process will not be discriminatory, but will simply reflect the factual situation. While there should be impartiality in the IAEA's methodology, this need not translate into uniformity in safeguards implementation.

We suggest that the application of safeguards in each state should be based on a strategy developed to take account of the circumstances of that state. The starting point would be a comprehensive country file for each state. The broad purpose of the file would be to provide a basis for evaluating the national capability for producing or securing nuclear material, as well as for upgrading nuclear material through enrichment or reprocessing. In addition to details of declared nuclear activities and nuclear-related exports and imports, the file should cover matters such as uranium deposits, availability of nuclear-related materials, nuclear technology (both indigenous and imported), nuclear-relevant manufacturing capabilities and R&D, and the extent of any nuclear-relevant skills base (including tertiary programs and training obtained elsewhere). The IAEA is currently developing an approach along these lines.

We also believe there should be a cohesive approach to determining what information is required, how it can be obtained, evaluated, and (if necessary) cross-checked, and how it can be updated. Expanded Declarations submitted under Additional Protocols would be a primary source for this information, but would still require appropriate independent corroboration. Other sources could include public databases, industry and scientific literature, information held in all departments of the IAEA, and inspectors' reports, as well as information that may be provided by other states, such as that acquired through "national technical means." Guidelines would be required to determine when the IAEA should actively pursue information acquisition—through commercial satellite surveillance, for example—including in the case of a request from other states. Also required is a process of quality assurance, to ensure that the compilation and maintenance of files across the IAEA, and the assessments drawn from them, meet necessary standards.

The information in each country file would be compared with reports submitted by the state under the Additional Protocol and used to develop safeguards strategies. Strategies would be designed to prioritize any "questions and inconsistencies" in country reports and determine the approach to be followed in resolving these issues. Some form of guidelines would be required to ensure that standards are appropriate and consistent, although such guidelines should not be strictly prescriptive so as to allow for flexibility.

DIFFERENTIATING BETWEEN STATES

A structured analytical framework is also required to provide guidance in reaching decisions on matters such as:

- the degree of detail required on specific matters in the country file;
- the priority and associated timeframes to be accorded to resolving particular questions and inconsistencies;
- the extent of efforts to acquire additional information;
- the implementation of complementary access and short-notice inspections; and
- the scope of reductions in routine inspection activity under the program for integrated safeguards.

Some commentators have expressed the hope that the practical application of strengthened safeguards measures will somehow fall into place through the incidence of questions and inconsistencies that happen to arise. According to this theory, the greatest number of questions and inconsistencies can be expected to arise in those states where there might be some proliferation concern.

We think it is just as likely, however, that initially at least the greatest number of questions and inconsistencies will arise in those states that have the largest and most complex nuclear programs. Concentration of safeguards effort on these states, without any justification other than the number of questions and inconsistencies, would run counter to the general view among states that the focus of the strengthened safeguards activities should be on areas of proliferation concern, not on the largest civil programs. Conversely, it is quite possible that a state of proliferation concern might raise relatively few obvious questions and inconsistencies, and some other rationale will be required as the basis for determining safeguards effort.

Clearly safeguards effort should be focused where assurance of non-diversion is objectively assessed to be least. This is necessary on the grounds of both effectiveness and efficiency. Rather than rely on chance, or informal processes that run the risk of arbitrariness, criteria should be developed to guide the sort of decisions outlined here. It should be possible to arrive at a range of objective criteria that can be generally accepted as appropriate for these purposes. Developing new criteria that are appropriate and acceptable will require considerable thought and political sensitivity. Some ideas are suggested here as a starting point, with the expectation that the final outcome might be substantially different:

(1) Factors relating to the state's nuclear capabilities, and the character and extent of the state's fuel cycle:

- whether the state has enrichment and/or reprocessing facilities, or an interest in developing these capabilities, and whether its activities in this regard are consistent with the status, scale, or direction of the state's declared nuclear program;

- the state's nuclear manufacturing capability, and whether its nuclear technology is indigenous or imported;
- whether the state's declared program provides potential cover or assistance for an undeclared program;
- whether the state has a large research reactor(s) and hot cells; and
- whether the state has uranium resources.

(2) Factors affecting the assurance that the IAEA is able to derive from safeguards activities in the state:

- whether the state has an Additional Protocol in effect;
- the quality and completeness of information provided to the IAEA, and the extent of questions and inconsistencies arising in the course of the IAEA's evaluation; and
- the degree of cooperation with the IAEA in matters related to safeguards implementation (including technical competence and performance of the SSAC).

(3) Factors relating to potential proliferation pressures or possible proliferation indicators:

- whether the state has, or has had, a demonstrated or suspected interest in developing weapons of mass destruction;
- whether the state has suspicious nuclear-related procurement activities;
- whether the state possesses or is developing nuclear-capable delivery systems; and
- the state's strategic environment, such as whether it is located in a region of tension.

We have attempted here to avoid subjective factors, such as the orientation of a state's foreign policy, whether the state has an "open" or "closed" society, and so on.

The end goal would be the determination of weighting factors that the IAEA could take into account in allocating safeguards efforts, whether in terms of strengthened safeguards measures or reductions in routine inspections. Such an approach need not be strictly prescriptive; it would simply guide the IAEA in making judgments based on specific circumstances.

It is important to keep two points in mind:

(1) particularly in the case of states with modest nuclear programs, there would be practical limits to the reduction in routine inspection activity possible compared with current levels, and in fact overall activity may well rise; and

(2) the assessment of states under a scheme of this kind should be kept under regular review, so changes can be made, in either direction, as circumstances warrant.

It will be a considerable challenge to gain general agreement to certain of the aspects outlined here, but we believe those working for efficient as well as effective safeguards should be persistent, for two reasons. First, this is a possible way of establishing transparent and objective guidelines as a rational basis for prioritizing the IAEA's efforts and meeting its confidence-building function. Second, states should not consider IAEA evaluations made on such a basis to be an adverse reflection upon them: the safeguards system should be seen as a confidence-building measure, assisting states to assure others of their observance of nonproliferation commitments. To the extent that there are factors that might arouse concerns on the part of other states, it is very much in a state's own interest to ensure that the safeguards system is perceived to be effective in addressing those concerns. For example, states in a region of tension ought to be receptive to the advantages of more rigorous safeguards measures applied to them and their neighbors, and on reflection should be prepared to welcome an approach of this kind.

ISSUES RELATED TO SAFEGUARDS INTEGRATION

The safeguards system has always been a dynamic one, with new measures being introduced as they are developed and proven. In this sense, the reduction or replacement of some established safeguards measures by new measures, where the latter bring greater effectiveness and efficiency, should be neither unexpected nor problematic.

In considering issues of integration, however, a distinction should be drawn between improvements in efficiency, which can be made as a result of new technology, and changes that can be made as a result of increased confidence in the absence of undeclared activities. While the term "integration" is often used to encompass both these possibilities, in the most substantive sense integration really concerns only the latter.

Where there are simple efficiency improvements that could yield very substantial savings without a major change in existing safeguards approaches, these should proceed independently of the conclusion of Additional Protocols. For example, replacement of interim inspections on indirect-use material[15] and irradiated fuel by remote monitoring and short-notice inspections will yield efficiency gains and increase effectiveness by improving timeliness and deterrence.

The implications of integration are far greater where increased assurance of the absence of undeclared nuclear activities, derived from strengthened safeguards activities, gives rise to the possibility of substantial changes to established safeguards practices. The development of safeguards aimed at undeclared activities has obvious implications for the application of classical safeguards aimed at diversion from declared inventories: in the case of indirect-use material and irradiated fuel, diversion is plausible only if the state has the capability of upgrading the material by enrichment or reprocessing. If it is possible to derive an acceptable level of assurance that the state has no undeclared enrichment or reprocessing capability, diversion of these materials will largely cease to be an issue, and need not occupy significant inspection time.

Some of the benefits of integration will be achieved only in the long term. At this stage, the technical means and procedures necessary to demonstrate a high degree of assurance as to the absence of undeclared enrichment and reprocessing have yet to be established. Indeed, absolute assurance is unlikely ever to be achieved. This should not blind us to the possibility that significant gains could be achieved in the relatively short term.

Take, for example, the possibility of minimizing inspection activities on material from which nuclear weapons cannot be made without enrichment or reprocessing—indirect-use material and irradiated fuel. In appropriate cases, this could be done through greater use of the SSAC. Inspection activities essential to the proper closing of the material balance could be performed by the SSAC subject to audit on an unpredictable basis by the IAEA. This could be supplemented by short-notice inspections by the IAEA. The IAEA could then feel some confidence in reducing routine inspection activity in a particular state, through a combination of good results from strengthened safeguards activities and an evaluation along the lines discussed in the preceding paragraphs.

TRANSPARENT REPORTING ON SAFEGUARDS IMPLEMENTATION

First and foremost, the IAEA safeguards system has a confidence-building function, through providing both assurance that states are complying with their nonproliferation commitments and a mechanism to enable states to demonstrate this compliance. Under the classical safeguards system, in which the IAEA's methodology was well understood, fulfilling this confidence-building role was relatively straightforward. Now, with the IAEA's activities extending into more qualitative and subjective areas, it is absolutely essential that states develop a clear understanding of the new approaches and methodologies in order for the safeguards system to continue to provide the necessary degree of assurance.

The principal vehicle for the IAEA to state its safeguards conclusions and to outline its safeguards activities is the Safeguards Implementation Report (SIR), presented each year to the IAEA Board of Governors. Although considerably improved in recent years, the SIR still requires a specialist level of understanding, and on safeguards performance it avoids mentioning any specific state (other than those found not to be in full compliance with their safeguards agreements, such as Iraq and North Korea). Deriving assurance of the absence of undeclared nuclear activities is a particular challenge, both in the IAEA's evaluation of its performance and in the way it presents its conclusions to member states. Clearly such assurance can never be absolute, making states' understandings of the basis for the IAEA's conclusions all the more important.

States need to be satisfied that the IAEA has done all that is reasonable and prudent in each situation. As has been discussed, we believe there should be a clearly established methodology for how the IAEA collects and analyzes information, the extent to which it pursues specific matters, and the way it exercises its inspection and complementary access rights. There needs to be a quality-assurance process to ensure a satisfactory standard of performance across all relevant areas. Finally, there should be a rigorous process of evaluation, which would take into account not only safeguards performance as such, but the wider context, looking at factors along the lines discussed earlier. All these matters should be documented in guidelines that would be available to member states. Just as the strengthened safeguards system is concerned with transparency of states to the IAEA, it is essential that the IAEA should become transparent to states.

As one aspect of establishing a new approach to reporting on safeguards performance, both the IAEA and member states themselves should review whether the current practice of confidentiality operates to the detriment of greater transparency. Clearly confidentiality is essential for commercial and proliferation-sensitive matters, but not for reporting on safeguards performance. Given that the balance between "correctness" and "completeness" measures will be different for each state, to be meaningful the SIR will probably need to give an outline, for each state, of the activities on which the IAEA draws its conclusions.

There are some precedents for greater transparency. For some years Australia has published the IAEA's inspection findings (the statements which the IAEA prepares for each material balance area[16] in accordance with INFCIRC/153 paragraph 90(b)). The Australian Safeguards and Non-Proliferation Office is in the process of placing these on an Internet website for public access. This is an example of openness and transparency, which Australia urges others to emulate.

CONCLUSIONS

The present nonproliferation regime—based on peaceful use commitments verified by IAEA safeguards—has served the international community well. The overwhelming majority of states have renounced nuclear weapons, with the existence of a credible verification system an essential factor in their decision. The regime has thus created conditions favorable to international peace and security, under which most states have been able to benefit from peaceful applications of nuclear technology.

The IAEA safeguards system is an evolutionary, not a static, system. Safeguards practice has undergone substantial refinement since the introduction of INFCIRC/153. The safeguards system is entering a period of substantial evolution, changing from a mainly quantitative system providing a high degree of assurance about declared nuclear activities to a more qualitative system, which is addressing a much less tangible area—the absence of undeclared nuclear activities.

Under classical safeguards, the IAEA's methods were well understood and states were prepared to have the IAEA act literally as their agent—if the IAEA was satisfied about the performance of a particular state, most states were prepared to accept the IAEA's conclusions. With the new safeguards system, which incorporates a greater degree of subjectivity, the degree of assurance that states can derive will depend very much on their understanding of, and confidence in, the IAEA's methodology and the actual activities undertaken with respect to a particular state.

The IAEA faces a considerable challenge not only in establishing methodologies that are as technically effective as possible, but in reporting on its performance in a way that has necessary credibility and provides sufficient assurance to meet the political objectives of the safeguards system. It is very much in the interest of states to contribute constructively to this process.

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1 "Model Protocol Additional to the Agreement(s) between State(s) and the International Atomic Energy Agency for the Application of Safeguards," Information Circular (INFCIRC)/540, approved by the IAEA Board of Governors in 1997. This document is a model additional protocol designed for states having a safeguards agreement with the IAEA, in order to strengthen the effectiveness and improve the efficiency of the safeguards system.

2 Since 1993, the IAEA and member states have been engaged in a comprehensive and ongoing program for strengthening the effectiveness and efficiency of safeguards. In summary, this program may be described as addressing three main areas of development: measures to strengthen the IAEA's access to and use of information that could contribute to making safeguards more effective; measures related to increased physical access to sites and to the effectiveness of that access; and measures to optimize the use of the present system.

3 The only states remaining outside the NPT are India, Israel, Pakistan, and Cuba. The five nuclear weapon states, which are parties to the NPT, are not subject to comprehensive safeguards.

4 "The Structure and Content of Agreements between the IAEA and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons" was published by the IAEA as document INFCIRC/153 (Corrected). In February 1972, the Board of Governors requested the Director General of the IAEA to use this as the basis for negotiating safeguards agreements under the NPT.

5 These organizational arrangements on the national level are part of a state's system of accounting for and control of nuclear material (SSAC).

6 Nuclear material accountancy is the practice of nuclear material accounting by the facility operator and the SSAC as well as the verification and evaluation of this accounting system by a safeguards authority (SSAC or IAEA), with subsequent statements of results and conclusions making it possible to determine the degree of assurance provided by the safeguards measures. Nuclear material accounting refers to the activities carried out to establish the quantities of nuclear material present within defined areas and the changes in those quantities within defined periods.

7 The application of containment/surveillance measures is an important safeguards measure complementing nuclear material accountancy. Containment involves structural features of a nuclear facility or equipment that enable the IAEA to establish the physical integrity of an area or item by preventing undetected access to or movement of nuclear or other material, or interference with the item, IAEA safeguards equipment, or data. Examples are the walls of a storage pool, transport flasks, and storage containers. The integ-

rity of containment is assured by seals or surveillance measures (especially for containment penetrations such as doors, vessel lids, and water surfaces). Surveillance refers to the collection of information through inspector and/or instrumental observation aimed at the monitoring of the movement of nuclear material, and the detection of interference with containment or tampering with IAEA safeguards devices, samples, and data. The most important surveillance instruments are automatic optical devices and monitors.

[8] A strategic point is a location selected during examination of design information where, under normal conditions and when combined with the information from all strategic points taken together, the information necessary and sufficient for the implementation of safeguards measures is obtained and verified. It should be noted that the IAEA also has a right of "special inspection," beyond declared nuclear sites, but the IAEA Board of Governors has decided this should be invoked only where there is clear evidence of a breach of safeguards obligations.

[9] This is an issue stemming from the quantitative approach of the classical system, in that inspection effort is directly proportional to the quantities of nuclear material at each facility. One consequence is that classical safeguards require intensive inspection effort (almost 11,000 person-days in 1996). Another is that a very substantial share of IAEA inspection effort is devoted to just three states, Germany, Japan, and Canada (in recent years these three accounted for some 70 percent of total IAEA inspection time, though this is now understood to be around 50 percent). Certainly, criticisms of this emphasis overlook the safeguards complexities of the sophisticated fuel cycles in these three states. Nonetheless the introduction of more qualitative safeguards methods could be expected to lead to significant reductions in routine inspection effort, although the sensitive stages and materials of the fuel cycle—enrichment and reprocessing, HEU (highly enriched uranium) and separated plutonium—will always be the main focus of verification activities.

[10] The expanded declaration is intended to obtain from the state additional information that would make its nuclear program more "transparent." This will include information on, *inter alia*, nuclear-related R&D activities, production of uranium and thorium, production of heavy water and graphite, and nuclear-related imports and exports. The objective is to gain a consistent picture of the whole of a state's program and to provide an effective audit basis that, together with extended access, increases coverage of safeguards-relevant materials and activities.

[11] Complementary access will allow IAEA inspectors access anywhere in and around a nuclear site, compared with present access which is limited to defined "strategic points." An important aspect will be the introduction of unpredictability into the timing and the scope of inspections, through the greater use of unannounced inspections. Complementary access will also provide the opportunity for access to nuclear-related locations included in expanded declarations, in order to resolve questions or inconsistencies arising from the IAEA's information analysis, and to other locations to carry out environmental sampling.

[12] Location-specific environmental sampling means the collection of environmental samples at, and in the immediate vicinity of, a location specified by the IAEA for the purpose of assisting it to draw conclusions about the absence of undeclared nuclear material or nuclear activities at the specified location. The IAEA has begun to deploy the new technique of environmental sampling and analysis to look for indications of undeclared nuclear activities (or confirm the absence of such activities). This involves the measurement of fission products or nuclear material in environmental samples, such as water, soil, air, or vegetation, or in swipes taken from building surfaces. The effectiveness of this technique was demonstrated in the detection of Iraq's clandestine uranium enrichment program. Field trials have shown that on-site swipe sampling can provide unambiguous information about the full range of past and current nuclear activities at the locations tested. Thus short-range environmental sampling at or in the vicinity of declared nuclear sites should be able to detect undeclared nuclear activities at those sites, or the operation of safeguarded installations at times, or in modes, other than those declared. Short-range environmental sampling at or near a site selected for a complementary access visit would also determine whether or not there are undeclared nuclear activities at that site.

[13] Wide-area environmental sampling means the collection of environmental samples (e.g., air, water, vegetation, soil, smears) at a set of locations specified by the IAEA for the purpose of assisting it to draw conclusions about the presence or absence of undeclared nuclear material or nuclear activities over a wide area. Wide-area environmental monitoring techniques could indicate the presence of undeclared nuclear activities some distance away from declared facilities. It is hoped that substantial regions of a state, or even an entire state, may be covered in this way. Work is currently being undertaken to evaluate the potential of these techniques.

[14] At the time of writing (December 1998) the IAEA Board of Governors had approved additional protocols with 38 States: 34 of them with non-nuclear weapon states with comprehensive safeguards agreements, and four with nuclear weapon states. Four protocols had entered into effect (Australia, Holy See, Jordan, and New Zealand), and three protocols were being applied provisionally (Armenia, Ghana, and Uzbekistan).

[15] Direct-use material is material that is defined for safeguards purposes as being suitable for the manufacture of nuclear explosive components without transmutation or further enrichment, such as plutonium containing less than 80 percent plutonium-238, HEU, and uranium-233. Unirradiated direct-use material would require less processing time and effort than irradiated direct-use material (contained in spent fuel). Indirect-use material comprises all nuclear material except direct-use material, e.g., natural uranium, depleted uranium, and LEU (low-enriched uranium), all of which would require further enrichment to be converted into HEU, or irradiation in a reactor to produce plutonium-239 or thorium (which can be irradiated to produce uranium-233).

[16] The material balance area is an area inside or outside a facility where: (a) the quantity of nuclear material in each transfer into or out of each "material balance area" can be determined; and (b) the physical inventory of nuclear material in each material balance area can be determined when necessary, in accordance with specified procedures, in order that the material balance for IAEA safeguards purposes can be established.