Safeguards in transition: Status, challenges, and opportunities

Political and technological developments are strongly influencing the IAEA's system for verifying the peaceful uses of nuclear energy

by Bruno Pellaud

After phases of intensive development in the 1970s and consolidation in the 1980s, the IAEA's international safeguards system is now in a phase of transition. The 1990s look to be a time when verification activities are further expanded in response to global developments and challenges in the field of nuclear non-proliferation.

How far have safeguards come, and where are they headed? I would like to offer some thoughts and perspectives on the main challenges and opportunities facing IAEA safeguards, in the context of some recent developments and the overall evolution of the safeguards system.

Building the foundation

In mid-1971, just 3 years after the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) opened for signature, the Safeguards Committee of the IAEA Board of Governors finished its work on the model NPT safeguards agreement. Its efforts were formulated in what would become a fundamental document of the safeguards regime, namely Information Circular 153 (INFCIRC/153).

The INFCIRC/153 safeguards system depends strongly on nuclear material accountancy and its international verification. It is based on a basic concept: as long as all nuclear weapon-usable material is verified to be in peaceful activities, one can be confident that it is not used to produce nuclear explosive devices. Since weapon-usable nuclear material is essential for any such device, a tight control on material was considered to be sufficient for international non-proliferation verification purposes.

While in the 1970s, the concepts and verification techniques were indeed developed and implemented, we saw in the 1980s the full implementation of the system and its continuous improvement. The system was never considered to give total assurance of non-proliferation because of the possibility that weapon-usable material could be produced clandestinely in an unsafeguarded, unreported parallel programme. There was also the theoretical possibility that a country could prepare for a large-size nuclear weapon development programme without using any significant quantity of nuclear material. It would stockpile the necessary weapon-usable material in peaceful installations under IAEA safeguards and only divert this material from safeguards at the last moment, when the Government would be certain that its experts could produce functioning nuclear weapons within a very short period of time.

At any rate, in the INFCIRC/153 concept, the timeliness of detection of diversion was considered to be critical. Of course, this concept turned out to be expensive in terms of inspection effort. There was, certainly, some expectation that any strategy to produce nuclear weapons from unreported weapon-usable material could most probably be detected at an early stage by national intelligence organizations, for example, through the use of satellite surveillance. The case of Iraq has taught us otherwise. Even though the Government of Iraq had spent enormous resources in terms of money and manpower on a large complex of dedicated facilities for the nuclear-weapon development programme and made remarkable progress in some parts of the programme, this effort became known after the Gulf war and only then did the locations involved become accessible to IAEA inspections.

As a consequence, the safeguards community began to seriously re-think some fundamental tenets of safeguards. Already in September 1991, IAEA Director General Hans Blix told the Board

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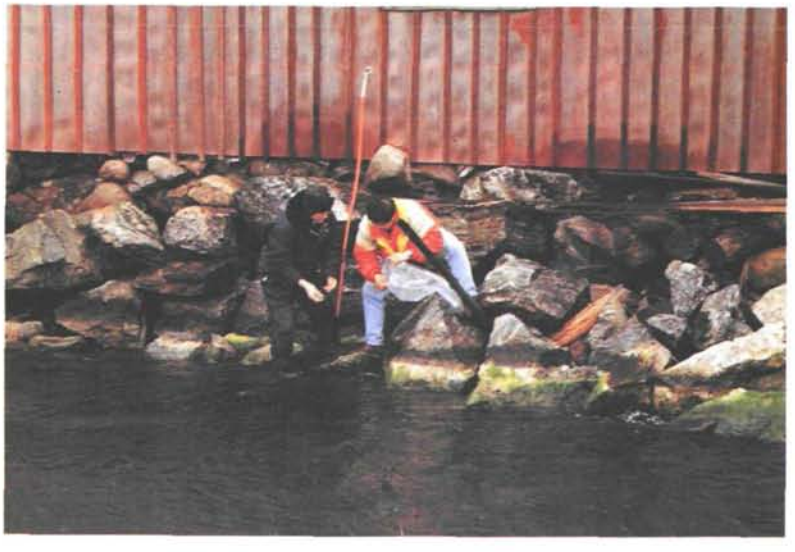
Scenes from IAEA safeguards and verification activities *(clockwise from top left):* Examining seals at IAEA headquarters through the use of laser disk recording; preparing for fuel measurements at the damaged research reactor at Tuwaitha in Iraq; inspectors using a special viewing device to verify irradiated fuel in storage ponds; taking environmental samples during field trials in Sweden; visiting a reactor in the Democratic People's Republic of Korea (DPRK); and rendering harmless the Kalahari test shafts associated with the terminated nuclear-weapon programme in South Africa. *(Credits: Iraq photo — Pavlicek, IAEA)*



of Governors that the Agency's safeguards system would have to undergo a threefold strengthening to cope effectively with suspect cases — namely through the access to additional information, through the unrestricted access to any relevant location, and through the strong support by the world community, explicitly the United Nations Security Council.

Among the strengthening options considered by the Board in 1992, the most important involves the clarification of the Agency's rights to conduct, when appropriate, special inspections at locations that might be relevant for safeguards. Others refer to the need for the early provision and verification of design information commencing during construction of facilities, and extending over their lifetimes through commissioning and normal operation. This will provide an improvement in the foundations for implementing nuclear materials accountancy and containment and surveillance measures, in particular, as may relate to undeclared activities within declared facilities. Next, more extensive information will be analyzed to look for patterns that might suggest undeclared nuclear activities within a State. Additional reporting on exports and imports of nuclear material, specified equipment, and non-nuclear material will constitute one means to gain access to such information.

From that time on, it became indeed mandatory to contemplate a safeguards strategy that would no longer be based exclusively on nuclear material accountancy. Rather, it would also look for and follow up inconsistencies in information that might be an early indication of a possible nuclear-weapon programme.

Here a word of caution. As it took years to achieve political agreement on the INFCIRC/ 153 system, it might take quite some effort and time to achieve a political consensus on its expansion.

Influence of recent events

A number of recent events in the safeguards field have influenced or are still influencing the development of the expanded safeguards system.

The case of Iraq exposed some apparent weaknesses of the INFCIRC/153 system. Here was a country — which had agreed to a comprehensive safeguards agreement — launching and proceeding far into a nuclear-weapon development programme, and all this without reaching the level of alarm within this safeguards system. This event not only opened the way for some re-thinking of the INFCIRC/153 system but also promoted the willingness of many countries to permit IAEA safeguards in a less restrictive and more open way. Several countries have since invited the IAEA to visit any location it wishes to, even if the location was not reported to the safeguards system.

In general terms, one can say that through the events in Iraq — and certainly also through the end of the cold war — the co-operation and openness in many countries has further improved. But the case of Iraq has also given the IAEA valuable experience that went well beyond normal safeguards practice: for the first time the Agency learned to recognize the signs of a clandestine nuclear weapons programme, its components, its industrial infrastructure, its research and development requirements, and its overt and covert procurement paths.

Secondly, there was the case of South Africa. When South Africa concluded its safeguards agreement with the Agency in 1991, the Agency was confronted with the problem that major unsafeguarded facilities, including one plant for the production of highly enriched uranium, had been previously operated outside any kind of international control for many years. Therefore, the IAEA General Conference requested the Director General to verify to the extent possible the completeness of the inventory of nuclear material and installations included in South Africa's initial report to the IAEA. As a result of this request, an IAEA team made a number of visits to South Africa to consult with officials and to examine historical accounting and operating records of both operating and closed-down facilities. The team's general conclusion was that it had found no evidence to suggest that the declared inventory of nuclear installations and material was incomplete. Then came unexpectedly, in March 1993, South Africa's announcement that it had abandoned its former nuclear-weapons programme. South Africa extended at that time an invitation to the IAEA to examine with full transparency the scope, the nature, and the facilities of the weapons programme. The IAEA accepted the invitation.

After numerous additional visits and the examination of records, facilities, and remaining non-nuclear components of the dismantled nuclear weapons, the IAEA came to a number of conclusions: it concluded that the cumulative amount of highly enriched uranium produced by the South African pilot enrichment plant was consistent with that programme; and that no indications suggest that there remain any sensitive components of the nuclear-weapons programme not having been either rendered useless or converted to commercial non-nuclear applications or peaceful nuclear use. From the findings, one can state that, firstly the nuclear-weapons programme of South Africa was terminated; secondly, that all nuclear devices were dis-

mantled prior to South Africa's adherence to the NPT; and thirdly that all nuclear material involved in the weapons programme was returned to peaceful uses prior to the conclusion of the safeguards agreement. No violation of the NPT or the safeguards agreement by South Africa has therefore been detected. The South African case has certainly further expanded the experience of the Agency, sharpened its inspection skills and heightened its capability to look into non-nuclear material-related activities of a clandestine nuclear-weapon development programme.

The situation in the Democratic People's Republic of Korea (DPRK) has been different. Among the latest developments are the DPRK's withdrawal from membership of the IAEA in June 1994. The action followed the IAEA Board of Governors' adoption of a resolution in which it found that the DPRK is "continuing to widen its non-compliance with the safeguards agreement" and called upon the DPRK to extend full co-operation to the IAEA by providing access to all safeguards-relevant information and locations. As IAEA Director General Hans Blix informed the Board in June 1994, at this point the Agency is enabled to implement adequate safeguards with regard to the DPRK's declared nuclear material, but it is not in any position to verify whether the nuclear material which the DPRK has declared is in fact all that should have been declared. As long as the IAEA continues to be denied access to information and locations relevant to the DPRK's nuclear programme, the Agency will not be able to say whether the DPRK's declaration of its nuclear material subject to safeguards is accurate and complete.

For quite different circumstances, the cases just mentioned have brought home to everyone concerned the fact that verification of the initial inventory is not easy in States that had extensive nuclear programmes before concluding an NPT safeguards agreement.

In South America, the Agency recently has begun the process of verifying the completeness of the initial inventory of two large countries. After an earlier ratification by Argentina, the Brazilian Parliament and Senate have now approved the quadripartite safeguards agreement between the IAEA, Argentina, Brazil, and the Brazilian-Argentine Agency for the Accounting and Control of Nuclear Material (ABACC). Both Argentina and Brazil have operated nuclear facilities, including small enrichment plants, over extended periods of time outside the IAEA safeguards system. We are nevertheless confident that the question of completeness of the initial inventory will, like in the case of South Africa, be rapidly resolved with the full co-operation of the parties concerned.

A similar problem, but which may turn out to be more complex, faces the IAEA as some of the new independent States of the former USSR join the NPT as non-nuclear weapon States. Belarus and Kazahkstan have done so; Ukraine will also, sooner or later. In these cases it may indeed be extremely difficult to reconstruct historical data on nuclear material, even with the utmost support and openness of the governments involved. Yet the Agency will have to satisfy itself that all nuclear material is declared.

New and emerging verification technologies

Improvements in conventional safeguards should remain high on the priority list of the IAEA Department of Safeguards. The great majority of work involves the day-to-day verification of nuclear operations under existing safeguards agreements. This is by no means a static activity. In such conventional activities, the Agency will have to cope with an expanded workload. For nearly a decade, the IAEA has been required to meet these challenges under zero growth budget constraints, which has added an additional dimension of complication.

Regarding new safeguards technologies in general, the use of computers by inspectors in the field obviously is having a profound impact on safeguards implementation; yet we are at a very early stage of this revolution. In the area of safeguards instrumentation development, the emergence of unattended verification systems and of digital image surveillance also is making a significant difference.

Unattended verification systems have already been used successfully to reduce inspection effort, decrease the burden on facility operators, and provide expanded verification coverage. They combine computer-operated non-destructive assay systems with containment and surveillance, such that the measurements are made under controlled and authenticated arrangements. Such systems are sometimes the only way to implement safeguards at complex nuclear facilities, especially in automated plants. Several unattended monitoring systems are now under consideration, under development, and even in use. Examples are the plutonium assay systems for use in Japanese mixed-oxide conversion and fuel fabrication facilities; a Core Discharge Monitor developed in Canada for on-load power reactors; the Consulha system developed in France for monitoring the unloading of spent fuel; and the integrated verification system under development in Germany.

The development of the second generation bundle counter is particularly important since it is the prototype for the next generation of unattended monitoring systems. The goal is to develop modular hardware and modular software incorporated in an open architecture system. With this concept, the flexibility for accommodating a variety of applications will be designed into the basic architecture, without the need to establish a customized system for each facility. Moreover, since an international standard will be employed, developers in various laboratories around the world can contribute sensors that can be accommodated within such a system, confident that appropriate interfaces will be available.

In the last 2 years, there has been a tremendous growth in digital image transmission, together with the adoption of agreed standards for high-speed, real-time data compression, digital imaging, digital processing, digital storage, as well as digital encryption of image data. Digital image technology will have a fundamental impact on the surveillance measures used by the Agency. The overall effectiveness of our optical surveillance will be significantly improved and the technology will allow innovative applications, such as the use of mail-in arrangements and remote monitoring. The mail-in concept foresees the mailing of encrypted surveillance information by the facility operator to the IAEA offices. This concept would save inspection resources by reducing the need for inspectors to visit certain facilities, such as light-water reactors, as frequently as currently required.

Furthermore, the Agency continues to investigate innovative methods to apply randomization principles in safeguards. Recently, a field test was performed on the application of short-notice random inspections for inventory change verification at a fuel fabrication plant. According to this approach, the plant operator declares the contents of nuclear material items before knowing if an inspection will occur to verify them.

Indeed, the IAEA safeguards development programme includes many requirements and tasks related to the current routine implementation of safeguards. Much of the work is carried out within the framework of Member State Support Programmes. They provide both financial help and technical expertise.

Beyond the development of hardware and software, the catalogue of work covers a host of other activities to ensure that IAEA safeguards continue to provide the assurance sought by Member States. This work includes updating the safeguards criteria currently in effect for 1991-95, to strengthen them as soon as techniques and inspection modes are judged appropriate and feasible. Examples of such elements are the application of safeguards to small quantities of nuclear material; the streamlining of departmental procedures for granting requests for an exemption of nuclear material from safeguards; and for the termination of safeguards for measured discards.

Initiatives for strengthening safeguards

In reviewing the Iraqi experience, it is clear that Agency safeguards did not provide adequate assurance that States subject to comprehensive safeguards agreements would submit all nuclear materials to safeguards or that undeclared operations were not carried out in facilities that were submitted for safeguards. As a result, the IAEA has initiated a substantial amount of work on new approaches aimed at strengthening the safeguards system. While most of the evaluation and planning activities necessary to realize these improvements will not be completed for some time, the outcome of this work will have a fundamental impact on technical aspects of IAEA safeguards in the future.

Last year, the IAEA General Conference and the Board of Governors asked the Secretariat to explore alternative means to strengthen the safeguards system and to improve its cost-efficiency. In April 1993, the Director General's Standing Advisory Group on Safeguards Implementation (SAGSI) had under the same heading formulated a set of specific recommendations. After having been discussed by the Board in its June meeting, these recommendations were translated into the Secretariat's development programme for a strengthened and more cost-effective safeguards system, a programme that has become known as "93+2". This effort will provide for the evaluation of the technical, legal, and financial implications of various recommendations, first of all those of SAGSI.

The programme requires extensive participation by Member States. All strengthening measures that go beyond the scope of safeguards agreements can only be implemented with the agreement of the States concerned. The IAEA should be in a position to make a proposal, including the legal implications, for a strengthened and more cost-effective safeguards system by early 1995.

One area that appears particularly interesting is the application of environmental sampling for safeguards purposes. These methods allow for chemical and isotopic analysis of minute samples (as small as 10^{-15} grams) which may be collected within declared facilities or away from

nuclear facilities (e.g., water, soil, biota samples) that might provide indications of clandestine activity. This method has been and will continue to be used in Iraq.

Several Member States have offered their assistance in the conduct of environmental monitoring field trials and related technical areas. A plan for environmental sample collection and analysis has been established for 1994 with a series of participating Member States. The usefulness of field trials is not limited to environmental monitoring. Ways and means to increase the co-operation with national accounting systems are also candidates for field trials.

Challenges and opportunities

The INFCIRC/153 safeguards system has not yet achieved the desired broad degree of universality. As any worldwide arms limitation arrangement, the non-proliferation regime will only achieve its full intended purpose if all relevant countries participate. Substantial progress has been made over recent years: South Africa joined the NPT; Argentina, Brazil, and Chile ratified the Treaty of Tlatelolco; China and France joined the NPT as nuclear-weapon states; and full-scope safeguards will soon be in force in Brazil and Argentina. Moreover, Algeria has announced its intention to join the NPT.

In other areas as well, things are moving. New confidence-building initiatives have been put forward by the United States. In particular, if and when the process of nuclear arms reduction in nuclear-weapon States reaches the phase of releasing substantial quantities of direct-weapon-usable material from weapon programmes into civil use or possibly only to storage, IAEA safeguards on such material could provide assurances that the material would not be used in a nuclear-weapon programme again. Until now only the highly enriched uranium released when South Africa terminated its nuclear-weapon capabilities falls into this category of direct-use material previously used in a weapon programme. This material is now placed under IAEA safeguards and is dedicated to peaceful uses. In this connection the US initiative to submit excess fissile material from the US defense programme to IAEA safeguards is an important step.

The Agency may also be given a role in the verification of the Comprehensive Test Ban Treaty now under discussion at the Conference on Disarmament in Geneva and possibly also in the verification of a cut-off in the production of fissile materials.

Alongside these challenges and opportunities stand certain developments that may threaten the safeguards system's credibility.

Firstly, there is the ambiguity in the DPRK. If the Agency remains unable to verify that there is no nuclear-weapon programme in the DPRK, the application of safeguards there will at some point be of questionable value. We can only hope that, eventually, a credible solution will be found by which the peaceful character of the nuclear programme of the DPRK will be confirmed.

Secondly, there are the longstanding restrictions on IAEA resources. More than 10 years of zero-growth budget at a time of greatly increasing workloads has unfortunately led to a reduction in the Agency's attainment of its inspection goals, if not yet to an unacceptable degree. Although I am fully aware of the economic situation in many Member States, it must be emphasized that with a continuing zero-growth budget the Agency will not be able to cope with the extended programmes and demands placed on it. For the successful execution of its functions, the Agency needs the continuing full support of its Member States, individually and collectively, if the reputation of the safeguards system is to be maintained.

Certainly, the Agency has reacted to the challenges of recent years and has tackled the opportunities by launching important initiatives. It is, however, up to the Member States and their political judgement to determine the objectives and scope of our work. The discussions on our programme and budget in the IAEA Board of Governors and the General Conference, and certainly also the results of the NPT Review and Extension Conference in April 1995, will have a strong influence on the direction in which IAEA safeguards will develop.

I am convinced that through its safeguards activities the IAEA has also contributed substantially to the promotion of the peaceful use of nuclear energy throughout the world, by providing assurance that nuclear trade and co-operation would not lead to the proliferation of nuclear weapons. Without the verification activities of the IAEA, nuclear commerce would have hardly found the present degree of public acceptance.

The new challenges and opportunities may indeed permit the IAEA to contribute even more directly to world peace and prosperity. ❐