BRIEFING

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Verification of a Chemical Weapons Convention: Summary of Lessons Learned from the Verification Experience of the International Atomic Energy Agency

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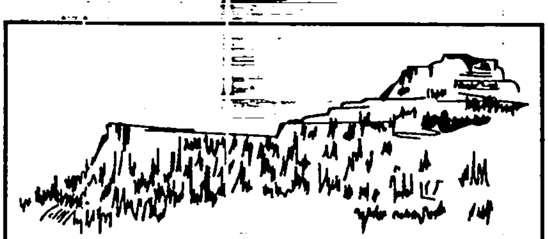

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VERIFICATION OF A CHEMICAL WEAPONS CONVENTION: SUMMARY OF LESSONS LEARNED FROM THE VERIFICATION EXPERIENCE OF THE INTERNATIONAL ATOMIC ENERGY AGENCY

Mark Mullen

SUMMARY

In recent years, there has been considerable progress toward a multilateral Chemical Weapons Convention (CWC) that would, when ratified by a sufficient number of nations,[1] establish a global ban on the production, possession, and use of chemical weapons. In addition to the multilateral negotiations toward a CWC, on June 1, 1990, the US and the USSR signed a bilateral agreement on the destruction and nonproduction of chemical weapons and on measures to facilitate the CWC. One of the principal challenges arising from both the bilateral and the multilateral chemical weapons agreements is to develop and implement verification measures.

Although the verification system that would be required under the CWC would be complex and technically challenging, it would not be entirely unprecedented. The International Atomic Energy Agency (IAEA), founded in 1957, has many years of experience with a multilateral verification regime (IAEA safeguards) that monitors compliance with the Nuclear Non-Proliferation Treaty and certain other agreements to confirm that nuclear material is not diverted from peaceful uses. The objective of this report is to examine the IAEA's safeguards experience and to determine what lessons can be learned from it that might be applicable to CWC verification.

The IAEA safeguards system shares some common features with the proposed multilateral CWC verification system: it is multinational in character and worldwide in scope; it is administered by an international organization, with a similar organizational structure and similar legal and institutional arrangements; it relies heavily on on-site inspections; and in developing its safeguards procedures, the IAEA has had to address such concerns as the protection of confidential information and the need to minimize the intrusiveness of inspections. However, there are significant differences between the two systems, including the situations in which monitoring is required,[2] the nature of the materials processed, the mutability of the mate-

rials to be verified, and the existing regulations and internal controls that apply in the two contexts.

Because of these differences, the IAEA safeguards system is not a direct model for CWC verification. Nevertheless, useful lessons can be derived from the IAEA experience. This report discusses a wide variety of lessons, ranging from broad policy issues to specific methods and technologies. It is important to recognize, however, that before the IAEA experience can be applied in the chemical weapons context, some degree of adaptation or modification is generally necessary.

The major lessons that have been derived from an examination of the IAEA experience as it relates to CWC verification are listed below. The ordering of the lessons proceeds from broad policy issues at the beginning of the list to more detailed technical issues toward the end. Each of the major lessons derived from the IAEA experience is discussed more fully in the text of the report.

- The IAEA experience indicates that the technical effectiveness of verification must be balanced against political acceptability. Because of its multilateral nature, CWC verification will require the same kind of balance.
- Concentration on a limited set of technically manageable verification tasks has been important to the IAEA's mission. Like the IAEA, the verification organization to be established under the CWC (the Organization for Prohibition of Chemical Weapons, or OPCW) will perform a technical function in support of political goals. The definition and implementation of that technical function will be key in determining the nature and success of the OPCW.
- The IAEA has a dual mission: promotion and control of the peaceful uses of nuclear energy. It is not yet clear whether the OPCW will have a dual mission (e.g., control of chemical weapons and promotion of the peaceful uses of chemistry and chemical technology), but the possibility requires careful consideration of structural and balance issues.
- Flexibility is needed in the implementation of verification measures. Implementation documents (subsidiary arrangements and facility attachments) must provide for flexibility to incorporate improvements in verification. At the same time, they must be sufficiently detailed and specific to provide the inspectorate with clear authority to implement the necessary verification measures while protecting the rights of inspected parties.
- Resource limitations are a fact of life for all international organizations, including the IAEA. Methods devised by the IAEA to take maximum advantage of limited resources may be useful to the OPCW. Examples include "risk-based" approaches for setting priorities and allocating resources, measures to improve efficiency (e.g., the establishment of field offices and the computerization of inspection paperwork), and the effective use of off-budget technical support from member states.

- The IAEA experience underscores the importance of effective technical support to the inspectorate. The methods and approaches used by the IAEA, which have evolved through many years of experience, may be of value to the OPCW. The technical support programs of member states, for example, may provide a useful model for the OPCW.
- Staffing the international inspectorate is a major challenge. The IAEA experience suggests a number of specific issues that will need to be addressed and offers possible approaches for consideration by the OPCW. However, the specific issues and the ways they have been addressed are less important than the more general lesson that such issues warrant significant attention from governments and from the management of the OPCW.
- The IAEA experience underscores the importance of "national implementation measures," as they are called in the CWC; the corresponding term in the IAEA context is the "State System of Accounting and Control." The effectiveness and efficiency of IAEA safeguards are strongly influenced by the activities of State Systems, which are the regulatory authorities (e.g., the Nuclear Regulatory Commission in the United States) responsible for fulfilling certain obligations defined in safeguards agreements, for example, establishing and maintaining a system of records and reports. National implementation measures under the CWC are likely to be equally important.
- Materials accounting has limitations as a verification measure in the chemical context. The IAEA experience not only provides a basis for understanding the strengths and limitations of materials accounting but also suggests alternative approaches that have the potential to overcome some of the limitations. Examples of alternatives include automated in-line measurement systems, more extensive use of containment and surveillance, and more extensive use of short-notice random inspections.
- The IAEA experience indicates the importance of systematic evaluation and reporting of verification effectiveness. The OPCW may benefit from an examination of the positive and negative aspects of the IAEA's experience in this area. For example, the IAEA has had to balance the desire for transparency, i.e., openness in evaluation and reporting, against concerns about the potential misuse of sensitive information. The IAEA has also had to develop approaches for communicating complex technical information on the performance of the verification system in a way that is understandable and meaningful to a wide range of interested parties, not all of whom are safeguards specialists.
- Measurement control and measurement quality assurance are essential to the credibility of verification. Although the OPCW may not rely on materials accounting to the same extent that the IAEA does, it will nevertheless rely heavily on measurements in monitoring compliance. A prin-

cipal lesson of the IAEA experience is to reinforce the importance and the difficulty of assuring measurement quality. The IAEA experience also indicates that assurance of quality is equally important for the other elements of the inspection program, in addition to measurements.

- Specific equipment, techniques, and concepts that are widely used in IAEA safeguards can be adapted to CWC verification. Examples include containment and surveillance techniques, systematic approaches for designing and evaluating verification procedures, statistical sampling techniques, and the establishment of a central analytical laboratory supported by a network of laboratories located in and operated by member states.

I. INTRODUCTION

The draft Chemical Weapons Convention (CWC), currently being negotiated at the Conference on Disarmament (CD) in Geneva, calls for the establishment of an international Organization for the Prohibition of Chemical Weapons (OPCW). The OPCW will be responsible for verification of compliance with the CWC.

A number of observers have noted that the mission of the OPCW would be similar in some respects to the verification mission of the International Atomic Energy Agency (IAEA).[3] The IAEA is responsible for verifying compliance with the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), and other agreements aimed at ensuring the peaceful uses of atomic energy.

In view of the apparent similarities between the two verification regimes, the Department of Energy, Office of Arms Control, commissioned a multilaboratory study by Los Alamos, Brookhaven, and Oak Ridge National Laboratories to examine the experience of the IAEA in verifying compliance with nonproliferation agreements with a view toward determining what lessons could be learned from the experience that might be applicable to CWC verification.

This report provides an overview of the major lessons identified as a result of the multilaboratory study. The report is organized into six sections. Section II presents a brief summary of the background and scope of the proposed CWC. Section III introduces the IAEA safeguards system and identifies some common features that it shares with the proposed CWC verification regime. Section IV delineates several important differences between the two verification regimes. Section V discusses 12 major lessons that have been derived from an analysis of the IAEA experience as it applies to CWC verification. Section VI contains concluding remarks.

II. THE CHEMICAL WEAPONS CONVENTION

Negotiations are currently under way at the CD in Geneva on a CWC that would, if adopted, prohibit the production, possession, and use of chemical weapons.[4] The draft CWC calls for an extensive set of verification measures to monitor compliance with the provisions of the CWC. An international organization, the OPCW, would be established to implement the verification measures.

The idea of banning chemical weapons is not new. In 1899, the First Hague Convention banned "the use of projectiles, the sole object of which is the diffusion of asphyxiating gases." The Second Hague Convention in 1907 forbade the use of "poison or poisoned weapons." The "Geneva Protocol Prohibiting the Use in War of Asphyxiating, Poisonous or Other Gases and of Bacteriological Methods of Warfare" was signed in 1925. It banned the use, but not the production or possession, of chemical weapons, and most signatories reserved the right to retaliate with chemical weapons if subjected to a chemical attack by an adversary. In 1972, a Biological Weapons Convention was signed that banned the development, production, and stockpiling of bacteriological (biological) and toxin weapons and required the destruction of all existing agents, toxins, weapons, equipment, and means of delivery. Further discussions on chemical weapons have continued for many years in such fora as the CD in Geneva and its predecessors. These early efforts to control chemical weapons suffered from a number of deficiencies. Except for the 1972 Biological Weapons Convention, they did not prohibit possession and stockpiling of the weapons, only their (first) use.[5] Thus, large stockpiles could be, and were, acquired without violating the treaties in any way. Furthermore, these early control measures had no provisions for verification. There were no mechanisms for detecting noncompliance and, if violations or alleged violations occurred, no meaningful follow-up actions were prescribed. The most direct evidence of the inadequacy of these control efforts is that chemical weapons were used not only in World War I but also in subsequent conflicts, despite the fact that many of the nations using these weapons were parties to the treaties.

Although the eventual outcome is by no means guaranteed and the ultimate effectiveness of the regime is still debatable, the CWC currently under discussion in Geneva would be considerably more comprehensive than these earlier efforts. In particular, it would ban not only the use of chemical weapons but also their development, production, and stockpiling. Moreover, its extensive verification measures, including the establishment of an international organization dedicated to that purpose, would represent a step beyond the previous agreements, which had essentially no verification provisions.

The scope of the verification regime envisioned in the draft CWC is very broad, and would include

- Verification of the storage and eventual destruction of existing stockpiles of chemical weapons;
- Verification of the destruction of chemical weapons production facilities;
- Verification of permitted activities at certain chemical facilities to monitor compliance with the convention;
- Investigations of alleged use of chemical weapons;
- Procedures for fact-finding or challenge inspections.

Certain aspects of the verification regime, e.g., challenge inspections, remain controversial and are subject to change before the convention is completed; but even if there are changes, it is already clear that implementation will represent a major technical and administrative challenge.

President Bush has placed a high priority on completion of the CWC, but the negotiations may continue for some time. In the interim, the US and the USSR have signed a bilateral agreement that bans further production of chemical weapons, begins the process of destroying existing stockpiles, and encourages further progress toward the multilateral CWC. Bilateral verification experiments are planned as a way of building confidence and gaining experience that will be useful in completing the CWC. Thus, the bilateral agreement, while separate, is closely linked to the multilateral CWC.

III. IAEA SAFEGUARDS

Although the development and implementation of the multilateral verification regime envisioned under the draft CWC would be a complex and technically difficult undertaking, it would not be entirely unprecedented. The IAEA has many years of experience with a multilateral verification regime (IAEA safeguards) that monitors compliance with the NPT and certain other arrangements to ensure that nuclear material is not diverted from peaceful uses.

The IAEA safeguards program is large and complex, both technically and politically. In round numbers, the safeguard budget is approximately $60 million per year. About 200 inspectors and 300 support staff are responsible for inspections at about 500 nuclear facilities and 400 other locations in more than 50 countries. Roughly 10,000 person-days of on-site inspection are carried out each year. The types of facilities inspected are diverse. The majority are nuclear reactors (power reactors and research reactors constitute about 70% of the 500 facilities). There are about 60 bulk-material-processing facilities that process uranium, manufacture nuclear fuel, or reprocess irradiated reactor fuel; a number of these facilities require continuous on-site inspection. In addition, there are about 40 separate storage facilities.

The IAEA safeguards system shares some common features with the proposed CWC verification system: it is multinational in character and worldwide in scope; it is administered by an international organization, with a similar organizational structure and similar legal and institutional arrangements; it relies heavily on on-site inspections; and in developing its safeguards procedures, the IAEA has had to address such concerns as the protection of sensitive information and the need to minimize the intrusiveness of inspections. A number of delegations to the CD, as well as outside observers, have noted the similarities and suggested that the IAEA experience could be instructive in developing the verification regime for the CWC. The objective of the DOE-sponsored multilaboratory study was to examine the extent to which the IAEA experience is, in fact, applicable.

IV. IAEA SAFEGUARDS: NOT A DIRECT MODEL FOR CWC VERIFICATION

Because of the similarities between the two systems, the IAEA's verification experience is a potentially valuable resource for the design and implementation of the CWC verification regime. Many of the problems the IAEA has encountered in implementing its multilateral verification regime will also confront the OPCW. The IAEA's experiences, favorable and unfavorable, in addressing these problems can help guide the OPCW in managing its own responses to problems. However, before the IAEA experience can be applied in the chemical context, it is important to recognize the differences as well as the similarities between the two verification contexts. The major differences include the following:

- *The situations in which monitoring is required.* Both IAEA safeguards and the proposed CWC verification regime require monitoring of manufacturing and processing facilities and storage areas used for peaceful purposes. However, prior to the recent events in Iraq, the IAEA has had no experience with challenge inspections,[6] investigations of alleged use, or verification of disarmament activities (destruction of weapons or verification of the shutdown and eventual destruction of production facilities). All of these situations would require monitoring under the CWC.
- *The nature of the peaceful activities monitored.* The civilian nuclear industry is relatively new and has grown up in parallel with the IAEA. The civilian chemical industry is much larger and more complex, and has been in existence much longer.
- *The nature of the materials processed.* The nuclear materials of concern to IAEA safeguards are principally uranium and plutonium. (In certain circumstances, IAEA safeguards also cover nonnuclear materials such as heavy water.) The range of materials of concern for CWC verification is much larger. Furthermore, uranium and plutonium have unique nuclear properties (radiation signatures) that facilitate verification because they can be detected by nondestructive or noninvasive methods. Comparable technology does not presently exist for the chemicals of concern for the CWC and, considering the inherent characteristics of the materials, may be more difficult to develop than in the nuclear case.
- *The types of facilities to be inspected.* Most of the facilities at which IAEA safeguards are applied are "item facilities," i.e., the material of interest is in the form of discrete items such as reactor fuel assemblies. Bulk-material-processing facilities represent only a small fraction of the total although they consume a disproportionate share of the IAEA's inspection resources. In the chemical context, the situation is reversed, with most facilities being bulk-chemical-processing plants; the only item facilities of any significance are chemical weapons storage depots, and these will be eliminated

within the first 10 years after the CWC enters into force. If the conventional IAEA inspection model were followed for bulk-chemical-processing facilities, the resource requirements would be very large.

- *The multiple-use nature of many chemical facilities.* Although there are exceptions, most nuclear facilities are designed for a single use (e.g., power production) or at most a limited number of closely related uses (e.g., production of several different types of fuel for reactors). In the chemical industry, by contrast, it is much more common for a facility to be designed for and capable of a large number of very diverse uses, some of which might be subject to controls under the CWC whereas others would not. Both nuclear and chemical facilities have the potential to be misused for proscribed purposes, but the greater flexibility of chemical facilities, in general, makes verification more difficult.
- *The mutability of the materials to be verified.* Uranium and plutonium normally remain under safeguards and available for verification for a relatively long time. A reactor fuel assembly, for example, typically remains subject to safeguards from the time it is manufactured, through several years in a reactor core and several more years in a cooling pond, until disposal in a repository or dissolution in a reprocessing plant—a minimum of 3 to 5 years and in most cases much longer. Chemicals controlled under the CWC, by contrast, are typically available for verification only briefly, between the time they are produced and the time they are consumed. Frequently, when they are consumed, not only do they become physically unavailable for verification, but they are also transformed into another chemical that is not controlled under the CWC.
- *The regulations that apply to the two industries.* Both industries are highly regulated from the standpoint of health, safety, and the environment, although the controls vary considerably from country to country. The nuclear industry, however, has been subject to additional regulatory attention because of concerns about the security implications of theft, sabotage, or unauthorized use of nuclear materials and facilities to produce nuclear explosives. These additional regulatory concerns in the nuclear industry have led to the development of stringent internal controls, materials accounting systems, and physical security measures that are generally more extensive than those that exist in the chemical industry, although there are sectors of the chemical industry (e.g., pharmaceuticals) in which accounting, controls, and security are very stringent. This difference has significant implications for verification because the technical possibilities for verification and the cost-effectiveness and perceived intrusiveness of inspections depend heavily on the nature and extent of the industry's existing controls.

Despite these differences, there are useful lessons that can be derived from the IAEA experience. It is important to recognize, however, that because of the differences between the nuclear and chemical contexts, some degree of adaptation or modification will be necessary in most cases if the IAEA experience is to be applied to CWC verification.

V. MAJOR LESSONS FROM THE IAEA EXPERIENCE

In this section, a brief overview is provided of 12 major lessons identified from an examination of the IAEA verification experience as it relates to CWC verification. The ordering of the lessons proceeds from broad policy issues at the beginning of the section to more detailed technical issues toward the end.

A. The Technical Effectiveness of Verification Must Be Balanced Against Political Acceptability

The historical evolution of IAEA safeguards has demonstrated that the success of such a verification system depends on striking an appropriate balance between conflicting goals: the technical effectiveness of the system on one hand and the wide acceptability of the system on the other. The point was well stated by US policymakers at the time the NPT was being negotiated. In a talk at a safeguards symposium in 1967, a representative of the Arms Control and Disarmament Agency stated the US position on international safeguards as follows:

> First and foremost, we (the United States) think that we must maintain safeguards that are effective. By effective, I mean sufficiently effective as to have a high probability that any significant diversion would be detected, and most importantly, to deter anybody from carrying out a diversion. However, safeguards procedures are no good if they are not also acceptable . . . . It does not do much good to have perfect safeguard procedures as long as only 20 percent of the people accept them . . . . So the intrusiveness of the inspection is a very major factor that needs to be studied in order to make these safeguards acceptable to those countries we wish to have sign a non-proliferation treaty. For this reason, we are very interested in any research which can decrease the intrusiveness by using automation or other techniques, and at the same time maintain the effectiveness which is desired.[7]

The need to balance technical effectiveness and acceptability reflects the fact that IAEA safeguards are essentially a cooperative exercise. Under the NPT, states accept safeguards as a way of providing independent assurance to the international community that they are complying with their nonproliferation commitments. In return, the NPT assures their right to participate fully in peaceful nuclear activities, including international exchange of nuclear material and equipment. In the implementation of safeguards, a balance must also be maintained. The IAEA cannot unilaterally impose safeguards measures that states are unwilling to accept.

The acceptability of IAEA safeguards to individual states has depended on a wide range of technical and political factors, including

- *Equity considerations.* Concerns have been expressed at various times about inequities between nuclear-weapon states and non-nuclear-weapon states, developed states and less-developed states, signatories of NPT and nonsignatories, EURATOM (the European Atomic Energy Community) and Japan, and between individual states in comparable circumstances. The principle of nondiscrimination is of paramount importance to many states. It is likely to be as important for the CWC as it has been for IAEA safeguards and the NPT.
- *Economic burdens of safeguards, both for states and for facilities.* The burdens include both the operating expenses of the IAEA safeguards program (for example, inspector salaries, travel expenses, equipment costs, and the costs of support services) and the impacts of inspections on facility operations (for example, the costs of escorting inspectors during inspections, recordkeeping and reporting expenses, and any facility downtime). Both monetary and nonmonetary cost impacts are of concern.
- *Potential loss of sensitive information, including commercial and industrial secrets and other sensitive information (e.g., national security information).*
- *Potential safety hazards and third-party liability that might result from safeguards.*
- *The technical basis of the verification system.* States generally prefer a disciplined, technically based system that has well-defined boundaries and limits. A system that is open-ended and that relies too heavily on political judgments rather than technical data tends to be viewed unfavorably.

Similar concerns have been raised in connection with the CWC. An acceptable CWC verification regime will need to address these concerns and still maintain an appropriate level of technical effectiveness, i.e., a sufficiently high probability of detecting noncompliance, thereby providing deterrence and assurance.

The experience of the IAEA shows that it is possible to strike a balance between the conflicting goals of technical effectiveness and acceptability in most cases. For example, despite serious concerns at the outset, the risks resulting from potential loss of commercial and industrial secrets and other sensitive information (e.g., national security information) as a consequence of IAEA safeguards have proved to be relatively small and acceptable. With experience, a system of adequate controls of confidential information has been developed in the IAEA, and these controls have been shown in practice to work reasonably well. At the same time, experience has enabled the IAEA to define more precisely the information and locations to which it truly needs access to apply safeguards. It remains to be seen whether an acceptable balance can be achieved in the chemical context.[8] The IAEA experience suggests, however, that the problem may be manageable.

A second example concerns the economic and operational burdens of safeguards. Early estimates of the cost and intrusiveness of safeguards were far higher than the levels that are now required. Advances in technology, such as the wide use of containment and surveillance and nondestructive measurement methods, reduced the cost burdens significantly, without compromising technical effectiveness. In fact, technical effectiveness has improved in many cases as a result of new technology. In addition, improved procedures and better definitions of safeguards objectives and criteria enabled the IAEA to concentrate its limited resources where they could be applied most productively. Again, these advances resulted both in reduced burdens and in improved effectiveness at the same time.

The role of improved technology and procedures in achieving a satisfactory balance between technical effectiveness and acceptability has been explicitly recognized for a long time, as indicated in the quotation at the beginning of this section. The IAEA experience suggests that any assessment of technical effectiveness or acceptability should reflect an evolutionary perspective. In many cases, a considerable length of time may elapse before the proper balance is achieved. It would be unwise to assume that every problem has a technical fix. But significant improvements are possible as experience is gained and as technology advances.

B. Concentration on a Limited Set of Technically Manageable Tasks Has Been Important to the IAEA's Success

A complex policy framework exists to manage the risks of nuclear weapons proliferation. It includes treaties, bilateral arrangements, export controls, national intelligence activities, security assurances, and verification provisions. Within this framework, IAEA safeguards have been assigned an important but limited role, which is focused primarily on a set of relatively narrow technical tasks, namely, implementation of measures to detect the diversion of nuclear materials from declared peaceful uses. The IAEA cannot physically prevent diversion, protect against theft or sabotage, inquire into the intentions of states, search for clandestine nuclear facilities, or collect information unrelated to its technical mission.[9]

Concentration on a clearly defined technical mission has had a number of positive results. The task of verification has been reduced to a technically manageable problem, and the IAEA has for the most part been able to avoid extraneous politicization of its safeguards activities. In addition, the IAEA has made substantial progress toward fulfilling its technical mission on a worldwide scale. The scope of IAEA safeguards has grown to more than 2000 inspections a year at more than 500 facilities and hundreds of other locations in 57 states. The technical effectiveness of these safeguards activities has also improved over the years. One indication of improving performance is documented in the IAEA's annual Safeguards Implementation Reports, which have shown steady progress in the level of attainment of inspection goals, as well as in other areas. The technical progress was also noted in the Final Declaration of the 1985 NPT Review Conference, which stated:

> The Conference notes with satisfaction the improvement of IAEA safeguards which has enabled it to continue to apply safeguards effectively during a period of rapid growth in the number of safeguarded facilities. It also notes that IAEA safeguards approaches are capable of adequately dealing with facilities under safeguards.[10]

At the same time, the IAEA's concentration on technically manageable tasks has also been a recurring subject of discussion. One persistent topic has been the effectiveness of IAEA safeguards in accomplishing this limited technical mission. As noted above, the general consensus is that IAEA safeguards do in fact provide substantial capability to detect and thereby to deter diversion. It is also widely recognized, however, that improvements in performance are still needed in certain areas. The Final Declaration of the 1985 NPT Review Conference, for example, stated:

> The Conference emphasizes the importance of continued improvements in the effectiveness and efficiency of safeguards, for example, but not limited to:
>
> (a) Uniform and non-discriminatory implementation of safeguards,
>
> (b) The expeditious implementation of new instruments and techniques,
>
> (c) The further development of methods for evaluation of safeguards effectiveness in combination with safeguards information,
>
> (d) Continued increases in the efficiency of use of human and financial resources and equipment.[11]

The IAEA's annual Safeguards Implementation Reports likewise indicate both progress and the need for further improvements.

In addition to the technical effectiveness of IAEA safeguards, one must also examine carefully their contribution to the larger nonproliferation framework. Again, although opinions differ on certain aspects of the issue, there is a consensus that IAEA safeguards do in fact make an important contribution to the goals of nonproliferation. The 1985 NPT Review Conference found

> IAEA safeguards provide assurance that States are complying with their undertakings and assist States in demonstrating this compliance. They thereby promote further confidence among States and, being a fundamental element of the Treaty, help strengthen their collective security. IAEA safeguards play a key role in preventing the proliferation of nuclear weapons and other nuclear explosive devices. Unsafeguarded nuclear activities in non-nuclear-weapon States pose serious proliferation dangers.[12]

The same issues arise in the context of CWC verification. Although the OPCW may be given a much broader charter than the IAEA, including the right to conduct challenge inspections and investigations of alleged use, the draft CWC makes clear that the Secretariat of the OPCW will be assigned a set of primarily technical functions. As is the case for IAEA safeguards, it will probably be difficult to assess the precise contribution of the OPCW's technical activities to the broader political goal of chemical weapons arms control. The IAEA experience does not suggest any simple solutions to this dilemma, other than to underscore the importance of clearly defined expectations. The highly technical nature of IAEA safeguards is to some extent a disadvantage when the IAEA is called on to describe its goals and activities. It is often difficult to communicate the significance of technical concepts such as "material balance uncertainty," "probability of detecting the diversion of a significant quantity," and "partial attainment of the inspection goal" in a way that clearly addresses the underlying political questions. By recognizing the importance of clearly articulating its objectives and limits to a wide audience comprising policymakers as well as technical specialists, the OPCW may be able to minimize, but not eliminate, the potential for misunderstandings.

C. The IAEA's Experience with a Dual Mission (Promotion and Control of the Peaceful Uses of Nuclear Energy) May Be Instructive for the OPCW

When the IAEA was founded in 1957, it was given a dual mission: (1) "to accelerate and enlarge the contribution of atomic energy to peace, health, and prosperity throughout the world," and (2) to "ensure, so far as it is able, that assistance provided by it or at its request or under its supervision or control is not used in such a way as to further any military purpose."[13] The NPT, which established the foundation for much of the current safeguards program, likewise included nuclear energy promotion ("Parties . . . shall also cooperate in contributing . . . to the further development of the applications of nuclear energy for peaceful purposes, especially in the territories of non-nuclear-weapon States Party to the Treaty, with due consideration for the needs of the developing areas of the world." [Article IV]), along with nonproliferation, safeguards, and negotiations toward arms reduction as a basic undertaking. Historically, this dual mission was an important factor in enhancing the acceptability of IAEA safeguards. Without the commitment to promoting the peaceful uses of nuclear energy, many nations would have had no interest in the IAEA and would not have subscribed to the NPT. This dual mission has naturally created some tensions within the IAEA system. These tensions have been most apparent in the budget process, where there has been a continuing need to balance the two missions in the allocation of resources. Opinions differ as to the impacts of the dual mission, but it is clear that they have been substantial and have made the IAEA a more complex organization than it might have been.

The draft CWC has not yet established a definitive position on activities or undertakings to promote the peaceful uses of chemistry or chemical technology. Article XI, Economic and Technological Development, has not yet been written. Discussions thus far on Article XI, as reflected in Appendix II of the rolling text, do not give a clear indication of the direction of the negotiations on this point or their likely outcome. It is interesting to note, however, that the language suggested in Appendix II is taken almost verbatim from the NPT and it suggests the "fullest possible exchange of chemicals, equipment and scientific and technical information relating to the development and application of chemistry for purposes not prohibited by the Convention." Similarly, Article VIII, which sets forth basic guidelines for the OPCW, states that one of the functions of the Conference of State Parties shall be "to [encourage] [promote] international cooperation for peaceful purposes in the chemical field." Thus, it is conceivable that there will be pressures to include promotional measures as part of the convention.[14]

The IAEA experience suggests that a dual mission must be carefully weighed and designed. The CWC has the advantage of the universal nature of its basic undertakings, which contrasts with the NPT's inherent distinction between nuclear-weapon states and non-nuclear-weapon states. Under the CWC, *all* signatories will forswear the possession and use of chemical weapons. *All* signatories that currently possess chemical weapons will destroy them. *All* signatories will accept verification measures on an equal basis. By contrast, the NPT did not require nuclear-weapon states to eliminate their weapons or to accept safeguards on an equal basis with non-nuclear-weapon states.[15] Thus, the fundamental political balance is different in the CWC. In view of this difference, a dual mission may be less important for accommodating the differing interests of the parties and thereby winning wide acceptance of the system.

D. Flexibility Is Needed in the Implementation of Verification Measures

IAEA safeguards have evolved significantly over the years as new technologies have become available, as new treaties and agreements have been reached, and as the safeguards program and the nuclear industry have expanded. The evolution has clearly been positive, but there have been occasional difficulties caused by the lack of flexibility of certain safeguards agreements. On the other hand, there have also been cases in which the flexibility of agreements has resulted in a gradual erosion of certain safeguards provisions.

The legal basis for IAEA safeguards derives from a hierarchy of documents that define in an increasingly detailed and specific manner the rights and obligations of the IAEA and the inspected party. The first level is, for most countries, the NPT itself, in which the signatories undertake to accept IAEA safeguards. The NPT, however, relegates the details of this safeguards undertaking to a separate safeguards agreement, to be negotiated later. This lack of specificity was intentional. In the interests of getting wide acceptance of the NPT at an early date, it was agreed that the safeguards details would be deferred for later discussion.

The second level of the hierarchy is the safeguards agreement between the IAEA and the state. In the case of NPT safeguards, the agreement is modeled after a document known as INFCIRC/153,[16] which was negotiated several years after the NPT was opened for signature. It incorporated major innovations in safeguards concepts and approaches as well as carefully defined limits on inspections, including limits on access and on the number and duration of inspections. As a result of these changes, the document managed to resolve major concerns that had been expressed by several states about the intrusiveness of IAEA safeguards, as previously defined.

INFCIRC/153 and the safeguards agreements that are based on it still leave many details unspecified. The third level of the hierarchy, the subsidiary arrangements, are intended to spell out the remaining details. They consist of two parts: (1) a general part, which applies to the state as a whole and prescribes such details as reporting requirements, and (2) the facility attachments, which spell out the detailed safeguards provisions for each facility. The general part is negotiated first, followed by the facility attachments. In some cases, the negotiations may continue for years, until all the details are worked out. Even after the agreements are completed, additional negotiations are necessary from time to time to update the safeguards measures in light of inspection experience, new technology, or changes in the facilities.

In an evolutionary process of this kind, flexibility has major advantages. If the treaty and agreements are inflexible, with all of the verification details fixed at an early stage, it can be difficult to make changes later, when experience or technical advances suggest improvements. The IAEA has on occasion encountered resistance from states when it suggested changes in safeguards measures that departed from the specific provisions of previously negotiated facility attachments. For example, a few states have at times resisted the introduction of new types of instruments or surveillance equipment on the grounds that they were not provided for in the agreements. In principle, if adequate flexibility is incorporated into the agreements from the outset, such problems can be minimized.

However, flexibility has disadvantages as well. One disadvantage is that flexibility allows verification approaches and effectiveness to become nonuniform over time, as different parties negotiate "customized" agreements that are tailored to their own particular preferences and circumstances. Although absolute uniformity is neither necessary nor desirable, standardization as a general principle is important to the credibility and efficiency of verification. A second disadvantage is the risk that there will be a gradual erosion of standards, as each successive negotiating party presses for verification measures that are less intrusive than those obtained by other parties in previous negotiations. The IAEA has had to confront both of these tendencies in its negotiations. In principle, the risks could be minimized by limiting flexibility and attempting to settle as many details as possible at an early stage, perhaps even in the Treaty itself. In practice, however, the evolutionary nature of the verification system makes flexibility essential.

A key lesson for the CWC is that, although flexibility in agreements has risks, sufficient flexibility must be maintained to permit and even encourage gradual improvements in verification measures. Well-conceived and - drafted documents can be helpful to the inspectorate in carrying out its tasks. It should be recognized, however, that no document or series of documents, no matter how carefully crafted, can eliminate the problem of a noncooperative party. Furthermore, sustained, visible political support from the members of the organization is likely to be more effective in strengthening the inspectorate's negotiating position than any written agreement. Flexibility in the documents must be accompanied by other policy actions to manage the risks that flexibility entails.

E. Resource Limitations Are a Fact of Life for International Organizations

A persistent issue in the IAEA has been the continuing quest for sufficient resources to carry out effectively all the tasks that are expected. The issue became particularly prominent in the 1970s and early 1980s, when the scope of IAEA safeguards was expanding rapidly following the entry into force of the NPT. The rapid growth slowed somewhat in the 1980s, but budgets have been held to zero real growth since 1983 as a result of global economic conditions and political constraints on international organizations generally. Despite the tight budgets of the 1980s, the IAEA has continued to make progress in improving safeguards effectiveness, as indicated by the statement of the 1985 NPT Review Conference quoted earlier and as documented in the IAEA's own annual Safeguards Implementation Reports. More efficient use of available resources has made this progress possible. However, this trend cannot continue indefinitely. The amount of material under safeguards is continuing to grow, as is the number of facilities at which safeguards are applied. In addition, a number of large, advanced facilities that will require significant increases in inspection effort are planned over the next decade.

It should be recognized that the resource constraints experienced in recent years were clearly foreseen many years ago. The level of resources provided for safeguards has resulted from a lengthy and complex process involving political, economic, and technical factors. As is true of most enterprises, the question of what level of resources to allocate has been one of the most basic issues in IAEA safeguards, and has played a dominant role in the evolution of the system. The question of inspection staffing requirements, in particular, has played a major role. Studies as far back as the 1950s had demonstrated that the level of assurance that could be obtained from safeguards was strongly related to inspection staffing. At the same time, it was apparent that the intrusiveness, and thus the acceptability, of international inspection was also strongly related to inspection staffing, higher levels of staffing being regarded as more intrusive.

The tension between effectiveness and intrusiveness is also likely to be a major issue for the OPCW. One of the areas where this tension is likely to manifest itself is in the budget process. Resource allocations as reflected in operating budgets are in many respects the most fundamental test of commitment to verification effectiveness and are perhaps the best indicator of the relative priority assigned to the various missions and objectives of the organization. The IAEA experience has been that high expectations for safeguards effectiveness are not always reflected in the budget and that other, nonsafeguards, missions compete for the same limited funds.

The process by which IAEA budgets are prepared and approved is essentially as follows. Each year the budget is drafted by the Secretariat, and submitted to a budget committee of the Board of Governors for review. After this review is completed, the budget is then transmitted to the full Board for approval. Following approval by the Board, the budget is submitted to the General Conference, where it is considered first by a committee and then approved by the Conference as a whole. The General Conference also has the statutory responsibility for establishing the scale of contributions from member states; this scale, which was originally derived from the scale of contributions used by the United Nations (but which has subsequently evolved in response to the IAEA's own circumstances) is used to calculate the payments owed by each member state. The CWC rolling text (Article VIII, The Organization) outlines a similar process and a division of responsibilities among a Secretariat, an Executive Council, and a Conference of the States Parties, which closely resemble the IAEA's Secretariat, Board of Governors, and General Conference.

Resource limitations are to some degree a challenge in most organizations. The OPCW will inevitably face the same problem, although it is difficult to predict in detail the nature of its likely resource constraints.[17] The IAEA experience suggests a number of ways of coping with resource limitations; these may be transferable in part to the OPCW. The first step in coping with resource limitations is to set priorities and allocate resources accordingly. The IAEA's priorities are based on the principle of concentrating its inspections on material and facilities from which nuclear weapons could most readily be made. This principle is explicitly stated in NPT safeguards agreements and has been incorporated into the safeguards criteria that are used to plan, implement, and evaluate safeguards. A similar "risk-based" approach could be developed for the CWC and, in fact, is already implicit to some extent in its definitions of three schedules of chemicals and in certain parts of the draft inspection procedures contained in the appendices to the rolling text. A major advantage of setting priorities in a well-defined and systematic manner is that it provides a way of clearly stating the implications of limited resources in terms of reduced verification effectiveness or increased risk. The tradeoffs between resources and effectiveness are made explicit. This can help establish the motivation for expanded resources if the tradeoffs are perceived to be unacceptable.

A second approach is to improve efficiency. The IAEA has achieved this to some extent by establishing field offices so that inspectors can spend more time at facilities and less time traveling; by dividing the labor through the use of inspection assistants for certain routine inspection activities that do not require the same skill levels as a regular inspector; by reducing inspector turnover so that there is more time to recoup the initial investment in training and learning the job; by increasing computerization at IAEA headquarters and in the field so that inspectors are relieved of paperwork and can spend more time on inspection activities; and by improved planning and scheduling of inspections so that time in the field and at facilities is used more productively. Through measures such as these, the IAEA has managed to obtain more inspection effort from a limited staff.

A third method for coping with resource limitations has been to obtain resources off-budget, directly from states. A disadvantage of this method is that these indirect sources of support are outside the direct control of the IAEA and could potentially be withdrawn at any time. However, the IAEA has managed to cope with this uncertainty and derive substantial benefits from indirect, off-budget sources of support. The technical support programs of the member states are the most prominent safeguards example of this approach. The technical support programs are discussed in more detail in the next section.

F. Effective Technical Support to the Inspectorate Is Essential

As the IAEA safeguards program has evolved, there has been a continuing need to develop and deploy a wide range of sophisticated technologies. Several factors have created the need for these technologies: the desire to improve safeguards effectiveness, the desire to reduce the costs of safeguards to both the inspectorate and the plant operators, and the desire to reduce intrusiveness. Technological change in safeguards has also been driven by rapid technical advances in computers, electronics, video equipment, and other fields.

The OPCW will inevitably have a similar need for technology development and may benefit from the IAEA's experience in this area.

There are a number of different approaches by which needed technologies can be developed and deployed by an international inspectorate. Perhaps the most fundamental strategic choice is whether to develop the technologies in-house or to look outside for support. Although the IAEA has performed some R & D in-house, it has obtained the majority of its technology and associated technical support externally, through "technical support programs," i.e., extrabudgetary technical assistance provided voluntarily by IAEA member states. There are currently 15 such support programs. The bulk of their effort is devoted to developing equipment and assisting the IAEA in implementing it in the field. But in addition, they also offer training to inspectors, provide specialized expertise in the form of "cost-free experts" who serve multiyear assignments at IAEA headquarters, perform various types of studies, and provide consultants on topics of importance to the IAEA. The assistance they provide each year is equivalent to approximately 20% of the regular budget of the IAEA's Department of Safeguards and thus represents a substantial contribution to the resources available to IAEA safeguards.

The IAEA's use of member-state technical support programs has proved successful for both political and technical reasons. Because the technical support programs are outside the regular IAEA budget, they are detached from many of the normal pressures of the budgetary process. Technology development is not forced to compete against other priorities for a share of the IAEA's limited resources. This consideration is particularly important for the IAEA, where safeguards R & D must compete against other politically important missions, such as technical assistance to developing countries and near-term needs to deploy inspectors in the field.

On the technical side, use of the support programs facilitates access to a worldwide pool of expertise, nuclear facilities, and technology that is far superior to what could be maintained in-house with any reasonable budget.

As the technical support programs have evolved, a number of lessons have been learned that may be useful to the OPCW if it utilizes similar mechanisms. The lessons are not unique to the IAEA; similar lessons have been drawn from other technology development programs. However, the IAEA experience is of particular interest for the OPCW's technical support efforts because of the similarities between the two systems.

First, the technical support programs can exert substantial influence over the safeguards program by choosing to support certain technologies and activities. To ensure that these efforts are consistent with the priorities and objectives of IAEA management, the IAEA has learned that it must provide strong guidance and direction to the member-state support programs, most importantly by carefully defining the R & D needs and clearly communicating them to the member states. Second, the member states must be willing to direct their efforts toward satisfying the IAEA's requirements. Finally, both the IAEA and the technology developer must follow a disciplined approach to the development of new technology, including strict adherence to an agreed set of procedures designed to ensure high quality and reliability under sometimes adverse field conditions.[18]

G. National Implementation Measures Have a Major Impact on Verification Effectiveness and Efficiency

One of the cornerstones of IAEA safeguards under the NPT is the State System of Accounting and Control, or SSAC, that each State is obliged to establish and maintain.[19] Although the SSAC has a number of purely domestic functions (e.g., protection against theft and sabotage) that are beyond the scope of international safeguards, it fulfills two key functions as far as IAEA safeguards are concerned. First, it maintains a comprehensive system of accounting and control, analogous to the internal control system in financial accounting, that serves as the foundation for IAEA verification. The IAEA independently verifies the information and findings of the SSAC, rather than maintaining a completely separate accounting system of its own. This approach is analogous to that of a financial auditor, who begins by examining a firm's internal controls and accounting and then performs independent tests to assess the correctness of the financial statements. Second, the SSAC serves as the interface between the IAEA and the facilities that are inspected. How well the SSAC performs these two functions has a major impact on the effectiveness and the efficiency of IAEA safeguards. Early safeguards agreements did not explicitly call for SSACs. As experience was gained, their importance was increasingly recognized, and, beginning in the 1970s, they were explicitly provided for in safeguards agreements pursuant to the NPT.

The draft CWC (see Article VII, National Implementation Measures) calls for the establishment of a National Authority to "serve as the national focal point for effective liaison with the Organization and other States Parties." Article VII also calls upon the states to "cooperate with the Organization in the exercise of all its functions and in particular to provide assistance to the Technical Secretariat including data reporting, assistance for international on-site inspections . . . and a response to all its requests for the provision of expertise, information and laboratory support." Some additional details on the functions of the National Authority are contained in the appendices to the rolling text.

The IAEA experience has been that SSACs vary widely in their technical effectiveness and degree of cooperation. Because shortcomings in the SSACs can hamper IAEA safeguards effectiveness, the IAEA and certain member states (including the US) have found it important to pursue a variety of initiatives to improve SSACs. To improve technical effectiveness, these initiatives have included the development of guidelines and examples of good practice, international training courses, bilateral discussions and exchanges, advisory groups, and joint technical efforts by the IAEA and states. Improving the quality, consistency, and timeliness of reports is an example of a topic that has required considerable attention and that will also be important for the OPCW.

To improve the cooperativeness of SSACs, a different approach is needed. The IAEA cannot compel states to do anything. When cooperation is lagging, the IAEA can collect data on the problems and report them to the states concerned or to the Board of Governors. To resolve the issues, however, diplomatic and political steps are often necessary. These steps may be taken either within the IAEA structure or outside it in bilateral or multilateral exchanges. The process can take time.

The role of national implementation measures in the CWC is not yet fully defined. Based on the IAEA experience, several steps are likely to be needed. First, it will be necessary to spell out in more detail what information the National Authority will be expected to make available to the OPCW. The record-keeping and reporting requirements for verification of the CWC will have to be defined more explicitly than they have been thus far in the rolling text. These details need not be in the CWC itself, but clear guidance is needed in some form so the states can understand what is required and, if necessary, promulgate laws or regulations to obtain the needed information from the facilities subject to verification. Second, the other functions of the National Authority (e.g., assistance with international on-site inspections) will require further development. Although they may be difficult to implement in practice, the IAEA experience suggests that the possibility of more explicit agreements on procedures for facilitating international inspections (providing multiple-entry visas, expediting the shipment of samples, speeding communications, formalizing the planning and coordination of inspection visits, etc.) may be worth pursuing. The appendices to the rolling text, particularly the Protocol on Inspection Procedures, already include some provisions along these lines.

H. Materials Accounting Has Limitations As a Verification Measure in the Chemical Context

In IAEA safeguards, materials accounting is the "safeguards measure of fundamental importance, with containment and surveillance as important complementary measures."[20] The basic concept is that of a measured material balance, independently verified by IAEA inspectors. Each facility is divided into a number of areas, called material balance areas, in which a material balance can be struck. The plant operator continuously measures all inputs to and outputs from each material balance area. Periodically, a physical inventory is taken of all material in the material balance area, and a material balance is constructed, based on the bookkeeping identity: beginning inventory + inputs - outputs = ending inventory. The operator maintains detailed accounting records at all times on the inputs, outputs, and inventories. Based on these records, reports are prepared and submitted to the IAEA (through the SSAC).

The IAEA verifies the plant operator's accounting by a combination of measures, including (1) review and analysis of the reports, (2) comparison of the reports to the records, (3) audit or examination of the records (to test for internal consistency), (4) independent counting, identification, and measurement of selected items to check the correctness of the records and reports, and (5) certain supporting activities such as observing the calibration and functioning of the operator's measurement systems. On the basis of these measures, the IAEA is in a position to assess independently whether all declared nuclear material is accounted for.

Certain elements of the IAEA's materials accounting verification procedures are clearly applicable to CWC verification and are explicitly called for in the annexes to the rolling text. Examples include item counting, independent measurements, records examination, and the review and analysis of reports. However, verified materials accounting as a general strategy has limitations in the chemical context. It will be important to recognize these limitations as the detailed verification procedures for the CWC are elaborated and tested.

The fundamental problem is that IAEA-style materials accounting, although it might be possible in theory as a CWC verification measure, would be extremely expensive, both for the inspectorate and for the facility operators. The IAEA experience clearly demonstrates that effective verification at large bulk-processing plants (which are the nuclear facilities that most closely resemble chemical plants) is very costly in terms of inspection resources (staff and equipment). The cost is driven by (1) the need to verify inputs and outputs and (2) the need to ensure that undeclared flows are not occurring. For both of these reasons, very frequent or continuous inspections are typically needed in large bulk-processing plants, with resulting high costs.

The cost for the plant operator is also high. In addition to the costs of accommodating very frequent or continuous inspections, the plant operator must maintain detailed records based on an extensive set of high-quality measurements. In the nuclear case, such a system of records and measurements, while expensive, is already required in most cases for other reasons (domestic regulations and the economic need to carefully control valuable materials), so the incremental costs attributable to IAEA inspections are reduced. In the chemical context, the necessary accounting and measurement systems would, in general, extend well beyond what is required for domestic regulations or for management purposes.[18] If such systems were required for CWC verification, the incremental cost impact would be very large.

Even in the IAEA context, the cost burdens of verification at large bulk-processing facilities have been substantial. The vast majority of facilities at which IAEA safeguards are applied are item facilities like reactors, which can be safeguarded effectively at relatively modest cost. Bulk-processing facilities such as enrichment plants, reprocessing plants, and fuel-fabrication plants represent a small fraction of the facilities, but they consume a large fraction of the inspection resources. The resource requirements for safeguarding these plants, particularly the large advanced designs that have begun to come under safeguards, have prompted the search for more cost-effective inspection approaches. These alternative approaches may be of value in the chemical weapons context.

One approach that is being developed and implemented for IAEA safeguards at some plants is the extensive use of automated in-line measurement systems that reduce the need for inspector presence. At present, there is considerable R & D activity in this area to develop such systems for future large plants. These systems are most feasible and effective when they can be built into the design of the facility from the beginning. Retrofitting existing facilities is less attractive. The automated systems also require careful attention to the problem of authentication—ensuring that the information generated by the automated system is not falsified in some manner.

A second approach is to use containment and surveillance more extensively. Containment and surveillance measures can be used to monitor stored material, detect undeclared movements, and indicate possible tampering with seals or other equipment. As a general rule, this approach is best suited for safeguarding discrete items (e.g., containers in storage) rather than bulk quantities of material. Again, this approach is more feasible and effective if it can be designed into the facility from the beginning.

A third approach is to develop procedures for performing short-notice random inspections. This has been explored for different purposes at two kinds of plants: low-enriched-uranium fuel-fabrication plants and uranium-enrichment plants that normally produce only low-enriched uranium. In the case of the fabrication plants, the short-notice random inspections are currently being tested; they have the potential to provide an efficient means of verifying flows, with less inspection effort required than if inspections were nonrandom and announced well in advance. In the case of enrichment plants, the short-notice inspections (called limited-frequency, unannounced-access, or LFUA, inspections) provide a relatively unintrusive way of verifying that the facility is operating only in the declared manner, i.e., producing only low-enriched uranium.

Although the potential value of the concept has been recognized for a long time, unannounced or short-notice inspections have traditionally been regarded as highly intrusive and undesirable. They also pose logistical difficulties both for the plants (unplanned interruptions of normal plant activities) and for the inspectors (obtaining visas, tickets, and supplies on short notice). For these reasons, IAEA safeguards have made only limited use of the concept. However, the recent experience is beginning to suggest that in some situations short-notice inspections may be less intrusive than alternative approaches. As more experience is gained with the concept, concerns about its intrusiveness may diminish.

None of these alternative approaches is without drawbacks of its own. Overreliance on automation, for example, has the potential to reduce inspector vigilance and to inhibit direct observation by inspectors and the exercise of inspector judgment. Short-notice random inspections, as noted earlier, create logistical problems in some cases, and may be vulnerable to cheating if the element of surprise is somehow compromised. It is unlikely that these approaches by themselves can provide simple technical fixes to the limitations of materials accounting in the chemical context. However, the IAEA experience may be helpful in developing alternative approaches that are workable for CWC verification and in avoiding approaches that have been shown to be unacceptable or undesirable in practice.

I. Staffing the International Inspectorate Is a Major Challenge

As far back as the Acheson-Lilienthal report in 1946,[22] it was recognized that the success of any international system to control nuclear weapons would depend heavily on nontechnical factors. The authors of the Acheson-Lilienthal report noted that a major issue confronting an international control system would be

> whether it would in fact be possible to recruit the very large and very highly qualified organization of experts and administrators needed for the work. The work itself, which would be largely policing and auditing and attempting to discover evidences of bad faith, would not be attractive to the type of personnel essential for the job. The activity would offer the inspectors a motive pathetically inadequate to their immense and dreary task.[23]

Although the IAEA differs substantially from the Atomic Development Authority envisioned in the Acheson-Lilienthal report, the challenge of recruiting, retaining, and motivating adequate numbers of qualified inspectors has proved to be as important as the report foresaw. The same challenge will confront the OPCW. The IAEA experience suggests that the problem is manageable, although considerable effort and management attention are required.

Personnel practices at the IAEA are based on the United Nations system. Job categories, salaries, post adjustments, retirement benefits, and other personnel practices at the IAEA are essentially the same as in the UN and its specialized agencies and affiliated organizations. The system is implemented by IAEA management under the guidance of the Board of Governors and the General Conference. Thus, the IAEA has some flexibility in its personnel practices but is constrained to stay within the general framework of the UN system.

The recruiting of inspectors is long and involved and is complicated by the international nature of the process. Appointments are based not only on job qualifications but also on nontechnical factors, such as the need to observe geographical quotas. To be selected, applicants must be sponsored by their governments. Political factors are particularly important for management posts (section heads, division directors, and higher posts).

Historically, the IAEA has been able to recruit adequate numbers of qualified staff to serve as inspectors. Work as an IAEA inspector offers intrinsic and extrinsic rewards that are appealing to many applicants. However, there are negative aspects (discussed in more detail below) that discourage some potential applicants. There is also a widespread belief that conditions (particularly salaries) for professional staff like inspectors have deteriorated in recent years under the influence of zero-growth budgets. Some countries take steps to compensate for these negatives in order to make employment at the IAEA more attractive for their citizens.[24] The Japanese, for example, supplement the incomes of Japanese government employees who accept jobs at the IAEA. US government employees are given "equalization allowances" when they return to government service from employment at the IAEA. The US and other governments in some cases actively seek out and encourage highly qualified individuals to serve at the IAEA, although these recruiting efforts vary in their degree of formality. The key point is that governments can and do take steps to ensure a steady supply of qualified applicants.

Once the inspectors are recruited, training and motivating them are the major challenges. Although these challenges are important in any organization, the unique aspects of an inspector's job and the multinational nature of the IAEA are complicating factors.

Training new inspectors has been formalized to a significant extent in recent years. A series of standard courses is offered to new inspectors during their first few months on the job. Although the training programs in the IAEA are now well developed, there was a tendency in the early years to rely on more informal approaches, such as on-the-job training and an occasional course. The introduction of a more systematic approach began in the late 1970s, with strong support and assistance provided by the US technical support program. One lesson of the IAEA experience that could be of value for the OPCW would be to give earlier attention to the issue of training.

In addition to learning the technical requirements of the job, new inspectors face a variety of nontechnical challenges. Examples include the high cost of living in Vienna, coping with foreign languages, adjusting to a different culture (including a different working environment and management style than they experienced at home), finding suitable housing in an unfamiliar city, obtaining medical care in an unfamiliar system, handling financial matters such as taxes and banking, and the impact of frequent duty travel on themselves and their families.[25] These problems and concerns span a broad range, and different individuals respond to the challenges in different ways. Some inspectors seem to thrive under almost any circumstances, whereas others never manage to adjust to the job and the lifestyle. The IAEA experience does not offer any easy answers to these types of problems. The IAEA provides a wide array of support services for staff, including such things as a housing office, a commissary, services to facilitate buying a car, an orientation for new staff members, and optional language lessons for a small fee. Some useful steps can be taken by governments to supplement these measures. The US, for example, offers an orientation program for new IAEA staff from the US. The program includes assistance to staff members and their families both before and after they arrive in Vienna.

Before an inspector can participate in inspections in a given state, he or she must be accepted by the state, through a process known as designation. The IAEA Director General formally proposes inspectors for consideration by the state. The state is supposed to inform the Director General within 30 days whether each proposed inspector is accepted or not; in practice, the process frequently takes longer than 30 days. It is not unusual for states to object to proposed designations. Although the reasons need not be given, the most common problems have been political criteria (e.g., inspectors have been rejected if their governments have not signed the NPT or do not accept IAEA safeguards in their own facilities or if their country is politically unacceptable for any other reason); limits established by states on the total number of inspectors that they will accept at any time; and requirements imposed by states that inspectors speak a particular language (e.g., Spanish or French). When a proposed inspector is rejected, the Director General submits additional proposals, and the process continues until a sufficient number of inspectors have been accepted by the state. Although the right to reject certain inspectors or categories of inspectors is important to most states and is unlikely to be eliminated, the process of designation is time consuming and inefficient. The IAEA has learned over the years how to manage the problems so that the impact is minor. The most significant lesson of the IAEA experience in this area is the importance of cooperation. When the state is cooperative, a way can usually be found to balance its political need to place restrictions on certain categories of inspectors against the operational needs of the inspectorate. Much of the effort to resolve problems of these kinds involves informal consultations between IAEA management and representatives of the member states. Strong working relationships between the representatives of states and the IAEA Secretariat are extremely important for dealing effectively not only with designation issues but also with many other issues that are handled at least partly by informal means. Other designation lessons involve the logistics of the process, for example, proposing an inspector for designation to a group of countries simultaneously rather than one country at a time, initiating the designation process earlier, even before the inspector reports for duty, and proposing inspectors in groups to streamline the approval process. The OPCW will confront similar problems with designation. In the "Protocol on Inspection Procedures," the rolling text of the CWC outlines a designation process that closely resembles that of the IAEA. The experience of the IAEA in managing the process will not eliminate the problem for the OPCW, but it may minimize the resulting inefficiencies.

Once an inspector has survived the initiation period, been designated, and adjusted to the job and the living situation, longer-term questions such as career development, performance appraisals, and opportunities for advancement arise. Inspectors are recruited initially for a 3-year term. Some inspectors choose to leave after their first term. Many extend for an additional 2 years. If, after the first five years, they wish to continue as inspectors, they may apply for an additional term of 5 years and in principle may continue to extend their employment in 5-year increments until they reach the normal retirement age.[26] There is no guarantee, however, that an inspector's appointment will be extended. Unless there are unusual circumstances, 5-year appointments are commonly renewed. Nevertheless, some staff members believe there should be more job security. For IAEA management, as for many organizations, the challenge is to obtain a staff that includes a mix of junior and senior people. In recent years, turnover among inspectors has been relatively low.

Once hired, an inspector may find it difficult to be promoted. Some IAEA staff members, including inspectors, advance to higher grades by leaving the IAEA for several years and then returning to a higher post; but once a staff member leaves, there is no assurance that he or she will be able to return at a higher grade. Promotions, like appointments, are influenced by political factors and other considerations, such as age and years of experience; job performance is not the sole, or even the principal, concern in many cases.

In terms of career development, performance appraisals, and other tools to motivate staff, the IAEA has taken a number of steps in recent years to improve its systems; but progress has been slow. The international nature of the organization is a significant constraint. The personnel systems in such organizations tend to be cumbersome. Moreover, styles and philosophies of management vary widely in different countries and cultures. It is difficult to impose American or Western standards and practices on an organization made up of staff from many nations. The IAEA is making progress in these areas, but the pace is slower than many staff members would like. In terms of drawing lessons from the IAEA experience that can be useful in implementing the CWC, the specific issues that the IAEA has faced and the ways they have been addressed are probably less important than the recognition that such issues are important and warrant significant attention from governments and from the management of the OPCW.

J. Systematic Evaluation and Reporting Are Important Functions

A credible verification system must include provisions for evaluating its own effectiveness and reporting the results to interested parties. The IAEA, in its early years, relied on relatively informal approaches to evaluation. Reports on its activities were limited in scope and depth. In the mid-1970s, as the IAEA safeguards program expanded rapidly and as international interest in the IAEA's nonproliferation role intensified, the need for more systematic and comprehensive evaluation and reporting became apparent. A series of steps were taken to create a strong internal evaluation function (originally called the Safeguards Evaluation Section) and to report more fully on IAEA safeguards activities. A new annual report known as the Safeguards Implementation Report was devised. It presents information on the overall results of safeguards, the attainment (or nonattainment) of goals, problems encountered in safeguards implementation, and progress in addressing the problems.

A systematic evaluation and reporting function is important for at least two reasons. First, it establishes an explicit mechanism for identifying needed improvements in the verification system. Second, it communicates to interested parties the accomplishments and limitations of the system. This allows parties to assess realistically the performance of the system vis-à-vis their own interests and to take appropriate actions (e.g., diplomatic initiatives to strengthen the system, or bilateral contacts to persuade other states to modify their policies).

It should be noted that there are inherent difficulties in establishing a strong evaluation and reporting function in a multinational verification organization. Concerns about confidentiality tend to conflict with the desire for openness and candor in evaluations and reports. On the one hand, states are concerned about the misuse of confidential information and are reluctant to see verification details widely disseminated. On the other hand, excessive confidentiality makes it difficult for outside observers to assess the performance of the system independently. A somewhat different concern is how to communicate complex technical information on the performance of the verification system in a way that is understandable and meaningful to a wide range of interested parties, not all of whom are safeguards specialists; the same sort of problem arises in many other technical fields. The IAEA has not yet fully resolved these difficulties but is continuing to refine its evaluation and reporting systems as experience is gained. Although the OPCW will need to develop its own mechanisms for evaluation and reporting, the IAEA experience may facilitate the process. Considering the rapid growth expected in the first few years after the CWC enters into force, early attention to this issue may be warranted.

K. Measurement Control and Quality Assurance Are Essential

Independent measurements by IAEA inspectors are the cornerstone of the IAEA safeguards program. If safeguards are to be credible, the measurements must be valid and, equally important, their validity must be demonstrable. This requires a systematic quality assurance effort for all measurements performed by inspectors, and also by plant operators, whose data are being verified.

The importance of measurement control has been recognized in the nuclear industry since the 1940s. Significant effort and resources were devoted to the development and validation of highly precise and accurate measurement methods for the key materials in the nuclear fuel cycle. Regulations and standards were written, standard reference materials were developed, programs for the training and qualification of analysts were established, and interlaboratory comparisons and round robins, including some that were international in scope, were conducted. The impetus for much of this early work was purely domestic. High-quality measurements were required by national regulatory authorities because of the high strategic value of nuclear materials. The high monetary value of the materials was also a factor.

When IAEA safeguards were established, it was possible to build on the prior efforts of the nuclear industry and domestic regulators, which facilitated the IAEA's task considerably. Provisions for measurement quality and measurement control were incorporated into safeguards agreements. NPT safeguards agreements, for example, require that "the system of measurements on which the records used for the preparation of reports are based shall either conform to the latest international standards or be equivalent in quality to such standards."[27] The agreements also require the SSAC to establish measurement control programs and the plant operators to maintain operating records on measurement control procedures, calibrations, etc. Despite the existence of these requirements and the substantial experience base in the nuclear industry, an extensive effort has been and still is required to maintain and strengthen measurement quality assurance programs for IAEA safeguards purposes. Facilities and states have had to continue their activities. The IAEA has had to establish programs of its own as it introduced new measurement techniques and procedures.

Although the OPCW may not rely on materials accounting to the same extent that IAEA safeguards do, it will nevertheless rely heavily on measurements in monitoring compliance. Consequently, assuring the quality of measurements will be an essential concern. Many of the concepts and techniques of measurement quality assurance are generic and could be adapted from the nuclear context to the chemical context. However, the IAEA experience underscores the value of building on prior efforts where possible. Therefore, the starting point for the OPCW should be the extensive work on measurement methods that has been done over the years by military organizations engaged in research on chemical agents. Work on environmental measurements will be applicable in some cases as well, although, as is true for the nuclear experience, adaptation will be required. The technical problems are potentially very challenging; in some cases, for example, the verification measurements may involve trace analyses of samples taken under adverse conditions (e.g., investigations of alleged use), and the range of chemicals (agents and decomposition products) that may need to be detected is extremely broad.

The principal lesson of the IAEA experience is to reinforce the importance and the difficulty of assuring measurement quality. Assurance of quality is also equally important for the other elements of the inspection program. The needed quality assurance programs require a continuing effort as long as the system is operational, and they are costly. However, because the validity of the verification system is crucial, there is no alternative to a rigorous quality assurance program.

L. Specific Equipment, Techniques, and Concepts Can Be Adapted

Although many of the details remain to be worked out, it is already clear that verification approaches for the CWC will be substantially different from those used by the IAEA. These differences notwithstanding, the IAEA has considerable experience with specific equipment, techniques, and concepts that can usefully be adapted to CWC verification. Selected examples are discussed briefly here.

- *Seals.* Several of the seals that are used in IAEA safeguards could be adapted for a variety of chemical applications, for example, monitoring of weapons stockpiles, monitoring of shipments of chemical weapons from storage to destruction facilities, sealing of transportation containers for inspection samples, sealing of instrument cabinets and enclosures, and verification of nonproduction in former chemical weapons plants.

- *Closed-circuit-television (CCTV) surveillance.* Surveillance systems similar to those used in IAEA safeguards could be applied as one part of a system to verify destruction of chemical weapons, to confirm nonproduction of chemical weapons at shutdown production facilities, or to monitor stockpiles.
- *Statistical sampling techniques.* The IAEA has made extensive use of statistical sampling plans to conserve inspection resources. Similar techniques can be used throughout the CWC verification system, although in general they need to be tailored to each specific application.
- *The concept of strategic points.* The IAEA uses the concept of strategic points as a mechanism for managing access to facilities, thereby addressing concerns about controlling the loss of sensitive information. Strategic points are defined as those locations "selected during examination of design information" at which "the information necessary and sufficient for the implementation of safeguards measures is obtained and verified." Application of this concept has made it possible to negotiate workable limits on inspection access without compromising the effectiveness of safeguards.
- *Specification of quantitative technical objectives.* The IAEA has expressed its technical objectives in terms of the probability of timely detection of any significant noncompliance, and the deterrence of noncompliance through the risk of early detection. Although CWC verification is based on different requirements, the concept of timely detection of any significant noncompliance seems applicable, if adapted and implemented appropriately.
- *A central analytical laboratory, supported by a network of analytical laboratories.* The IAEA maintains its own central Safeguards Analytical Laboratory, located near IAEA headquarters in Vienna, which performs chemical and isotopic analyses of inspection samples. Analyses are also performed, under appropriate controls to ensure measurement quality and integrity, by a network of 18 analytical laboratories located in and operated by IAEA member states. This arrangement serves to distribute the workload and expand the pool of expertise available for safeguards measurements.
- *Analytical methods for designing and evaluating verification approaches.* The IAEA has developed a number of systematic verification planning and analysis techniques that can be adapted for CWC verification system analysis. The techniques, which are all closely related, include diversion-path analysis, safeguards-effectiveness assessment methodology, and probabilistic assessment of safeguards effectiveness.

VI. CONCLUSIONS

The IAEA safeguards system differs in many significant respects from the system that will verify compliance with the CWC. But there are sufficiently many similarities and analogous features of the two systems that examination of the IAEA experience is instructive. The 12 major lessons discussed in this report span a broad range, from policy and institutional issues to specific equipment and techniques.

The IAEA is unique in that it is the only worldwide, multilateral arms control verification system in existence. It has been applying safeguards routinely for many years now. Considering the technical and administrative complexity of the proposed CWC verification system, it is natural to take full advantage of the IAEA experience where it is relevant. However, the IAEA experience is not the only source of useful lessons for designing and implementing the CWC verification system. Valuable lessons can also be learned from other arms control agreements, such as the Intermediate-Range Nuclear Forces (INF) Treaty and the Strategic Arms Reduction Talks (START), and from confidence-building measures such as the on-site inspections of conventional military activities based on the 1986 Stockholm Document. Useful insights may also be obtainable from experiences that do not involve arms control; examples include on-site inspections performed for domestic regulatory purposes, the independent reviews performed by financial auditors, and the practices of various investigative agencies.

The most directly useful source of lessons, of course, is from experiences directly linked with CWC verification, namely the ongoing National Trial Inspections, the bilateral verification exercises that are being held by the US and the USSR, and other verification exercises and demonstrations that will be carried out over the next few years. In the early years of IAEA safeguards, similar efforts, known as integral safeguards experiments, played an important role in the development and refinement of safeguards approaches and techniques.

Given the difficulty of its verification responsibilities, the OPCW will need to take full advantage of all available sources of experience and insight. In addition, planning for the verification system should allow for the OPCW to evolve over time, based on its initial verification experiences and changes in the political and technical environment. The IAEA experience demonstrates that the gradual growth and improvement of the institution over time is a key factor in determining whether the political and technical goals of verification will be achieved.

NOTES AND REFERENCES

1. Currently, it is envisioned that entry into force will occur after ratification by 60 nations.

2. The CWC verification regime, for example, will cover destruction of existing chemical weapons stockpiles and production facilities, investigations of alleged use of chemical weapons, and challenge inspections. The IAEA safeguards system, by contrast, is limited to verification of peaceful nuclear activities and until recently has had no experience with

challenge-type inspections. IAEA safeguards agreements do include provisions for "special inspections," which are analogous to challenge inspections in some respects, but prior to the recent inspections in Iraq pursuant to UN Security Council Resolution 687 the IAEA had never performed a challenge-type inspection of the kind foreseen in the CWC. The scope of this report is limited to IAEA safeguards as they have traditionally been practiced. Possible changes in IAEA safeguards as a result of the Iraq experience and other recent developments are not considered. A "lessons learned" study of these recent developments should be deferred until additional experience has been gained in Iraq and perhaps elsewhere.

3. See, for example, D. Fischer and P. Szasz, *Safeguarding the Atom: A Critical Appraisal* (London: Taylor and Francis, 1985); N. Sims, *International Organization for Chemical Disarmament*, SIPRI Chemical and Biological Warfare Studies No. 8, Oxford University Press, 1987; B. terHaar and P. deKlerk, "Verification of Non-Production: Chemical Weapons and Nuclear Weapons Compared," *Arms Control*, Vol. 8, No. 3, 1987, pp. 197-212; K. Apt, "Chemical Warfare Arms Control: Issues and Challenges," Center for National Security Studies Report No. 6, Los Alamos National Laboratory, LA-11451, 1988; J. Keeley, "International Atomic Energy Safeguards: Observations on Lessons for Verifying a Chemical Weapons Convention," Arms Control Verification Occasional Papers No. 1, Ottawa, Canada, Department of External Affairs, 1988; H. Schriefer and J. Keeley, editors, "International Atomic Energy Agency Safeguards as a Model for Verification of a Chemical Weapons Convention," *Proceedings of a Workshop Held at Banff Springs Hotel, Alberta, Canada, October 21-24, 1988*, Arms Control Verification Occasional Papers No. 3, Ottawa, Canada, Department of External Affairs; and K. Apt and J. Markin, "A Systems Approach to Chemical Weapons Verification," Center for National Security Studies Report No. 10, Los Alamos National Laboratory, LA-11846, 1990.

4. According to the January 1991 rolling text, the CWC would ban (1) the development, production, acquisition, stockpiling, or retention of chemical weapons; (2) the transfer of chemical weapons to anyone, either directly or indirectly; (3) any assistance, encouragement or inducement to engage in activities prohibited by the CWC; (4) use of chemical weapons; and (5) preparations for use of chemical weapons. The last item, preparations for use, is bracketed. In addition, states that possess chemical weapons or chemical weapons production facilities would be required to destroy them. Conference on Disarmament, *Report of the Ad Hoc Committee on Chemical Weapons to the Con-*

ference on Disarmament on Its Work During the Period 8-18 January 1991, CD/1046 (18 January 1991), pp. 13-14.

5. As noted earlier, most signatories of the 1925 Geneva Protocol reserved the right to retaliate with chemical weapons if subjected to chemical attack.

6. The scope of IAEA safeguards may change in the future as a consequence of the situation in Iraq and other developments. Provisions for "special inspections," for example, which have not been fully exercised in the past, may be strengthened. In certain circumstances, IAEA safeguards agreements provide for "special inspections," which are analogous in some respects to challenge inspections. NPT agreements, for example, give the IAEA the right to conduct special inspections "if the Agency considers that information made available by the State, including explanations from the State and information obtained from routine inspections, is not adequate for the Agency to fulfill its responsibilities under the Agreement." Special inspections, in principle, permit the IAEA to gain access to information and locations that are not normally subject to inspection and to exceed agreed limits on allowable inspection effort. Procedures are defined for consultations between the IAEA and the state and for settlement of disputes if the IAEA and the state do not agree on the need for additional access.

7. H. Scoville, "Arms Control Implications of Safeguards," in *Proceedings of the Symposium on Safeguards Research and Development Held at Argonne National Laboratory, June 26, 1967*, Report WASH-1076, pp. 19-22.

8. For example, provisions may need to be defined to ensure that information collected for verification purposes is appropriately protected from misuse by potential CW proliferators.

9. See, for example, L. Scheinman, *The International Atomic Energy Agency and World Nuclear Order* (Washington, D.C.: Resources for the Future, 1987).

10. United Nations Department for Disarmament Affairs, "Third Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons, 1985, Final Declaration," NPT/CONF.III/64/I, Annex I.

11. Ibid.

12. Ibid.

13. International Atomic Energy Agency, *Statute, As Amended Up To 1 June 1973*, Vienna, 1973, p. 5.

14. Article X of the CWC, Assistance and Protection Against Chemical Weapons, also has an element of technical assistance, but it is concerned with security

assistance rather than promotion of the peaceful uses of chemistry and chemical technology.

15. Although the NPT did not require the nuclear-weapon states to accept safeguards, President Johnson in 1968 offered to place nuclear facilities not deemed to be of national security importance under IAEA safeguards as a gesture of good faith and as a demonstration of US commitment to nonproliferation. The other two nuclear-weapon states that are parties to NPT (the UK and the USSR) also agreed to accept safeguards under similar "voluntary offers." In addition, China and France, both of which are nuclear-weapon states not parties to NPT, have also concluded safeguards agreements covering some nuclear activities.

16. International Atomic Energy Agency, *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, Vienna, 1972.

17. Estimates of the resource requirements for the OPCW have varied widely, with most estimates suggesting an organization at least as large as the IAEA's Department of Safeguards and perhaps substantially larger in the first 10 years, when the OPCW will need to monitor the storage and eventual destruction of existing chemical weapons stockpiles.

18. These lessons have been formalized by the US Support Program through an approach called the Low Risk Transition Plan (LRTP). L. Green, E. W. Karlin, and E. V. Weinstock, "Providing Reliable Equipment to IAEA Through a Low Risk Transition Plan," in *Proceedings of the 29th Annual Meeting of the Institute of Nuclear Materials Management*, Las Vegas, Nevada, June 26-29, 1988, pp. 347-50.

19. In the United States, for example, the Nuclear Regulatory Commission is the State System. In the European Community, EURATOM (the European Atomic Energy Community) is the State System. Each country is free to define its own legal and organizational arrangements for the State System. Most have assigned the responsibility to an existing domestic nuclear regulatory authority.

20. The Structure and Content of Agreements, paragraph 29.

21. Because of the great diversity of the chemical industry, this statement requires qualification. Certain sectors of the chemical industry (pharmaceuticals, for example), for regulatory and management reasons, do in fact have very detailed and rigorous accounting and recordkeeping. In addition, regulation of the chemical industry has been increasing in recent years, particularly with respect to environmental matters. Nevertheless, most of the types of facilities of concern for

CWC verification still have less stringent accounting and record-keeping systems than typical nuclear facilities.

22. The Acheson-Lilienthal report was one of the earliest postwar initiatives in the area of nuclear arms control. Department of State, *A Report on the International Control of Atomic Energy*, Washington, D.C., 1946.

23. Ibid.

24. These efforts by governments on behalf of IAEA employees or potential employees may be perceived by some as detrimental to the independence of inspectors. However, inspectors are not assigned to perform inspections in their home countries. Other institutional checks and balances limit the extent to which inspectors can promote narrow national interests at the expense of broader interests. Thus, the perceived lack of independence is not a significant problem in practice. It is interesting to note that historically there have also been concerns about inspectors being too independent.

25. K. Sanders and E. Weinstock, "An Orientation Program for U.S. Citizens Going to the IAEA," in *Proceedings of the 29th Annual Meeting, Institute of Nuclear Materials Management*, Las Vegas, Nevada, June 26-29, 1988, pp. 210-17.

26. Until recently, the retirement age has been 60. The IAEA is currently in the process of raising it to 62.

27. It should be noted, however, that comprehensive, widely accepted international standards for measurement precision and accuracy are not yet in place, although steps have been taken in this direction.