2 Introduction

Production of fissile nuclear material (highly enriched uranium or plutonium) is the most difficult step in making a nuclear weapon. Consequently, constraining a would-be proliferant nation's ability to produce such materials has always been a central component of international nonproliferation efforts. (For this reason, the widespread availability of nuclear weapon material from the former Soviet Union on the black market would deal a grievous blow to the nonproliferation regime.[1]) In particular, the Non-Proliferation Treaty (NPT) requires those countries that join the treaty as non-nuclear-weapon states to accept international monitoring of all their facilities that might produce, use, store, or otherwise handle nuclear materials. Such monitoring is conducted by the International Atomic Energy Agency (IAEA) through its system of nuclear safeguards.

Indeed, controls over nuclear materials and production facilities serve a number of purposes in nonproliferation policy. Safeguards play a role in each of the four basic categories of nonproliferation policies[2]:

1. **obstacles** to impede those working to acquire weapons of mass destruction;
2. **punitive measures** to deter or punish proliferants;

[1]Potential leakage of nuclear material from the former Soviet Union is discussed in some depth in U.S. Congress, Office of Technology Assessment, *Proliferation and the Former Soviet Union*, OTA-ISC-605 (Washington, DC: Government Printing Office, September 1994).

[2]These categories are described in detail in U.S. Congress, Office of Technology Assessment, *Proliferation of Weapons of Mass Destruction: Assessing the Risks*, OTA-ISC-559 (Washington, DC: Government Printing Office, August 1993), esp. pp. 5, 19-25, and 83-115.

3. **rewards** to increase the attractiveness of voluntarily forgoing these weapons; and, perhaps most important of all,
4. **regional or global security improvements** to reduce the perceived needs for the weapons.

IAEA safeguards are intended to impede nuclear proliferation by ensuring that the diversion of nuclear materials from safeguarded nuclear facilities to weapon purposes will be caught and made known to the world community. To the extent that they can assure a country that its neighbors or adversaries are not developing nuclear weapons, safeguards lessen that country's perceived need to develop its own nuclear arsenal.

Given the importance of the IAEA's system of nuclear safeguards to international nonproliferation efforts, this report analyzes what such safeguards can and cannot be expected to accomplish, identifies areas where they might be improved, and presents various options for accomplishing this. Options analyzed in this report fall into two broad categories: 1) those that could be implemented primarily within the current framework of NPT constraints and IAEA safeguards, thus improving on institutions and practices already in place; and 2) those that would extend beyond the current framework. The latter include measures to address actions of states not party to the NPT and policies that would have to be undertaken outside the domain of the NPT and IAEA safeguards.

The focus in this report on IAEA safeguards and nuclear materials should not be taken to imply that safeguards constitute the only nonproliferation tool. Many other measures, such as export controls, classification of weapon-related information and data, security assurances, diplomatic and military commitments, and international treaties, are also essential to international nonproliferation efforts.[3]

A HISTORY OF INTERNATIONAL CONTROL EFFORTS

Even before atomic weapons were first used at the end of World War II, some senior U.S. policymakers and scientific leaders realized that atomic energy might have to be controlled internationally. This conclusion followed because:

- atomic weapons made devastation possible on a scale that was not previously imagined;
- they derived from scientific knowledge that was or soon would be available worldwide, such that no nation would be able to maintain a monopoly in atomic weapons; and
- some of the knowledge and technology needed to produce atomic weapons was related to that needed to realize whatever peaceful applications atomic energy might provide.

In January 1946, the fledgling United Nations created a United Nations Atomic Energy Commission and charged it with preparing proposals for "the elimination from national armaments of atomic weapons and of all other major weapons adaptable to mass destruction," together with "effective safeguards by way of inspection and other means to protect complying States against the hazards of violation and evasion."[4] Anticipating this action, the U.S. Secretary of State had already

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[3]See ibid. for a review of the array of policy tools that can be used to combat proliferation. For a discussion of evidence that might indicate the production of weapons of mass destruction and technical hurdles that might provide opportunities to control their spread, see U.S. Congress, Office of Technology Assessment, *Technologies Underlying Weapons of Mass Destruction*, OTA-BP-ISC-115 (Washington, DC: U.S. Government Printing Office, December 1993). Dual-use export controls are analyzed in U.S. Congress, Office of Technology Assessment, *Export Controls and Nonproliferation Policy*, OTA-ISS-596 (Washington, DC: U.S. Government Printing Office, May 1994). Proliferation issues arising from the breakup of the Soviet Union are addressed in *Proliferation and the Former Soviet Union*, op. cit., footnote 1.

[4]"Establishment of a Commission To Deal with the Problems Raised by the Discovery of Atomic Energy," United Nations General Assembly Resolution I, *Resolutions Adopted by the General Assembly During the First Part of Its First Session from 10 January to 14 February 1946*, United Nations Document A/64 (London, England: Church House, 1946), p. 9, quoted in Leniece N. Wu, *The Baruch Plan: U.S. Diplomacy Enters the Nuclear Age*, Foreign Affairs Division, Congressional Research Service, prepared for the Subcommittee on National Security Policy and Scientific Developments, House Committee on Foreign Affairs, August 1972, Committee Print, p. 8.

impaneled a commission chaired by Under Secretary of State Dean Acheson to "study the subject of controls and safeguards necessary" to protect United States interests under such a regime.

The Acheson-Lilienthal Report

In turn, the Acheson committee commissioned a panel of technical experts chaired by David Lilienthal, chairman of the Tennessee Valley Authority, to "apprais[e] all the relevant facts and formulat[e] proposals." The Lilienthal panel considered proposals by which nations would retain the capability to produce fissionable materials but would pledge not to do so for weapon purposes, and would submit to international inspections that would forestall and detect such prohibited activities. However, the panel found that no such approach was workable:

> We have concluded unanimously that there is no prospect of security against atomic warfare in a system of international agreements to outlaw such weapons controlled *only* by a system which relies on inspection and similar police-like methods.[5]

Verifiable nuclear disarmament, according to the panel, required that individual nations be completely prohibited from producing fissionable materials or conducting other "dangerous" activities that could directly support a weapon program. All such activities would be undertaken exclusively by an international organization established for that purpose. Using nuclear fuel provided by the international organization, nations would be permitted to operate nuclear reactors to produce power, or to use radioactive materials for research purposes, since such activities could not, according to the panel, lead to the production of weapon materials.[6] The scope of activity permitted to individual nations, however, would have to be strictly limited:

> So long as intrinsically dangerous activities may be carried on by nations, rivalries are inevitable and fears are engendered that place so great a pressure upon a system of international enforcement by police methods that no degree of ingenuity or technical competence could possibly hope to cope with them.[7]

Initial Failure of International Control

The Acheson-Lilienthal report was released in March 1946. In the same month, President Truman appointed financier Bernard M. Baruch to represent the United States at the U.N. Atomic Energy Commission's negotiations over the international control of nuclear energy. Baruch's proposal to the U.N. Commission in June 1946 was largely based on the Acheson-Lilienthal report but had some important differences, particularly regarding Baruch's insistence that the international control mechanism include specific provision for enforcement that would not be subject to Security Council veto. Known as the Baruch Plan, this proposal met a hostile reception from the Soviet Union. Ultimately, the United States and the So-

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[5]"A Report on the International Control of Atomic Energy," U.S. Government Printing Office, Washington, 1946, 79th Congress, 2d Session, House Document 709, prepared for The Secretary of State's Committee on Atomic Energy by a Board of Consultants: Chester I. Barnard, J.R. Oppenheimer, Charles A. Thomas, Harry A. Winne, David E. Lilienthal, Chairman, Mar. 16, 1946, p. 4.

[6]One of the assumptions of the Lilienthal panel was that nuclear materials suitable for nuclear power generation could be "denatured" so that they would not be usable in nuclear weapons. For uranium, which can only be used in a nuclear explosive if it is highly enriched in the uranium-233 or -235 isotopes, this assumption is true. However, although the panel believed that plutonium, too, could be produced in a form that would not be suitable for nuclear weapons without difficult additional processing, it is now known that so-called reactor-grade plutonium can still be used in nuclear explosives. For several reasons, such plutonium is somewhat less desirable for weapon use than so-called weapon-grade plutonium, but it is usable nonetheless. See *Technologies Underlying Weapons of Mass Destruction*, op. cit., footnote 3, pp. 131-133.

Indeed, the Lilienthal panel did anticipate that future developments might lessen or eliminate the barriers to using such "denatured" nuclear materials in weapons. They therefore stated that the distinction between "safe" activities and "dangerous" ones be continually revisited as technology advanced.

[7]"A Report on the International Control of Atomic Energy," op. cit., footnote 5.

viet Union could not agree on issues such as the process by which international control would be phased in and the U.S. nuclear arsenal phased out, the inspection rights that the international control organization would have, and the mechanism for enforcing the international control regime. Indeed, even had agreement on these issues been reached, the U.S. Senate's consent to the ratification of any such treaty would have been far from assured.

In the absence of international control, subsequent U.S. efforts to constrain the spread of nuclear weapons took place in a context completely different from that envisioned by the Acheson-Lilienthal and Baruch plans. Rather than basing its security on a binding international regime that would eliminate all nuclear weapons in national hands, the United States instead depended on the retention and further development of its own nuclear arsenal. So long as the United States could promise to respond to a nuclear attack with in-kind retribution, it could relax significantly the requirements that would otherwise have been placed on any international system to monitor and control nuclear technology. In lieu of any such system, proliferation did ensue; the Soviet Union detonated its first atomic bomb in 1949, and Britain followed in 1952. Later, three other countries would also carry out nuclear tests: France, in 1960; China, in 1964; and India, in 1974.

Atoms for Peace

In December 1953, with both U.S. and Soviet nuclear arsenals expanding, President Eisenhower proposed that both nations make contributions from their stocks of fissionable materials to a new international organization that would put these materials to peaceful use. This "Atoms for Peace" program was intended to serve the dual purpose of drawing down the stockpile of nuclear weapon materials among the superpowers as well as fostering peaceful applications of nuclear technology, such as producing electric power and contributing to agriculture, medicine, and other branches of science. In his speech before the United Nations outlining his proposal, President Eisenhower suggested that a new International Atomic Energy Agency be set up to take custody of nuclear material, ensure its security, and turn it to peaceful use.

In 1954, Congress amended the laws that severely restricted the transfer of nuclear materials and technology, and the United States began to enter into bilateral nuclear cooperation agreements with other countries. These agreements included provisions, called safeguards, by which the United States could assure itself that its nuclear materials and technology were not being put to military use. At the same time, the United States entered into negotiations to create the International Atomic Energy Agency. These negotiations concluded in late 1956 with the approval of the IAEA Statute, Article II of which gives the IAEA the mission to "accelerate and enlarge the contribution of atomic energy to peace, health, and prosperity throughout the world."[8] The IAEA was established the following year as an independent intergovernmental organization, affiliated with—but not a subunit of—the United Nations.[9]

The International Atomic Energy Agency

Created within the context of the existing international system, the International Atomic Energy Agency is necessarily far weaker than the supranational international control organization that would have been established under the Acheson-Lilienthal or Baruch plans. The IAEA was not given highly intrusive powers of inspection or enforcement over its member states, nor did it assert control over their nuclear activities or material.

[8]The IAEA Statute was approved October 23, 1956 and entered into force on July 29, 1957.

[9]*The Agreement Governing the Relationship Between the United Nations and the International Atomic Energy Agency,* INFCIRC/11, Oct. 30, 1959, specifies the affiliation between the two organizations, establishing various administrative and reporting linkages. The two bodies, however, are independently governed and have separate charters.

Rather, it was given the authority to enter into so-called safeguards agreements with individual nations to ensure that any nuclear materials, equipment, or facilities offered up for inspection were not used to produce nuclear weapons.

The first such agreement was concluded between the IAEA and Japan in 1959, but the agency did not adopt a comprehensive safeguards system until 1965.[10] Now set forth in IAEA document INFCIRC/66/Rev. 2, this system of safeguards was to be applied, upon request, to individual nuclear activities within a state and to all activities receiving IAEA assistance. INFCIRC/66 safeguards apply to individual plants, shipments of nuclear fuel, or supply agreements between states supplying nuclear fuel or technology and states importing it, and they are the basis for nearly all agreements between the IAEA and states that are not party to the nuclear Non-Proliferation Treaty.[11]

The Non-Proliferation Treaty, which entered into force in 1970, extended the scope of the IAEA's safeguards activities. By joining the NPT, non-nuclear-weapon states (e.g., all those except the United States, Russia, the United Kingdom, France, and China) commit themselves to refrain from manufacturing or otherwise acquiring nuclear weapons or explosive devices, and to submit to IAEA safeguards. Instead of applying only to selected nuclear activities on request, however, safeguards under the NPT—known as *full-scope* safeguards—are required of non-nuclear-weapon states on *all* nuclear materials in all peaceful nuclear activities within their territory or under their control.[12] To accommodate this new mission, the IAEA developed INFCIRC/153, a more comprehensive model safeguards agreement encompassing every aspect of a state's nuclear fuel cycle except the initial mining and milling of uranium ore. All non-nuclear-weapon states that are party to the NPT are obligated to conclude safeguards agreements with the IAEA, but the converse is not true. There are countries with safeguarded nuclear facilities, including one (Brazil) that has concluded a full-scope safeguards agreement, that are not members of the NPT. Box 2-1 distinguishes among states that are members of the Non-Proliferation Treaty, states that are members of the IAEA, and states that have concluded safeguards agreements with the IAEA.

IAEA SAFEGUARDS

IAEA safeguards are a system of procedures involving material control and accountancy, containment and surveillance, and verification (including onsite inspections at declared facilities) that are implemented through agreements between the IAEA and individual countries. They are designed primarily for two purposes: 1) to detect proliferation activities that involve diversion of materials from the civilian nuclear fuel cycle; and 2) to provide warning of any such occurrence to an international forum in a timely fashion. (Exactly what constitutes "timely" warning is somewhat controversial, as explained in the section on timeliness goals in chapter 3.) **Though they may deter proliferation by posing a risk of discovery, safeguards by themselves cannot prevent proliferation; nor can they predict a country's intent or future activity.**

The safeguards process consists of three stages:

1. *examination by the IAEA of state-provided information*, which covers design of facilities, inventories, and receipts for transfers and shipments of materials. States subject to safeguards must establish so-called state systems of accounting and control, or SSACs, to keep track

[10]David A.V. Fischer, *The International Non-Proliferation Regime, 1987* (New York: United Nations, 1987), pp. 4, 38

[11]Ibid., p. 38.

[12]Non-Proliferation Treaty of 1970, Article III(1). For non-nuclear-weapon states, nuclear materials that are in use for military, but nonexplosive, purposes such as naval propulsion are exempt from safeguards. However, a state may not create a separate fuel cycle outside safeguards to produce nuclear materials for these purposes. To date, this exemption has never been invoked.

BOX 2-1: NPT Members, IAEA Members, and Safeguards Agreements

Signing the Non-Proliferation Treaty, concluding a nuclear safeguards agreement with the international Atomic Energy Agency, and joining that agency are three independent actions. Taking any one of them does not automatically accomplish any of the others. Membership in the Non-Proliferation Treaty obligates a state to go on to conclude a so-called full-scope safeguards agreement with the IAEA, but many NPT members (all with no significant nuclear facilities in their territories) have not yet done so. In addition, neither of those actions depends on or affects a state's decision to become a member of the IAEA. Appendix B provides a list of countries in each of these three categories.

NPT Membership. States join the Non-Proliferation Treaty either as nuclear-weapon states or non-nuclear-weapon states. Nuclear-weapon states are defined in the NPT as those that had "manufactured and exploded a nuclear weapon or other nuclear explosive device" before January 1, 1967. The only states that have done so are the United States, Russia (successor of the Soviet Union), the United Kingdom, France, and China, all of which have joined the NPT. All other states are non-nuclear-weapon states. Joining the NPT imposes a number of binding obligations on a state, depending on whether it is a nuclear-weapon state or a non-nuclear-weapon state.

Safeguards Agreement. Non-nuclear-weapon states are required by the NPT to accept full-scope IAEA safeguards over all their nuclear activities. Such safeguards agreements are modeled upon a standard agreement known as INFCIRC/153 (see text). However, not all NPT members have concluded such agreements with the IAEA. Non-NPT members can also enter into safeguards agreements with the IAEA, either over all their nuclear activities as if they were NPT members, or (more often) over specific nuclear activities within their territories. The limited safeguards agreements that cover only a specified set of activities, materials, or facilities are modeled after a different IAEA standard known as INFCIRC/66.

Although not required to do so by the NPT, all the nuclear-weapon states have concluded so-called voluntary offers in which they provide the IAEA with a list of *civil* nuclear facilities at which they will voluntarily accept safeguards. From this list, the IAEA selects those facilities where safeguards will actually be applied. Due to resource constraints, it chooses to do so only at a few. Much of the text of these voluntary offers parallels the text of INFCIRC/1 53, with the very important difference that there is no obligation to place all nuclear facilities under safeguards, nor to refrain from using nuclear materials in nuclear weapons (except that those materials *under safeguards* must not be used for weapons). Consequently, military nuclear activities in the nuclear weapon states remain outside the scope of these offers. [1]

IAEA Membership. Membership in the IAEA gives a state a voice in the governance of the agency, including its role in implementing nuclear safeguards agreements between the agency and individual nations. It also makes a state eligible to participate in various IAEA programs, such as those that offer states technical assistance in peaceful applications of nuclear power. However, whether or not a state is a member of the IAEA is completely unrelated to any obligations a state may accept by joining the NPT or by concluding a safeguards agreement with the IAEA. States need not be members of the IAEA to join the NPT or to enter into safeguards, and a state may join the agency without joining the NPT or concluding a safeguards agreement.

[1] The United States has offered to accept safeguards at any of its civil nuclear facilities and also at facilities where nuclear material declared to be excess to its nuclear weapon program is stored.

of nuclear materials under their jurisdiction. The SSACs submit their records to the IAEA for independent verification, much as a bank auditor would be asked to provide independent confirmation of the accuracy of a bank's accounting.
2. *collection of data and independent information by IAEA inspectors,* either to verify material inventories, operating records, or design information, or, in special circumstances, to clarify unusual findings.
3. *evaluation by the IAEA* of this information for completeness and accuracy.[13]

Any discrepancy of nuclear materials between the recorded (book) inventory and the physical inventory determined by measurements and inspections is called *material unaccounted for* (MUF). When MUF exceeds the amount that the IAEA can reasonably attribute to measurement uncertainties, the possibility of diversion exists and must be resolved.[14]

Subjectivity of Safeguards

For each of the different types of facilities under safeguards (e.g., research reactors, power reactors, fuel fabrication facilities, enrichment plants, reprocessing plants), the IAEA has formulated a safeguards *approach* and developed safeguards *criteria* that, when successfully attained, permit the IAEA to assert that material has not been diverted from a given facility. **Despite the objective, systematic way in which the IAEA nuclear safeguards system has been codified and implemented, however, the underlying judgment as to what the safeguards system needs to be able to do and how well it needs to do it is inherently a subjective one.** The stated purpose for IAEA safeguards, as specified in the safeguards agreements between the IAEA and those countries that have accepted safeguards over all their nuclear facilities (usually as a consequence of adherence to the Non-Proliferation Treaty), is:

> ...the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or of other nuclear explosive devices or for purposes unknown, and deterrence of such diversion by risk of early detection.[15]

However, this statement, by itself, does not specify quantitative goals. What constitutes a "significant quantity"? How soon need diversion be detected to be "timely?" The answers to these questions, as explained in chapter 3, are controversial; different observers will set different standards. (Even apart from determining a reasonable estimate for the minimum amount of nuclear material necessary to make a bomb is the underlying decision as to whether the safeguards system need only be able to detect diversions of that size, or whether it has to be sensitive to fractions of that amount.) Over what period of time might a diversion take place before the IAEA deems it too slow to have much chance of being detected? (This is a different question from that of how soon after a diversion has been conducted should the IAEA be in a position to report it, which is the criteria for "timely detection.") Is it sufficient for the IAEA to attempt to detect diversions of one significant quantity per year, as it now sets out to do? Or does the agency need to meet the far higher (indeed, impracticably high) standard of assuring that a state has not been able to divert one "significant quantity" since the dawn of its nuclear program, no matter how long ago that may have been? **No matter what minimum rate of diversion the IAEA**

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[13]Material in this section on IAEA safeguards is from *Technologies Underlying Weapons of Mass Destruction,* op. cit., footnote 3, pp. 185-189.

[14]This discussion is taken from ibid. For an extensive discussion of safeguards concepts and methodologies, see David A.V. Fischer and Paul Szasz, *Safeguarding the Atom: A Critical Appraisal* (London: SIPRI, Taylor and Francis, 1985); and Lawrence Scheinman, *The International Atomic Energy Agency and the World Nuclear Order* (Washington, DC: Resources for the Future, 1987), esp. ch. 4 and 5.

[15]INFCIRC/153, para. 28.

±aims to detect, a state willing to wait a little longer might successfully divert material at a slower rate.

Apart from determining parameters such as these upon which the rest of the safeguards system is built, the IAEA must also decide with what degree of confidence it needs to be able to assure that a diversion has not occurred. **No verification system can provide absolute certainty, and no safeguards system can prove that diversions have not occurred.** All that can be done is to provide some level of confidence—which can be quantified—that diversions have not taken place. The resources required of the safeguards system increase as the required confidence level increases; conversely, with given resources, the minimum detectable diversion grows as the required confidence level increases. Moreover, at some level, measurement uncertainties place fundamental limits on the sensitivity and the confidence levels that can be attained. **As discussed in chapter 3 and appendix A, large facilities such as the reprocessing plant now under construction in Japan will reach or exceed these limits, at least with the safeguards techniques now in use.**

The two objectives specified in INFCIRC/153 and quoted above make competing demands upon the safeguards system. Ensuring the "timely detection" of diversion of nuclear materials implies that the system must have a high likelihood of success, and the IAEA now sets out the goal of having a 90 percent probability of detecting diversions. However, the "deterrence of such diversion," which is also set out as a goal in INFCIRC/153, might be accomplished with a much less capable system. Even if the IAEA were to have as little as 50 percent confidence in detecting a diversion, anyone attempting to divert material would be as likely as not to get caught, and a system with only a 10 percent chance of detecting a diversion is sufficient to prevent a divertor from having more than 90 percent confidence that its activities would escape notice.

In particular, the difference between assured detection and deterrence affects how one interprets the significance of the measurement uncertainties that are unavoidable in making any inventory of nuclear materials. Critics of IAEA safeguards, particularly as applied to large plutonium reprocessing plants, imply that the uncertainty in a plant's measured inventory gives the amount of material that might be diverted without detection. In other words, they argue that if the amount of plutonium processed in the course of a year is only known, for example, to ±80 kilograms, a diversion of 80 kilograms might not be caught.[16] While it is true that in such a case, a diversion of that size could not be ruled out, it cannot be assumed that such a diversion would go undetected, either. Measurement uncertainties work both ways, *and nobody can know in advance which way the measurement will be off.* A diverting state might hope that an 80-kilogram diversion would be masked by a measurement that would otherwise have been 80 kilograms too high, yielding a measured throughput equal to what the value should have been had there not been any diversion. However, the error in measurement might equally likely go the other way, yielding a measurement that in the absence of diversion would have been 80 kilograms *below* the expected value. In this case, an 80-kilogram diversion would compound, rather than cancel, the 80-kilogram measurement error, resulting in a measurement 160 kilograms below what would be expected in the absence of diversion—a discrepancy likely to attract attention. Such odds would prevent a state from planning a diversion strategy with confidence.

[16]A measurement uncertainty of ±80 kg means that about 68 percent of the time, the *measured* value for annual plutonium throughput will lie within 80 kg of the true throughput. With such an uncertainty, there is about a 16 percent chance that the measured throughput would be more than 80 kg higher than the actual throughput, and an equal chance that the measured throughput would be less than 80 kg lower. This uncertainty of 80 kg—10 significant quantities—is chosen here purely for the sake of illustration. Chapter 3 and appendix A discuss the issues involved with measurement uncertainties at actual and proposed large reprocessing plants.

Since subjective determinations underlie any safeguards system, it is impossible to make an objective determination of effectiveness.

Limitations of Safeguards

Despite their value in detecting and deterring nuclear proliferation, IAEA safeguards—and the NPT regime that requires their adoption by non-nuclear-weapon states—have a number of limitations, from the perspective of preventing proliferation, that are difficult to remedy within the current framework (see box 2-2). Although these limitations have long been recognized, some of them have been brought into clearer focus by the Iraqi and North Korean violations of their safeguards obligations. These limitations include:

- ***States are not obligated to accept IAEA safeguards.*** Israel, Pakistan, and India, which have acquired nuclear weapon capability while remaining outside the NPT, are not subject to full-scope safeguards. Their nuclear weapon programs therefore face no real constraints under international law. States that are parties to the NPT can withdraw from the Treaty upon 90 days' notice, ending their legal obligations.[17]
- ***IAEA safeguards focus on nuclear materials*** and do not cover facilities unrelated to nuclear materials that could nevertheless be used by a nuclear weapon program. For example, they do not address research and development (R&D) for non-nuclear components of nuclear weapons, nor does the NPT explicitly ban such R&D. Although the NPT's prohibition against nuclear weapon "manufacture" has been widely interpreted to prohibit development of dedicated non-nuclear components, the Treaty provides no mechanism for verifying this prohibition.[18] Nevertheless, if discovered, such development would call into question a state's commitment to abide by safeguards on those facilities that were subject to them.
- ***The IAEA may face constraints on its ability to verify that the state's declaration is complete and accurate,*** even though NPT member states are required to declare all inventories of nuclear material to the IAEA, as well as all installations and locations that contain or are destined to contain nuclear material**.** The South African government granted the IAEA an extraordinary degree of access and cooperation, permitting the agency to verify independently that the South African declaration of its nuclear material inventory was reasonable. On the other hand, North Korea had made declarations that proved to be incompatible with the IAEA's independent measurements and analyses, and it has refused (in violation of its safeguards agreement) to permit the IAEA to conduct the inspections needed to resolve these discrepancies.
- ***Safeguards do not prohibit states from acquiring stockpiles of weapon-usable nuclear material*** (plutonium and highly enriched uranium) or the means to produce them, so long as the stocks and facilities are for peaceful purposes and are placed under safeguards. In fact, Article IV of the NPT explicitly allows for the indigenous development and sharing of technology for peaceful uses of nuclear energy. As such, the NPT embodies a nuclear "bargain": states gain access to peaceful nuclear technology in return for giving up their weapon options. Since much of the technology for developing nuclear energy is also applicable to nuclear weapons, however, it could be argued that this bargain is inherently self-defeating. Nevertheless, without it, many states would likely not have agreed to the international safeguards regime in the first place.

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[17]Note that international agreements besides the NPT may also constrain nuclear weapon programs. For example, both the bilateral denuclearization agreement between North and South Korea (which has not been implemented yet) and the bilateral Agreed Framework between North Korea and the United States contain provisions that impose stricter constraints than the NPT does on North Korean nuclear activities.

[18]See, e.g., George Bunn and Roland Timerbaev, "Avoiding the 'Definition' Pitfall to a Comprehensive Test Ban," *Arms Control Today,* vol. 23, No. 4, May 1993, pp. 16-17.

BOX 2-2: Compromises and Limitations of IAEA Safeguards from a Nonproliferation Perspective

It is not appropriate to evaluate nuclear safeguards solely from a nonproliferation perspective, since they were never intended to serve only nonproliferation objectives. The basic bargain underlying the nuclear nonproliferation regime is that non-nuclear-weapon states agree to forego weapon programs in return for assistance and encouragement in pursuing civil nuclear programs under safeguards. Therefore, safeguards represent an answer to "How can applications of civil nuclear energy be pursued without contributing to weapon programs?" rather than "How can nuclear proliferation best be opposed?" From a nonproliferation perspective, rolling back the spread of nuclear technology would be preferable to encouraging the spread of that technology under safeguards. However, that choice was not an available option. At the time that IAEA safeguards were being established, the alternative to the spread of *safeguarded* nuclear technology would more likely have been the spread of *unsafeguarded* nuclear technology.

Therefore, it is clear that even a perfectly functioning safeguards system has limitations from the perspective of its ability to forestall proliferation. Recognizing the caveats above, these limitations include the following:

- Safeguards are directed primarily to declared facilities.[1]
- Special inspections undertaken to resolve ambiguities must first gain cooperation of the inspected state.
- States have the right to reject particular inspectors designated for their country by the IAEA.
- Development of nuclear fuel-cycle activities is encouraged (by NPT Article IV).
- Production and possession of weapon-usable nuclear materials (plutonium and highly enriched uranium) are neither prohibited nor discouraged by either the NPT or the IAEA.
- Diversion of fractions of a "significant quantity" (SQ) from different locations can be difficult to detect.
- Less than one SQ can be sufficient for a nuclear device.[2]
- Exemptions from safeguards are allowed for material for military, nonexplosive applications (e.g., ship propulsion), as well as other purposes of less concern for potential diversion such as the manufacture of ceramics and alloys, and scientific research in amounts too small to pose threat of significant diversion to weapon purposes.
- Safeguards are not applied at the very front end of the fuel cycle, that is, to material in mining or ore processing activities.

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[1]This represents the situation under "routine" application of safeguards. However, if the agency determines that it requires additional information to ensure that safeguards commitments are being honored, its built-in authority allows it to request both further access to areas within declared facilities and special inspections at declared or undeclared facilities. If irreconcilable conflicts remain, the IAEA can take the issue to the U.N. Security Council, leading ultimately to the possibility that enforcement action be taken under Chapter Vll of the U.N. Charter.

[2]Although the IAEA significant quantity for plutonium is 8 kilograms, the U.S. Department of Energy has stated that "Hypothetically, a mass of 4 kilograms of plutonium or uranium-233 is sufficient for one nuclear explosive device. " (U.S. Department of Energy, Classification Bulletin WNP-86, February 8, 1994. Although this sentence is unclassified, the full text of the bulletin is classified.) This statement is not completely equivalent to stating that the SQ should be set equal to 4 kilograms, since the SQ makes an allowance for material lost in processing and machining the plutonium for use in a weapon. However, much of these processing losses can be recovered. No such statement equivalent to this Classification Bulletin has been issued with respect to uranium-235.

SOURCE: Office of Technology Assessment, 1995.

- ***Under safeguards, states can operate reprocessing plants to extract and store plutonium from spent fuel, import highly enriched uranium for use in research reactors, and build enrichment facilities capable of being converted to produce weapon-grade uranium.*** Such activities bring states into close contact with weapon-usable material and give them experience in its properties and handling.[19] Many countries unilaterally choose to withhold assistance in these nominally peaceful activities from states whose motives are suspect, but they are not required by the NPT to do so. Sometimes, states are even pressured within the IAEA context *not* to withhold such aid.
- ***The IAEA, by itself, lacks an effective means of enforcement.*** There are no agreed provisions that would allow the IAEA or the United Nations Security Council to forcibly destroy nuclear facilities or render them useless, even if found to be in violation of the NPT or safeguards. The Security Council, however, could take such measures on an ad hoc basis, as it has done in Iraq.
- ***The IAEA is subject to diplomatic, legal, and political pressures to treat all states equally,*** making it difficult to select some as being of particular proliferation concern and subjecting them to closer scrutiny. As a consequence, much of the IAEA safeguards budget today is spent on the well-developed fuel cycles in Japan, Germany, and Canada, which are not generally regarded as countries of current proliferation concern.

In summary, the demise of the post-World War II efforts to internationalize the control of atomic energy, and the ensuing development of a far weaker system of nuclear safeguards in which states voluntarily yield some measure of sovereignty to submit their individual nuclear activities to outside inspection, has put severe limitations on the ability of any international institution such as the IAEA to prevent nuclear proliferation. In such a world, attempts to deny a country possession of nuclear materials and technology though safeguards, export control, and other means will not always work. As one analyst has stated:

> Given the circumscribed powers and limited resources granted the IAEA by the international community...blaming this institution for failing to stop proliferation is patently absurd.[20]

Recent Events

In the last few years, several factors have coalesced to raise the profile of the nuclear nonproliferation regime. As mentioned above, IAEA inspections in North Korea in 1992 proved that North Korea's declarations about its past plutonium reprocessing activities were, at best, incomplete and misleading. For many observers, these revelations confirmed suspicions that North Korea was developing nuclear weapons in violation of its NPT commitment not to do so, and that it may, in fact, have already built one or more weapons. The year before, in the aftermath of the Persian Gulf War, international inspections discovered an extensive clandestine nuclear weapon program in Iraq, an NPT member state for which

[19]Reprocessing technology, for example, was declassified decades ago and is well described in the open literature. For an assessment of technical hurdles facing a potential nuclear proliferant, see *Technologies Underlying Weapons of Mass Destruction*, op. cit., footnote 3, ch. 4.

[20]Janne Nolan, testimony before the Subcommittee on Technology and National Security, Joint Economic Committee, U.S. Congress, 102d Congress, 2d session, part 2, "Arms Trade and Nonproliferation in the Middle East," S.Hrg. 102-1021, Pt. 2, Mar. 13, 1992, p. 38.

no safeguards violations had been discovered or reported by the IAEA before the war.[21] The chief impact of these discoveries will be, and to some extent already has been:

> ...to focus the nonproliferation regime more sharply on the risks of proliferation in the politically tense regions of the Developing World, to find ways of enhancing the IAEA's ability to detect clandestine programs, and to stress the role of the U.N. Security Council as the supreme international authority for enforcing non-proliferation obligations.[22]

In April 1992, little more than a year after that war, the major nuclear exporting countries (the Nuclear Suppliers Group or "London Group") agreed to a major new set of export guidelines restricting trade in a wide range of dual-use technologies pertaining to nuclear weapons (e.g., technologies useful for producing nuclear weapons that also have legitimate civil applications), and linking approvals for such trade to a country's overall nonproliferation credentials. Still more important was the Nuclear Suppliers Group's agreement to prohibit exports of explicitly nuclear-related goods to states that were not subject to full-scope IAEA safeguards (i.e., those covering every nuclear facility in the state's territory). This new policy had the effect of blocking a possible Russian sale of reactors to India and a French project to sell one to Pakistan.[23]

Within the same period, the breakup of the former Soviet Union, with its vast nuclear weapon stockpile and infrastructure spread among several republics, presented dangerous new complications to the nonproliferation regime. At least three republics other than Russia (Belarus, Kazakhstan, and Ukraine) had nuclear warheads and nuclear materials on their territories. With all these republics having become non-nuclear-weapon states party to the NPT, they have committed to return all nuclear weapons on their territories to Russia and to place all of their nuclear facilities under safeguards.[24]

In addition, the conference held in April and May 1995 to review and extend the NPT drew worldwide attention to the treaty itself and to the nuclear safeguards that it requires its non-nuclear-weapon state parties to adopt. The outcome of this conference—a consensus decision to extend the NPT indefinitely—will shape the nonproliferation regime into the next century.

Despite its weaknesses and the discrimination between the nuclear "haves" and "have-nots," the nonproliferation regime, centered as it is on the NPT, has largely been successful. The total number of declared or de facto nuclear weapon states, including the five which had declared their nuclear weapon status before the NPT's signing, has

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[21]Although carried out by the IAEA, the intrusive nuclear inspections conducted in Iraq since 1991 were mandated by U.N. Security Council resolutions 687, 707, and 715 and did not follow directly from Iraq's safeguards agreements. The IAEA has long had the authority under its full-scope safeguards agreements to conduct "special inspections" of undeclared sites. However, before 1991 it did virtually nothing regarding such sites, primarily due to the lack of political support in the international community for such intrusions on the national sovereignty of member states. It has since paid more attention to such sites, making its first—and so far its only—formal request for a special inspection of an undeclared site in 1992. North Korea, the target of the request, refused to allow it. On the other hand, several nations have permitted the IAEA to make less formal "visits" to undeclared sites.

[22]David Fischer, "Innovations in IAEA Safeguards To Meet the Challenges of the 1990s," in *The New Nuclear Triad: The Non-Proliferation of Nuclear Weapons, International Verification and the International Atomic Energy Agency* (Southampton, UK: Programme for Promoting Nuclear Non-Proliferation, Sept. 1992), p. 27.

[23]Refusing to export explicitly nuclear-related goods to states that are not under full-scope safeguards amounts to imposing an economic sanction on states unwilling to forego the nuclear weapon option. China has not agreed to abide by this policy, and it continues to export nuclear technology to states that are not under full-scope safeguards. However, China is obligated under the NPT to insist that IAEA safeguards be applied to nuclear-related items and facilities it exports, even if the recipient has not accepted safeguards on all its facilities.

[24]For further discussion of the former Soviet Union, see *Proliferation and the Former Soviet Union*, op. cit., footnote 1.

remained at eight or nine, a fraction of what some in the early 1970s were predicting. Forty states succeeded, ratified, or acceded to the NPT between January 1, 1991 and May 25, 1995, including France, China, Russia (as successor to the U.S.S.R.), and all of the other former Soviet republics, bringing the total number of parties to 178 (see appendix B).

Argentina and Brazil, two former "threshold" states that had been thought to be pursuing nuclear weapon programs in the past, have adopted strong nonproliferation measures through their commitments to the Treaty of Tlatelolco, which requires the implementation of comprehensive IAEA safeguards plus bilateral inspections of each other's nuclear activities through a newly formed agency called ABACC (the Argentine-Brazilian Agency for Accounting and Control of Nuclear Materials). Argentina has also gone on to join the NPT. Finally, a major advance for the nuclear nonproliferation regime was achieved in South Africa's accession to the NPT, for which it first dismantled its small clandestine nuclear arsenal and subsequently opened all of its nuclear facilities (including its ex-weapon facilities) to international inspection.

Despite growing adherence, however, the international safeguards regime has a number of shortcomings, as summarized in this chapter. The remainder of this report addresses various policy options for remedying these shortcomings.