Enhancing the Traditional IAEA Safeguards Regime 3

The traditional International Atomic Energy Agency safeguards regime can be strengthened in two ways. One approach is to improve the IAEA's ability to detect the diversion of "declared" nuclear materials—those materials that a state makes known to the IAEA and processes at facilities open to IAEA inspection. The other approach is to strengthen the IAEA's ability to detect undeclared materials and facilities where a state may be attempting to conduct nuclear weapon activities in secret. Until recently, international safeguards were restricted in practice to the first of these approaches, dealing only with declared materials at known sites. Now, however, steps are being taken to enhance the IAEA's ability to discover undeclared nuclear facilities.

To improve its chances of detecting covert nuclear facilities, the IAEA has already begun to incorporate new sources of information into its framework of implementing safeguards. It is studying the use of environmental sampling to detect covert sites[1] and is placing considerably more emphasis on determining the completeness and accuracy of the initial inventory of nuclear material that a state must declare to the IAEA when first coming under safeguards. In particular, it has made heavy use of "ad hoc" inspections for this purpose in states such as South Africa and North Korea, which entered the Non-Proliferation Treaty (NPT) after having already developed a substantial nuclear infrastructure. ("Ad hoc" inspections are those conducted before the

[1]See forthcoming OTA background paper on detecting nuclear facilities through environmental sampling (anticipated summer 1995), which examines the prospect of using environmental samples to identify or characterize covert nuclear weapon facilities by detecting radioactive or other characteristic substances they might emit.

completion of the formal attachments to a state's safeguards agreement with the IAEA that govern routine inspections at specific facilities.) With its new emphasis on determining the completeness of a state's initial declaration, the IAEA has apparently been successful in verifying the consistency of the South African case while uncovering clear discrepancies in the North Korean one. **It remains to be seen, however, whether the enhanced efforts and projected capabilities will be effective in states that refuse to cooperate fully with the IAEA's call for increased access and transparency, which has the potential to go well beyond the full-scope, NPT-type safeguards specified in INFCIRC/153.**

OVERALL CONFIDENCE IN SAFEGUARDS

Through 1990, official IAEA statements all tended to reflect the conviction that safeguards had continued to provide assurance that states were complying with their safeguards agreements. The only exceptions were two cases in 1981 and 1982, when the IAEA was unable to confirm compliance with safeguards at a Pakistani reactor and an Indian reactor due to the need to install additional equipment and take other measures to assure the absence of diversion.[2] Safeguards were, therefore, credited with playing a key role in preventing the proliferation of nuclear weapons and other nuclear explosive devices.[3] The IAEA has been cautious to place its capability into the proper perspective, deliberately calling attention to the fact that its statements were limited to *declared* nuclear material, and that categorical statements about the absence of undeclared installations could not be made on the basis of IAEA verification activities. It has also pointed out that the safeguards system is not so finely meshed that it would be likely to detect diversion of less than a "significant quantity" (SQ),[4] which it defines as "the approximate quantity of nuclear material in respect of which, taking into account any conversion process involved, the possibility of manufacturing a nuclear explosive device cannot be excluded."[5]

The most serious known violations of safeguards or NPT obligations—such as those uncovered in Iraq after the 1991 Gulf War—have involved not diversion from safeguarded facilities, but *undeclared* activities falling outside the domain of safeguards as it was then understood. Only in Iraq, North Korea, and Romania has the IAEA found violations that involved diversion of nuclear material or improper activities at a *declared* facility (i.e., one that has been disclosed to the IAEA and placed under safeguards). In Iraq and Romania, the violations at declared facilities involved quantities of nuclear materials that were substantially less than the amount whose diversion the IAEA would consider a serious proliferation risk. In North Korea, where the quantities in question could be significant, the concern is not the diversion of material from safeguarded facilities but rather the failure to declare all existing nuclear materials to the IAEA before safeguards were initiated. See box 3-1.

[2]The Indian situation was cleared up quickly, but Pakistan resisted installing the necessary equipment at its KANUPP power reactor for two years before agreeing to do so. During this period, the IAEA was careful not to imply that material had indeed been diverted, although the possibility existed. David A.V. Fischer and Paul Szasz, *Safeguarding the Atom: A Critical Appraisal* (London: SIPRI, Taylor and Francis, 1985), pp. 16-17; and David A.V. Fischer, *The International Non-Proliferation Regime, 1987* (New York: United Nations, 1987), p. 41.

[3]For example, see the draft document of the 1990 NPT review conference, NPT/CONF/DC/1/Add.3(a), Article III and preamble paragraphs 4 and 5, as cited in Lawrence Scheinman, *Assuring the Nuclear Nonproliferation Safeguards System* (Washington, DC: The Atlantic Council, October 1992), p. 7.

[4]See statement by Hans Blix, Director General of the IAEA, to the General Conference of the IAEA, GC(XXXVII)/OR.353, Oct. 11, 1993, p. 26.

[5]The definition also says that "significant quantities should not be confused with critical masses; the former take into account unavoidable losses of conversion and manufacturing processes." International Atomic Energy Agency, *IAEA Safeguards Glossary, 1987 Edition* (Vienna, Austria: IAEA, 1987), p. 23. The definition of significant quantities of various weapon materials is discussed later in this report.

BOX 3-1: Some Cases of Violation of Safeguards, or Inability To Certify Compliance with Safeguards

Iraq. Iraq's extensive violations of the Non-Proliferation Treaty—by building and operating a number of undeclared nuclear facilities and accumulating undeclared stocks of nuclear materials—have been the most notorious breach of international nuclear safeguards. In addition, Iraq violated its safeguards agreement with the IAEA by producing a small quantity of plutonium through the irradiation of indigenous, undeclared uranium fuel at an installation that was subject to IAEA inspection. Iraq's safeguards violations were detected only by inspections after the Gulf War.

North Korea. At best, North Korea made an incomplete declaration of its initial plutonium inventory when it concluded its full-scope safeguards agreement with the IAEA. At worst, the undeclared plutonium is evidence of a nuclear weapon program in violation of NPT and safeguards commitments. North Korea did not conclude its safeguards agreement with the IAEA for six years following its ratification of the NPT, in apparent violation of the treaty. (Safeguards agreements are to be completed within 18 months. Many other NPT parties have not met this deadline either, but they have no significant nuclear facilities and certainly no facilities for production of weapon-usable nuclear materials.) North Korea has refused to allow access to IAEA inspectors, both for routine inspections at declared facilities and for special inspections at two suspected waste sites. Having first announced and then suspended its withdrawal from the NPT, North Korea has asserted that it has a unique status under the NPT and is not subject to standard safeguards requirements. However, neither the IAEA nor other NPT parties recognize such a status.

The IAEA was able to discover discrepancies in the North Korean declaration of its initial inventory on the basis of its own sampling and analysis. Information supplied by member states contributed to the IAEA's request to conduct special inspections of two undeclared sites.

Romania. Following the ouster of the Ceaucescu regime, Romania acknowledged producing small amounts of plutonium without notifying the IAEA as required. In addition, it has admitted selling Norwegian-origin heavy water to India without requiring IAEA safeguards on the sale (it should have negotiated an INFCIRC/66 agreement with India) or reporting the sale to the IAEA, apparently in violation of the NPT requirement for such transfers.

Pakistan. In the early 1980s, when Pakistan became able to produce its own fuel for its KANUPP nuclear reactor, which was under IAEA INFCIRC/66 (non-NPT party) safeguards, the IAEA was unable to certify that Pakistan had not diverted nuclear material from this reactor. For two years, until Pakistan allowed additional equipment to be installed and procedures taken, the IAEA stated that it could not rule out the possibility of diversion there. During this period, the IAEA was careful not to imply that material had indeed been diverted, although the possibility existed.

All the instances above relating to NPT parties (i.e., the Iraqi, North Korean, and Romanian cases) became known to the IAEA after the Gulf War. Thus some argue that before Iraq's clandestine nuclear program was discovered, the IAEA not only remained free from pressure from its member states to be more intrusive and forceful (in fact, some member states objected to any additional intrusiveness), but had little incentive in this direction since no significant safeguards violations were known to have occurred.

SOURCE: David Fischer and Paul Szasz, *Safeguarding the Atom* (London and Philadelphia: Taylor and Francis, 1985) and Office of Technology Assessment, 1995.

IAEA

IAEA inspectors visiting a nuclear reactor in North Korea. By analyzing samples taken during its inspections, the IAEA determined that the North Koreans had not revealed all of their plutonium production.

If IAEA safeguards did not exist, the diversion of nuclear material from ostensibly civil facilities would pose serious dangers to the nonproliferation regime. Given the existence of safeguards, however, diversion of material from civil facilities is probably not the easiest or the most efficient route to obtaining weapon materials.[6] Moreover, in the past, states pursuing nuclear weapons such as India, Israel, Pakistan, Iraq, and South Africa have produced their weapon materials at undeclared-and therefore unsafeguarded-facilities.[7] **Therefore, ensuring the absence of *undeclared* facilities for producing nuclear materials is probably even more important to the international nonproliferation regime than is verifying with very high confidence that not even a single bomb's worth of nuclear material could have been diverted from *decklared* facilities.** Nevertheless, achieving a high probability that the diversion of a significant quantity of fissionable nuclear material from a declared facility will be detected—while maintaining a manageable false alarm rate—underlies the vast majority of NPT international verification activities. Both the application of safeguards to declared facilities and the detection of undeclared facilities are important to the nonproliferation regime, and the IAEA has a key role to play in both missions.

■ IAEA Organizational Culture and "Mindset"

Many feel that the IAEA is more conservative and more cautious than it should be or needs to be, and that it cannot easily adapt to a new, more ambitious agenda.[8] This attitude may stem from IAEA practice before the 1991 Gulf War, when it was not encouraged by its member states to seek undeclared facilities. Ten years earlier, former IAEA inspector Roger Richter testified in a widely publicized congressional hearing that the IAEA actively *discouraged* inquiries into undeclared activities. He asserted that an inspector "must prepare [oneself] mentally to ignore the many signs that may indicate the presence of clandestine activities going on in the facilities adjacent to the reactor

[6] Office of Technology Assessment, *Technologies Underlying Weapons of Mass Destruction,* OTA-BP-ISC-115 (Washington, DC: U.S. Government Printing Office, December 1993), pp. 181-183. This statement is based on the existence of safeguards, on the fact that the vast majority of nuclear material in the civil sector is in forms that are not directly usable or, if usable, not optimal for weapons, and on the uneconomic operating conditions that production of weapon materials would require in most commercial facilities.

[7] Iraq's undeclared activities violated its NPT commitments. The other states listed were not NPT members when they pursued their weapon programs and were, therefore, under no legal obligation to declare their nuclear activities or place them under safeguards.

[8] Lawrence Scheinman, *Assuring the Nuclear Non-Proliferation Safeguards System,* op. cit., footnote 3, p. *26*. See also, Gary Milhollin, "The New Arms Race: The Iraqi Bomb," *The New Yorker,* Feb. 1, 1993, pp. 47-55; and David Kay, "The IAEA—How Can It Be Strengthened?" paper presented at the conference *Nuclear Proliferation in the 1990s: Challenges and Opportunities,* Woodrow Wilson Center, Washington, DC, Dec. 1-2, 1992, especially pp. 9-14.

[under IAEA inspection]."[9] After the revelation of Iraq's covert nuclear weapon program, an unnamed IAEA official was quoted as stating that "we may have been too narrow" in the training provided for IAEA inspectors in the past, implying that to some extent the earlier criticism may have been warranted.[10]

As Lawrence Scheinman explains, there are institutional pressures within the IAEA that have acted to oppose the strengthening of safeguards:

> Historically—and even in the present political context—there has been a continuing reluctance of the [IAEA] board members to agree to new safeguards measures that will be any burden on themselves. Some member states accept safeguards grudgingly, but even non-nuclear-weapon states which are strongly committed to effective safeguards and to non-proliferation are chary of accepting new measures, even when it is not their behavior that necessitates these measures in the first place.[11]

Moreover, he argues, "sovereignty remains a vigorous and contradictory force against empowering international institutions with far-reaching authority."[12] However, Scheinman ultimately concludes that "with proper political leadership there is no reason that the IAEA should not be able to implement a more far-reaching and more intrusive safeguards regime. The basic responsibility for ensuring this task rests in the hands of the governments of its key member states, especially the United States."[13] It also rests with the Security Council and its relationship to the IAEA. Indeed, a number of potentially far-reaching steps have been taken since the 1991 Persian Gulf war to strengthen the IAEA, improve its nuclear safeguards, and otherwise bolster the nuclear nonproliferation regime.

Recent Improvements

In January 1992, a communiqué was issued by the U.N. Security Council in which its members, through their respective heads of state, declared that 1) "the proliferation of all weapons of mass destruction constitutes a threat to international peace and security"; 2) fully effective IAEA safeguards are integral to the implementation of the NPT; and 3) Security Council members "will take appropriate measures in the case of any violations notified to them by the IAEA."[14] This statement significantly strengthened U.N. support for the goals of IAEA safeguards and implied firmer actions by the United Nations in the future.

In late 1991, IAEA Director General Hans Blix called for several improvements to safeguards, including the need to incorporate outside intelligence about undeclared facilities, the need for inspectors to have the right to go anywhere unimpeded, and the value of "powerful support," such as that provided by the Security Council. Blix also established procedures within the IAEA to receive information from outside sources. At its meeting in February 1992, the IAEA's Board of Governors explicitly reaffirmed the IAEA's "right to obtain and to have access to additional information and locations in accordance with the IAEA Statute and all comprehensive safeguards agreements." Specifically included in this reaffirmation was the IAEA's right to use information derived

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[9] "The Israeli Air Strike," Hearings before the Committee on Foreign Relations, United States Senate, 97th Congress, 1st Session, June 18, 19, and 25, 1981, p. 112.

[10] Mark Hibbs, " 'Special Inspections:' A Transatlantic Turf War for Post-Iraq Powers: Nonproliferation After the Gulf War," *Nucleonics Week*, vol. 33, No. 5, Jan. 30, 1992, p. 14.

[11] Scheinman, op. cit., footnote 3, p. 42.

[12] Ibid., p. 28.

[13] Ibid.

[14] U.N. Security Council Press Release, SC/536, Jan. 31, 1992, as cited in Scheinman, op. cit., footnote 3, p. 6.

both from nonsafeguards activities (technical cooperation, safety, and research activities) and from non-IAEA or political sources.[15]

The Board also reaffirmed the IAEA's right to undertake "special inspections," including their use to ensure that *all* appropriate nuclear materials have in fact been placed under safeguards. In doing so, the Board declared that the requirement to engage in "consultation" with the state in question (pursuant to INFCIRC/153, paragraph 77) did not allow the state ultimately to deny the agency's right to special inspections.[16] (In practice, of course, the requirement for consultation can be used by states to delay inspections, making short-notice inspections impossible.) The IAEA had always had the authority to conduct special inspections, but before the Persian Gulf War of 1991, none had ever been conducted at an undeclared site. (The "anytime, anywhere, no-right-of-refusal" inspections conducted by the IAEA in Iraq were not conducted under its special inspection authority but rather under U.N. Security Council Resolution 687, which was imposed on Iraq under threat of force.)

Despite the Board's affirmations, intrusive inspections and reliance by the IAEA on national intelligence sources are unwelcome by many countries. **Since the IAEA has a strong institutional commitment to maintaining political support within its ranks, it will take some time to determine how successful proposals will be for increasing the scope of inspections or for the agency to act upon additional amounts of national intelligence information.** However, states provided the IAEA with much of the information it needed in the cases of Iraq and North Korea. In the latter case, the IAEA proved able to act on such information (in conjunction with its own sampling and analysis) to request a special inspection of two undeclared waste disposal sites.

In 1992, the IAEA took additional steps to improve the quality of the information available to it concerning safeguards-related activities. In February, the Board of Governors endorsed an IAEA proposal that design information be provided *at the time of the decision to construct or to authorize construction* of any nuclear facility, or to modify an existing facility. Such information is to be provided at least 180 days before construction starts. (This is a much stronger requirement than the prior practice, which held that such information be provided 180 days *before fissile material was to be introduced* at the site.) With this additional notice, the IAEA will be better able to plan for effective implementation of safeguards for the facility.

The importance of early design information was particularly stressed by the LASCAR (LArge SCAle Reprocessing plant) study, a four-year analysis of safeguards for future large-scale plutonium reprocessing plants. LASCAR, conducted by representatives from France, Germany, Japan, the United Kingdom, the United States, IAEA, and the European Atomic Energy Community (EURATOM), was an initiative that was proposed and financed by Japan. Acting in an advisory capacity to the IAEA, the LASCAR forum formulated new guidelines for IAEA safeguards on such facilities in May 1992.

[15]Some board members, however, argued that use of foreign intelligence information as the basis for inspections could be challenged, and some developing states would consider Agency use of such as a violation of their sovereignty. The adopted text dropped an explicit reference to foreign intelligence. The Board also declined to support establishment of a formal unit within the IAEA to process intelligence information.

[16]If a request by the Director General for a special inspection is refused, the Director General may bring the matter to the Board of Governors, who can request the state to take the required action without delay. If the matter remains unresolved, the Board has the obligation to report to the Security Council the inability of the Agency to verify "that there has been no diversion of nuclear material required to be safeguarded" (INFCIRC/153, paragraph 19). The Security Council can then determine if the situation threatens international peace and security, in response to which it could invoke options under Chapter VII of the U.N. Charter. The initial decision to call for a special inspection, however, rests with the Director General alone, and does not require action by the Board (though the latter can also request such an inspection). Scheinman, op. cit., footnote 3, pp. 12-13.

To further enhance its information-analysis capabilities, the IAEA's Board of Governors took steps at its February and June 1992 meetings toward adopting universal reporting of: 1) exports and imports of certain equipment and non-nuclear material, and 2) exports, imports, production, and inventories of nuclear material. However, these measures did not cover production of non-nuclear material and did not envisage routine verification other than cross-checks within the IAEA.[17] At the September 1992 meeting of the IAEA's General Conference in Vienna—the annual plenary of representatives from all the IAEA's member states—Hans Blix announced that states able to begin such reporting should do so on a voluntary basis. At the February 1993 meeting, the Board of Governors authorized the secretariat to implement proposals for such a system of universal reporting, including *production* of nuclear materials, specified equipment, and non-nuclear material commonly used in the nuclear industry.[18]

If a substantial number of states comply, increased reporting to the IAEA of their imports and exports of nuclear material and equipment will significantly strengthen the safeguards regime. Blix has claimed that if such data for Iraq had been available, the IAEA would probably have requested special explanations and visits to Iraq.[19] Many argue that such collection and analysis of information is one of the most important parts of the control system for weapons of mass destruction.[20] Nevertheless, the plan for universal reporting is still in its infancy, and only a handful of states provided information in 1992 and 1993, although many major suppliers are expected to comply eventually.

The 27 members of the Nuclear Suppliers Group (NSG) adopted new Dual-Use Export Guidelines in April 1992, extending international export controls on items useful for manufacturing nuclear weapons or weapon material.[21] These guidelines will tighten export restrictions on thousands of items in 65 categories of equipment and materials related to producing nuclear weapons, including specific types of lasers, carbon fibers, oscilloscopes, certain high-purity materials used in the nuclear industry or for weapon components, and computer-numerically-controlled machine tools. The NSG members also agreed not to export explicitly nuclear-related goods to states that are not subject to full-scope safeguards. According to officials from the Foreign and Trade Ministries of Japan, which has become the NSG's de facto secretariat, the emerging regime would become the largest international regulatory framework for the export of dual-use items.[22]

The most significant nuclear supplier that has not committed to adhere to the Nuclear Suppliers Group restraints is China. As a party to the Non-Proliferation Treaty, China is obligated to notify the IAEA of exports to a non-nuclear-weapon state of any nuclear materials, equipment, or facilities, and to place them under IAEA safeguards. Beyond its NPT obligations, China has pledged to

[17]Some of the enhanced reporting requirements that are being considered would require reporting of *any* amount of plutonium or enriched uranium transferred to or from either nuclear-weapon states or non-nuclear-weapon states (nuclear-weapon states already voluntarily report transactions in excess of 1 effective kilogram—see glossary—of nuclear material for peaceful purposes), and they include reporting of inventories and transfers of material not yet suitable for fuel fabrication or enrichment (such as uranium ore concentrates, U_3O_8) even if exported for peaceful *non*-nuclear purposes. Scheinman, op. cit., footnote 3, pp. 16-17.

[18]Programme for Promoting Nuclear Nonproliferation, *Newsbrief*, No. 21, First Quarter, 1993, p. 6.

[19]IAEA Press Release, Oct. 21, 1992, on Blix's statement to the U.N. General Assembly.

[20]See U.S. Congress, Office of Technology Assessment, *Export Controls and Nonproliferation Policy,* OTA-ISS-596 (Washington, DC: U.S. Government Printing Office, May 1994).

[21]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), app. 4-D.

[22]*Arms Control Reporter*, 1992, p. 602.B.219.

exercise restraint on nuclear exports. However, the United States has repeatedly approached China concerning its nuclear export activities, particularly with respect to Iran. Argentina, like China not a participant in the April 1992 NSG meeting, declared that it would establish effective controls over its exports of nuclear equipment and materials, and has committed to this under its quadripartite agreement with Brazil, the Argentine-Brazilian Agency for Accounting and Control of Nuclear Materials (ABACC), and the IAEA.[23]

Current IAEA Thinking on Improving Safeguards: "Programme 93 + 2"

With an eye toward strengthening and streamlining IAEA safeguards in the post-Gulf War political environment, the IAEA undertook a broad-ranging, internal evaluation of its safeguards regime. In 1993, it put forth "Programme 93 + 2," a number of recommendations for improving the efficiency and effectiveness of safeguards to be addressed in the two years before the 1995 NPT review and extension conference. This proposal consists of six parts plus an integration phase:[24]

1. increased transparency measures,
2. increased use of states' systems of accounting and control (SSACs),
3. environmental sampling,
4. use of "anytime, anyplace" inspections,
5. analysis of additional sources of information, and
6. expanded training of the inspectorate.

The intention is to integrate these improvements into the present system of safeguards in a coherent way. The proposal is motivated both by the need for cost savings and by a desire to increase the IAEA's access to relevant facilities and information sufficiently to provide assurances not only that a country's declared materials remain in peaceful use, but also that it has no *undeclared* nuclear facilities.

Under 93+2, a number of avenues to strengthen safeguards would be examined for their feasibility and utility. The implications of changing the definition of "significant quantity" thresholds for nuclear materials would also be reexamined. Options for increased utilization of the SSACs include using them to make the IAEA's work more efficient, sharing equipment and analytic capabilities, thus lessening the inspector's workload, and relegating some verification activities (e.g., for natural or depleted uranium) almost entirely to the state system.[25] Investigation of environmental sampling under 93+2 to detect undeclared facilities or activities would primarily be directed at applications where most believe it would be useful—in short-range monitoring of specific types of activity in a small number of countries.[26] In the short term, it will concentrate on performing background calibrations at various distances from known sites, developing a cleanroom analytic capability, and documenting various signatures from reprocessing, enrichment, and reactor operations. Increased access and the concept of unan-

[23] IAEA document INFCIRC/404, as cited in ibid.

[24] International Atomic Energy Agency, "Strengthening the Effectiveness and Improving the Efficiency of the Safeguards System: A Report by the Director General," GC(XXXVIII)/17, Aug. 29, 1994.

[25] The IAEA has also reached a new understanding with EURATOM for streamlining its relationship and procedures for carrying out their overlapping safeguards responsibilities in Europe. This "New Partnership Approach" is intended to reduce significantly the inspection resources that IAEA must devote to EURATOM countries, while maintaining the IAEA's ability to arrive at independent safeguards conclusions.

[26] As of August 1994, 20 states had agreed to participate in field trials of environmental monitoring or other techniques to strengthen safeguards. See IAEA General Conference, "Strengthening the Effectiveness and Improving the Efficiency of the Safeguards System," op. cit, footnote 24, p. 5. Field trials have shown that nuclear operations in coastal areas can be detected in water and sediment samples up to 20 kilometers from the facility (p. 17).

nounced inspections will be studied on a voluntary basis in countries such as Australia, Canada, Iran, Japan, South Korea, and Sweden, the eventual goal being in part to reduce some inspection activities (e.g., on spent fuel storage in Canada) while maintaining or increasing overall effectiveness. Finally, various open source databases and programs for organizing the kinds of information most relevant to safeguards will be explored.[27] Such data retrieval and analysis will be used to increase the utility of environmental sampling as well as arrangements for voluntary access.

The 93+2 program is ambitious and will address many important areas needing improvement within the IAEA. Nevertheless, a number of important issues remain to be addressed. These can be divided into techniques and procedures for implementing safeguards themselves, and institutional issues concerning the IAEA broadly.

STRENGTHENING SAFEGUARDS

Safeguards Objectives

The IAEA seeks to detect diversion of so-called significant quantities of nuclear material, defined as 8 kilograms of plutonium, or 25 kilograms of uranium-235 when in the form of highly enriched uranium. It has set its detection goals at 90 percent, with a false alarm rate of 5 percent (see box 3-2).[28] The IAEA safeguards system does not attempt to disguise the fact that diversion of lesser quantities may be more difficult to detect. Moreover, it does not aim to detect diversion of a significant quantity instantly, but rather to do so in a "timely manner," defined variously as monthly, every three months, or yearly, depending on the particular type of material and roughly the time required for it to be converted into a weapon. Detection thresholds are set at 90 percent for fissionable

BOX 3-2: Detection Probabilities and False Alarm Rates

Safeguards measurements for material accountancy and control are used by the IAEA to determine the amount of nuclear material at a facility that is unaccounted for ("material unaccounted for," or MUF) and to compare it to the value reported by the facility's operator. A sufficiently large MUF could indicate that nuclear material had been diverted. Alternatively, it could reflect an unrecorded process loss. Ideally, one would like measurements to result in a zero value for the MUF, thereby closing the books with all of a facility's nuclear material fully accounted for. However, measurement errors will, in general, produce nonzero estimates of MUF, *even if no material has been lost or diverted.* Given the known or estimated uncertainties in the measurements used to calculate MUF, it can be determined whether the MUF value is significantly different from zero (i.e., a magnitude that measurement errors alone would be unlikely to explain). Thresholds at which MUF is considered significant are determined after choosing acceptable levels for two types of errors:

- *Fake alarms, or "Type I"errors.* Claims of a diversion or loss of material when none has occurred. The probability of a false alarm, meaning that analysis of material accountancy measurements will indicate that material is missing when none in fact has been diverted or lost, is represented by α.
- *Missed diversion,* or *"Type II" errors.* Failure to conclude that a diversion or loss has occurred when in fact it has. The probability that a true diversion or loss will be not be detected is denoted by β (see figure a).

(continued)

[27] One such program, called INSIST, has been developed by the U.S. Department of Energy's Pacific Northwest Laboratory to help implement long-term monitoring in Iraq. It incorporates and manages multimedia data including photographs, maps, and facility layouts.

[28] Such goals apply to the conclusions reached at the end of a material balance period, when the IAEA verifies a physical inventory (e.g., monthly, every 3 months, or yearly, depending on the type of material).

BOX 3-2 (Cont'd.): Detection Probabilities and False Alarm Rates

If either type of error occurs too frequently, it could seriously erode the credibility of the entire system used to make judgments. False alarms can have political and procedural costs and might sometimes require extensive consultations to resolve. It is thus very important for the IAEA to maintain a low false alarm rate, and $\alpha = 0.05$ has been chosen as the maximum acceptable value.[1] Similarly, missed diversions can be very costly in terms of their consequences for proliferation. The IAEA uses 90 percent detection probability for detecting a "significant quantity" of diverted U-235 or plutonium in a form directly usable for weapons, thus defining β by $0.90 = (1- \beta)$, or $\beta = 0.10$.

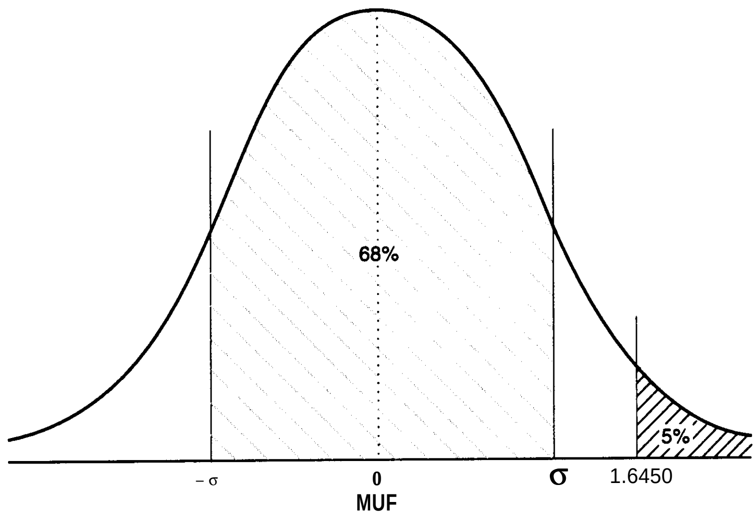

Figure a. Expected probability distribution of MUF (material unaccounted for) measurements from a system with an overall uncertainty of σ, assuming that no diversion of material has taken place and that no systematic errors act uniformly to shift all the measurements to one side or the other. Measurements will fall between - σ and + σ 68 percent of the time. Measurements will fall above +1 .64505 percent of the time.

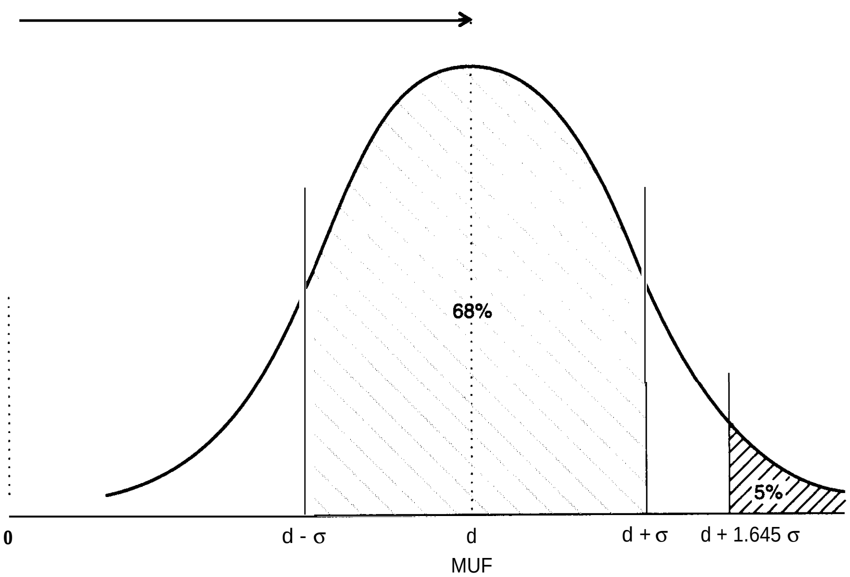

Figure b. Expected probability distribution of MUF measurements from the same system as figure a) in the event that amount "d" of nuclear material has been diverted. Measurements of missing or unaccounted-for material are most likely to be near d, falling between d-a and d+ σ 68 percent of the time.

[1]According to the IAEA, the false-alarm rate in practice is much smaller than 5 percent, even for material in bulk form, but especially for safeguards procedures that only require identifying and counting complete items (known as item accountancy). (See letter in response to Office of Technology Assessment questions, signed by Jan Priest, Division of External Relations, IAEA, and addressed to Marvin Peterson, United States Mission to the United Nations System Organizations in Vienna, Jan. 17, 1995, p, 5.) Each alarm requires additional investigation, credible explanation by plant operators, or other procedures to try to resolve the discrepancy and determine whether the alarm is warranted.

(continued)

BOX 3-2 (Cont'd.): Detection Probabilities and False Alarm Rates

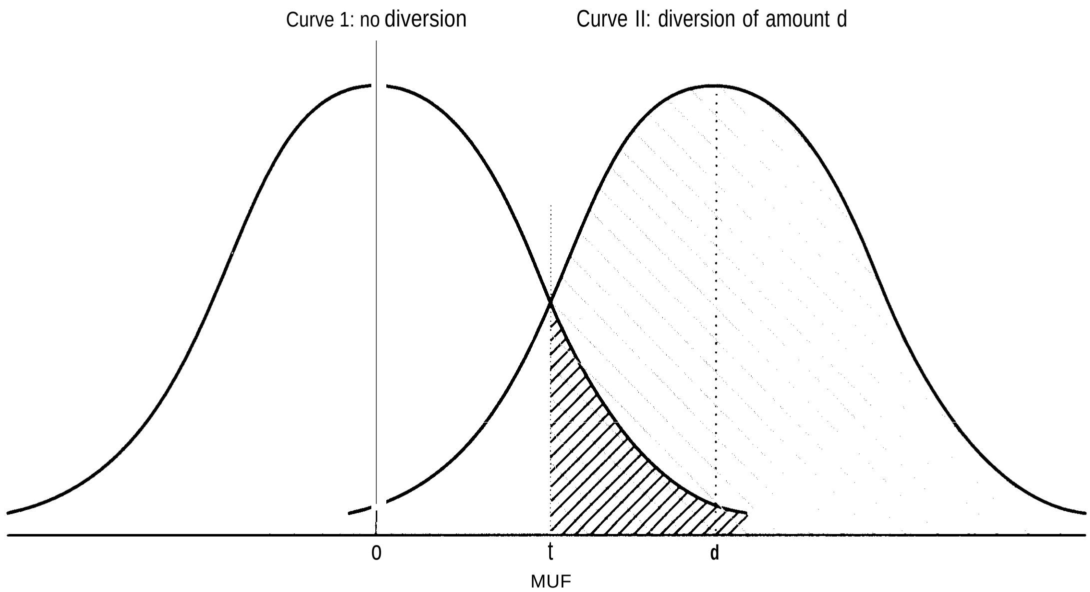

Figure c. To tell the difference between a measurement that indicates material is actually unaccounted for and a measurement that might be due solely to measurement error, a threshold is typically established. Measurements greater than the threshold—shown in this figure as "t''-are assumed to represent the absence of material, whereas measurements below the threshold are assumed to be consistent with all material being accounted for. Probability distributions for two different cases are shown here: curve I represents the case where no material is actually missing, and curve II represents the case where a diversion of amount "d" has been made. Therefore, the shaded area under curve I that is to the right of "t" represents the false alarm rate: the probability that measurements will appear to indicate diversion even when none has occurred. At the same time, the shaded area under curve II that is to the right of "t" represents the probability for detecting diversion of size "d, since it gives the probability that a measurement will show that more than "t" material is missing when "d" has actually been taken.

In sum, uncertainties associated with numerical measurements directly affect the uncertainty (and the false alarm rate) of conclusions based on those measurements. No system can provide absolute certainty in detecting loss of material or the absence of loss. The best that can be done is to design a system that has high detection probability and low false alarm rate. **However, these two goals are in opposition, forcing a balance to be struck between them.** For a given measurement system, detection probability can always be raised, but only at the expense of generating more false alarms.

Statistical analysis shows that by sounding an alarm when MUF values exceed 1.645a (where σ is the uncertainty, or "standard deviation, " with which MUF can be computed), the false alarm rate will be held to 5 percent or less, while true diversions or losses of twice the alarm threshold (3.290) would be detected with 95 percent probability. There would be a 90 percent chance of catching diversions over 2.93a. For example, if a plutonium measurement system were characterized by a one-standard-deviation uncertainty of ± 2 kg, sounding an alarm when MUF values exceeded 3.29 kg would have a 95 percent chance of detecting diversions as big as 6.58 kg of plutonium. Similarly, false alarms would occur only 5 percent of the time (see figures a through c).

However, even smaller diversions would also have some chance of being detected, using the same threshold and thus the same (low) 5 percent false-alarm probability. If a diversion equal to 3.290 has a 95 percent chance of being detected, for example, diversions at levels of 1 σ or 2 σ would have a 26

(continued)

BOX 3-2 (Cont'd.): Detection Probabilities and False Alarm Rates

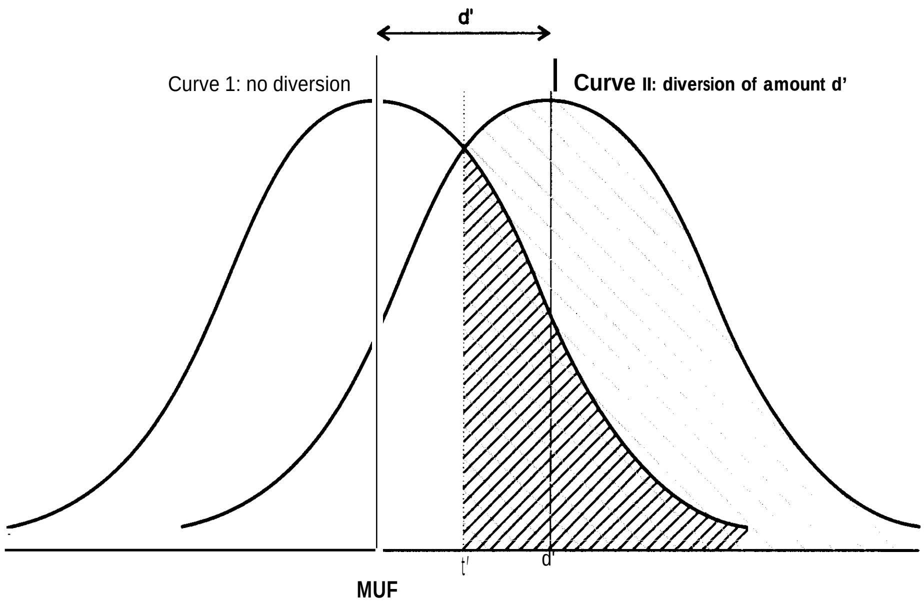

Figure d. The size of the diversion to be detected can be reduced by lowering the alarm threshold. **At the same time,** however, the false alarm rate will go **up. In this figure, an alarm threshold t' is used that is equal to half of the threshold t** shown **in figure c. The area under curve I to the right of t' is larger** than it **was in figure c, indicating that the false alarm rate will be higher in this case. Moreover, since less of the area under curve** II is to the right of the threshold t' in this picture, the chances are lower that an actual diversion will be caught. In other **words, the detection probability will be lower.**

percent or 64 percent chance, respectively, of being detected as well. Thus a plant operator who deliberately diverts *any* amount of material always has some chance of being discovered.[2] This assumes, of course, that the data used by the IAEA have not been falsified in some way by the operator

One option that has been considered for bulk-handling facilities (e.g., facilities that handle nuclear material in bulk form, such as solution or powder—these plants are among the hardest to safeguard) is to allow an increase in false alarm rate (e.g., to 20 percent or even 30 percent) in order to attain additional detection sensitivity.[3] Given that a MUF value higher than the detection threshold does not automatically imply (nor is it ever immediately assumed to imply) that material has *actually* been diverted anyway, these higher false alarm rates would be expected only to set in motion a more rigorous search for other sources of the anomalous readings, and not to trigger a crisis. Such an increase in allowable false alarm rates would be the result of lowering the detection threshold for sounding the alarm by about a factor of two, thus making half-size diversions detectable with higher confidence.[4] The disadvantage of such an adjustment is that considerably more work would be required to investigate all the false alarms. If so many false alarms lulled the inspectors into not taking this investigative effort seriously, the detection sensitivity could in effect degrade to a condition worse than before the detection threshold were lowered.

[2]Even if he diverts nothing at all, there is still a 5 percent chance that measurements will indicate a diversion or loss—this is the meaning of the false alarm rate. Therefore, during 5 percent of the accountancy periods, steps would have to be taken to resolve apparently discrepant measurements.

[3]See, e.g., R.D. Marsh and R.W. Foulkes, "Design of Safeguards Systems for Commercial Plutonium Processing Facilities," in *Nuclear Safeguards Technology* 1986, Proc. IAEA Symposium, vol. 1, Nov. 10-14, 1986 (Vienna, Austria: IAEA, 1987), pp. 31-46.

[4]For instance, if a given reprocessing plant's measurement system can achieve a 95 percent detection capability with 5 Percent false alarm rate only for diversions as large as 16 kilograms of plutonium, a 79 percent detection capability could be achieved for losses of just 8 kilograms if one could tolerate a false alarm rate of 21 percent. Such a change in detection capability would be accomplished simply by halving the threshold for sounding the alarm from 1.645 σ, which has 5 percent of the normal probability distribution curve to its right, to 0.823σ, which has 21 percent to the right. See figured.

nuclear material not only to facilitate catching the great majority of diversions, should they be taking place, but also to *deter* them in the first place. Nevertheless, safeguards can neither predict diversions ahead of time, nor physically prevent them, nor be guaranteed to detect them 100 percent of the time, **and they should not be expected to do so.**

Difficulties and Limitations

Technical difficulties can interfere with safeguards operations. For example, camera failure, delays in taking samples or inventorying materials, or staffing limitations may prevent the IAEA from fulfilling its safeguards objectives at particular facilities. In 1979, the IAEA was only able to completely attain 27 percent of the inspection goals it set for itself, although for material directly usable in weapons its goal attainment was 60 percent. By 1984, this record had improved to 53 percent for all materials and 71 percent for weapon-usable materials.[29] At major facilities, the IAEA attained 63 percent of its inspection goals in 1986 and 81 percent in 1990 before dropping back to 69 percent in 1992.[30]

Even if inspection goals are missed, the IAEA may still be able to certify that materials have not been diverted. However, it may not be in a position to do so within the deadlines it has established. All instances where missing information might prevent the IAEA from detecting diversion of material are investigated. Typically, additional information, such as from a subsequent inventory, provides proof that material was not in fact diverted during the period when inspection goals were unmet. Except for the Indian and Pakistani cases mentioned above, the IAEA ultimately certified the nondiversion of safeguarded material, even though it has not always met its inspection goals.

Two other fundamental limits on the ability of the safeguards system to detect diversions are the need for cooperation by the state and the IAEA's limited resources. Allowing international inspectors to regularly visit a country's nuclear facilities requires a country to relinquish some sovereignty, and the allowed routine inspection effort is spelled out in the comprehensive safeguards agreement a country negotiates with the IAEA. There are specific provisions for stepping beyond the constraints of such routine inspections, but these are also restricted in certain ways and do not provide the IAEA with a "hunting license" to search within the country arbitrarily. Although states are usually receptive to IAEA requests to visit other sites, they have no legal obligation to permit such access beyond their requirement to accept these restricted "special inspections" in cases where the IAEA considers that the information made available to it by the inspected state "is not adequate for the Agency to fulfill its responsibilities."[31]

The limits imposed by finite resources are most easily seen by a few comparisons. In the multibillion-dollar reprocessing plant to be built at Rokkasho-mura in Japan, tens of millions of dollars will be spent on equipment to comply with safeguards requirements, a substantial portion of which will be used to construct an onsite analytic lab and the rest for in-plant design features and measuring

[29] Fischer, op. cit., footnote 2, p. 42.

[30] D. Schriefer, D. Perricos, and S. Thorstensen, "IAEA Safeguards Experience," Symposium Proceedings, *International Nuclear Safeguards 1994*, March 14-18, 1994, Vol. 1, p. 40.

[31] INFCIRC/153, Article 73(b)

equipment.[32] Comparing this capital expenditure with the total annual IAEA safeguards budget of about $70 million for carrying out safeguards worldwide-covering over 40 countries, some 900 installations, and parts of at least four other reprocessing plants—indicates why the IAEA relies on the basic structure of verifying the *states'* systems of accounting and control and cannot install complete monitoring and measurement systems of its own.

The IAEA chose long ago to employ this strategy of exploiting the states' own systems of accounting and control, while carrying out certain procedures and independent measurements to *authenticate and verify* the state's measurement systems and thus the state's reports.[33] **The IAEA is thus dependent on the quality of the SSAC and the cooperation of the state in implementing safeguards.** If the SSAC is very sloppy, suspicions will be raised, and the IAEA may even call into question the validity of the state's measurement systems or reject the reports. The IAEA is not permitted to play the role of plant operator, however, and would not have the resources to do so even if it were.

■ Resources Available for Safeguards

OPTION: *Increase the financial resources available to the IAEA for carrying out safeguards.*

Under pressure from those countries providing the bulk of its funding, the IAEA has been held to virtually a zero-real-growth budget since 1985. In addition, since 1991, the Soviet Union's successor states have been unable to maintain the U.S.S.R. previous level of contributions, about 13 percent of the agency's budget.[34] Meanwhile, the IAEA is constantly subjected to late payments from member states, including the United States.[35] Despite its financial difficulties, the agency's safeguards responsibilities have been increasing:

- Several countries with significant nuclear infrastructures, such as Argentina, Brazil,[36] South Africa, Ukraine, and Kazakhstan, have

[32] For example, Rokksho will have ove,25 tanks and several separate buildings between the initial dissolver tank and the final Plutonium output stream-all connected by piping and monitored by various process-specific equipment. According to press accounts, construction of Rokkasho is expected to cost between 1.8 trillion and 2 trillion yen, or roughly $18 billion to $20 billion. See N. Usui and A. MacLachlan, "Japan AEC Looking at Delay in Startup of Reprocessing Plants," Nuclear Fuel, Feb. 14, 1994, pp. 10-11.

Rokkasho will be the only reprocessing plant of this size under complete IAEA safeguards. The THORP reprocessing plant in the United Kingdom and the French reprocessing plant at La Hague, which are even larger than Rokkasho, will have IAEA safeguards applied only to their product-storage areas. Since both are located in nuclear weapon states, neither is required to be completely safeguarded by the IAEA.

[33] Though the IAEA can perform some measurements independently by taking samples from the site (destructive assays) or by carrying portable equipment to it (nondestructive assays), other measurements can only be "authenticated" by IAEA personnl, by verifying the integrity of plant measurement equipment, and by watching to see that plant operators do their job properly. IAEA inspectors can also verify the emplacement of the equipment during construction and may install tamper-resistant devices.

The THORP reprocessing plant in the United Kingdom and the French reprocessing plant at La Hague will have IAEA safeguards applied only to their product-storage areas, and not to the entire plants, which is permissible since they are located in nuclear-weapon states.

[34] As of December 31, 1994, the payment status of those former Soviet republics that are members of the IAEA is as follows: Armenia, Kazakhstan, and Uzbekistan have made no payments. Belarus and Ukraine, which had formally been members of the IAEA even while the Soviet Union existed, are fully paid for 1991 but have not paid since then. Russia is fully paid for 1991 and 1992 and has paid 23 percent of its 1993 assessment and none of its 1994 assessment. Estonia has made a partial payment and Lithuania is fully paid for 1993 and 1994. From letter of Jan. 17, 1995 from Jan Priest, Division of External Relations, IAEA, addressed to Marvin Peterson, United States Mission to the United Nations System Organizations in Vienna, responding to Office of Technology Assessment questions, p. 3.

[35] At just over 25 percent of the total, the U.S. contribution is the largest single contribution to the IAEA of any member state.

[36] The 1991 agreement between Brazil, Argentina, the Argentine-Brazilian Agency for Accounting and Control of Nuclear Materials (ABACC), and the IAEA will add over $2 million yearly to the IAEA's safeguards costs upon entry into force. 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, U.K.: Programme for Promoting Nuclear Non-Proliferation, Sept. 1992), p. 29.

recently concluded or are concluding full-scope safeguards agreements with the IAEA, as required by the Treaty of Tlatelolco (in the case of Argentina and Brazil) or the nuclear Non-Proliferation Treaty (the others). These safeguards agreements require the IAEA to apply safeguards to all nuclear facilities in these countries, noticeably expanding the IAEA's total workload.

- In the 1990s, almost a dozen safeguarded facilities will be handling plutonium. These activities, including reprocessing as well as fabrication of MOX (mixed oxide, consisting of uranium oxide combined with plutonium oxide) fuel, make special demands on safeguards. Total costs to the IAEA for safeguarding these facilities will likely increase to $50 million per year and require a "quantum leap" in inspection effort.[37]
- The IAEA has greatly increased the attention and resources devoted to finding undeclared nuclear facilities, a mission it had not undertaken before the Gulf War.

Mitigating these additional expenses somewhat is the 50 percent reduction in IAEA inspection expenditures devoted to EURATOM states that has been made possible through closer collaboration and coordination between EURATOM and the IAEA. Through the New Partnership Approach, the IAEA and EURATOM intend to reduce redundancy in inspections of the same facilities while retaining the IAEA's ability to make its own independent assessments.[38] Even with these savings, however, **a zero-growth budget makes almost no sense in this environment.** The IAEA's current responsibilities do not lessen when it concludes new safeguards agreements, or when new facilities are added to existing safeguards agreements.

The United States has suggested "real growth" be interpreted to mean added expenditure *above and beyond that required to address these mandatory obligations*. In this way, the IAEA would not suffer financially from the imposition of new safeguards responsibilities that it does not have the ability to avoid. However, the United States has not been able to persuade other IAEA members to accept its view. Fiscal hardliners, including close U.S. allies such as Japan, Germany, the United Kingdom, and France, are not willing to make provision in the IAEA budget for these nondiscretionary increases.

Even if agreement could be reached to increase funding for the IAEA, issues of fairness and proportionality—both with respect to *who* should pay more and *how* the added money should be allocated between safeguards and technical cooperation programs—tend to complicate the debate over overall funding levels, as discussed below.

Options for the United States:

- **Pay IAEA dues on time.** Although IAEA assessments for a given calendar year are due on January 1, the United States delays its payment at least nine months, until the following fiscal year begins on October 1. (Delaying the payment from January 1 to October 1 had the effect of creating a one-time reduction in the federal budget the year the shift took place; moving the payment back would require a corresponding one-time increase.) This nine-month delay aggravates IAEA cash flow problems.
- **Raise the U.S. extrabudgetary contribution and level of technical assistance to safe-**

[37]See, e.g., Frans Berkhout et al., "Disposition of Separated Plutonium," *Science & Global Security*, vol. 3, Nos. 3-4, 1993, pp. 161-214.

[38]S. Thorstensen and K. Chitumbo, "Increased Co-operation Between IAEA and Euratom: The New Partnership Approach," Symposium Proceedings, *International Nuclear Safeguards 1994*, op. cit., footnote 30, p. 271

guards. The IAEA's formal safeguards budget, $68.6 million in 1994, is quite modest. It represents about one-third of the IAEA's regular assessed budget, which that year totaled $200.1 million.[39] In addition to the regular budget, the IAEA also receives extrabudgetary contributions, some of which are devoted to safeguards. Total United States funding for the IAEA in 1994 consisted of a $49.9 million assessment and a $30.0 million extrabudgetary contribution. Of this $30.0 million, $14.6 million was paid into the IAEA's Technical Cooperation and Assistance Fund, or TACF (see box 3-3).

Another $6 million went to specific technical cooperation activities that were not funded from the TACF, and the remainder—$9.4 million—provided extrabudgetary support for safeguards.[40] Therefore, the United States contributed $28.3 million towards IAEA safeguards in 1994, an amount on the order of one ten-thousandth of the United States national security and international relations budget.[41]

Given the extensive and increasing responsibilities of the IAEA safeguards program, and the U.S. interest in strengthening them, the United States might wish to consider greatly increasing its safeguards contributions. It has already pledged to increase its extrabudgetary contribution for 1995 to $40.0 million, of which $16.2 million will be devoted to safeguards.[42] Even at $100 million per year, this contribution would be a tiny share of the U.S. national security budget. Greatly increased safeguards budgets would allow the maintenance or even expansion of rigorous safeguards on "non-problem" states as well as increased attention to "problem" states. In this way, the IAEA could get around the major political difficulty of targeting safeguards efforts on the basis of any judgment of proliferation risk.

Even if the United States were to increase its own contribution, however, the IAEA faces institutional barriers to accepting the additional funds entirely for safeguards purposes. First is the pressure from many member states to balance the IAEA's safeguards activities with nuclear promotion and technical assistance activities. Raising one will almost certainly require raising the other (see the option on removing the linkage between safeguards and assistance, below). Second is the reluctance of many states—including advanced industrial states with large nuclear programs—to increase the safeguards effort devoted to their own nuclear facilities, particularly if they are required to pay for it. Third is the perception that safeguards only matter to those few states that are paying the bulk of its expenses, and that therefore the rest of the IAEA's membership need not pay for or care very much about them.

Options available to the IAEA:

- **Relax safeguards standards (significant quantities, timeliness goals, or achievement of inspection goals).** This is not an option any party would like to see implemented, but rather could be the de facto consequence of the increased demands that have been placed on the IAEA if additional funds or efficiencies in operation are not found.
- **Increase overall assessments charged to IAEA member states**. Over the past decade, and particularly since the Gulf War, the IAEA's member states have been extremely reluctant to

[39]To minimize the effect of exchange rate fluctuations, the IAEA budget is assessed in a mix of U.S. dollars and Austrian schillings. However, changes in exchange rates may nevertheless introduce disparities between budget figures for different years, or between budgetary assessments and actual payments.

[40]1994 budget figures are from "IAEA Funding in 1994," provided by the U.S. Department of State, March 1995.

[41]The $28.3 million for safeguards breaks down into $18.9 million from the U.S. formal assessment, which represents 28.1 percent of the IAEA's regular safeguards budget, plus the $9.4 million in extrabudgetary safeguards support.

[42] "IAEA Funding in 1994," op. cit., footnote 40. In recent years, the United States has provided over 70 percent of the total extrabudgetary cash contributions for safeguards. This percentage can be expected to increase significantly for 1995, given the increase in the U.S. extrabudgetary safeguards contribution.

BOX 3-3: Technical Assistance Programs[1]

The IAEA has engaged in technical assistance and cooperation with member states since 1958, at first in accordance with the "Atoms for Peace" program suggested by the United States and later in accordance with Article IV of the Non-Proliferation Treaty. That Article gives all NPT parties "the right to participate in the fullest possible exchange of equipment, materials, and scientific and technological information for the peaceful uses of nuclear energy ., . especially in the territories of non-nuclear-weapon States Party to the Treaty, with due consideration to the needs of the developing areas of the world." Its inclusion in the NPT was one of the *quids pro quo* for the IAEA's right to inspect sites containing nuclear material, under Article Ill.

In 1993, technical assistance funding supported 1,373 projects in 86 countries at a level totaling $45 million, an amount about two-thirds the size of that year's safeguards budget. The largest share, or just over 20 percent, of technical assistance funding was devoted to food and agriculture.[2] Just under 20 percent went to nuclear safety programs: radioactive waste management, radiation protection, and safety of nuclear installations. Assistance in physical and chemical sciences came to 18 percent of the total, followed by industry and earth sciences at 14 percent, human health at 14 percent, and nuclear power and the nuclear fuel cycle (other than the safety program mentioned above), together at 9 percent. The bulk of these funds, or $36,7 million, came from the IAEA's Technical Assistance and Cooperation Fund, consisting of voluntary contributions made by Member States (aimed at a target established by the Board of Governors) beyond their yearly assessed contributions to the IAEA. Member states also provided $5.6 million in cash in addition to their contributions to the Technical Assistance and Cooperation Fund, as well as $1.6 million in in-kind contributions. Finally, the United Nations Development Program provided $1,4 million for a number of specific projects.

Top recipients of IAEA Technical Assistance, 1958-93

Country	**$ millions**
Egypt	24,7
Brazil	18.5
Thailand	16,1
Indonesia	15.0
Peru	13.8
Pakistan	12.7
Philippines	12.4
Bangladesh	11.8
South Korea	11.7
Yugoslavia	11.7
Total of top 10 recipients	148.4
Total of all recipients	617.5

(continued)

[1] IAEA budgetary figures in this box are from International Atomic Energy Agency, *The Agency's Technical Cooperation Activities in 7993,* Report by the Director General, GC(XXXVlll)/INF/3, August 1994, tables on pp. 9, 10; table 7, Financial Summary, 1993, pp. 66-68; and table 8, Financial Summary: 1958-1993, pp. 69-71,

[2] Agriculture programs include a variety of projects based on the ability of radioactive isotopes to be traced as they Pass through Iiving organisms. For example, radioisotopes are used to examine the abilityof different crops to fix nitrogen from the atmosphere, thus reducing dependence on chemical fertilizers. Another agricultural area of study IS the development of superior strains of food plants through radiation-induced mutations and subsequent selection. A third is pest control using nuclear techniques, such as using high radiation doses to render insects sterile. When released into the environment in large numbers, these resects can overwhelm preexisting, fertile insects in competing for mates. In this way, further reproduction of the pest can be greatly reduced, A fourth area of research is the use of radiation to preserve food by killing pathogens and other organisms responsible for causing it to spoil.

BOX 3-3 (Cont'd.): Technical Assistance Programs

From its inception through 1993, the IAEA has provided $617 million worth of technical assistance in three broad categories: expert advice, equipment, and fellowships and training programs. The table lists the countries that received the most IAEA technical assistance through 1993.

Assistance programs in the areas of nuclear fuel cycle studies, and in physical and chemical sciences, have given rise to some concern regarding the potential for proliferation. One recent example would be a relatively large program of assistance ($0.8 million in 1993; $8.2 million total through 1993) to Iran, much of which was devoted to development of a major cyclotron laboratory. Iran recently imported a cyclotron from China for isotope production. Cyclotron-based techniques can also be used to separate isotopes on a small scale, Such separation is necessary to produce radioisotopes for research and can also be used to analyze how these isotopes are taken up by organisms. However, on a larger scale, this technology (electromagnetic isotope separation) is the very one used by Iraq in 1990 to produce highly enriched uranium for its nuclear weapon program, If uninterrupted, Iraq would have produced enough material within a few years to make nuclear weapons.

In general, assistance at the level and for the purposes provided by the IAEA makes little direct contribution to a nuclear weapon program. However, the skills and expertise that might be acquired by a state through such assistance could be relevant, both in terms of basic knowledge in dealing with nuclear materials and nuclear technology, and also possibly in terms of extrapolating techniques a state first learns through IAEA technical assistance, Even if such assistance might lend indirect support to a nuclear weapon program, though, the IAEA may not be able to refuse to provide it to a state that appears to be in full compliance with its nonproliferation commitments. Both Article IV of the NPT and the IAEA Statute itself mandate that assistance be provided to Member States. For example, although the United States believes that Iran is pursuing nuclear weapons, neither the United States nor the IAEA has provided public evidence that Iran has violated its Non-Proliferation Treaty commitments. Therefore, the IAEA has no basis on which to deny technical assistance to Iran.

More generically, questions could be raised about this sort of dual-use assistance to other states, whether or not the United States considers them to be of special proliferation concern, For example, cyclotron help is provided to several states, including South Korea, Indonesia, Turkey, Egypt, and, somewhat disturbingly, North Korea. North Korea received $266,000 in technical assistance from the IAEA in 1993, and a total of $6,4 million through 1993, before the IAEA's Board of Governors suspended technical cooperation in June, 1994 over North Korea's refusal to accept IAEA special inspections. Soon afterwards, North Korea withdrew from the IAEA. According to the IAEA and to the NPT's member states, North Korea remains legally bound by the terms of the NPT and its safeguards agreement. However, North Korea does not consider itself so bound, and it is not in full compliance with this agreement as of this writing.

raise its budget despite the growing demands. Even if they should agree to increase their respective assessments, they would still need to deal with balancing safeguards against technical promotion, and safeguards on the developing world against those on the industrialized states.

The reluctance of member states to accept increased assessments for many United Nations organizations stems at least in part from the perception that these organizations do not spend their funds efficiently. Increased efficiencies should be sought, in this view, before assessments are increased. The IAEA, however, does not appear to share the widespread reputation attributed to U.N. agencies in general for fiscal and managerial laxity. A 1993 *study of the IAEA safeguards program by the U.S. General Accounting Office, an organization that among other things investigates allega -*

tions of waste, fraud, or mismanagement, did not raise such questions regarding the IAEA.[43]

- **Weaken or remove the linkage between the safeguards budget and technical assistance programs.** Many developing states view their commitments to accept nuclear safeguards as balanced by the provision of technical assistance in nuclear energy and other peaceful applications of nuclear technology—one of the bargains built into the IAEA from its outset. These states continue to apply pressure to maintain a rough parity between the IAEA's allocations for safeguards and those for promotional activities and "technical cooperation" (see box 3-3).[44] Since pledges and actual payments to the technical cooperation program have declined, while demands on the safeguards budget have increased, it becomes increasingly difficult to maintain the "target ratio" between cooperation and safeguards. Therefore, it has become correspondingly difficult to contemplate a significant redirection of funds toward safeguards in developing states, even if such funds were to become available.

  The linkage between safeguards and technical cooperation, however, has been challenged on a number of grounds. First, there is no inherent relationship between the risks of diversion of nuclear materials worldwide—and the consequent demands on the safeguards budget—and the need for technical assistance and promotion in the fields of nuclear science and technology. Second, it is not clear that technical assistance in nuclear-related technologies is the most appropriate way to meet the needs of developing countries. Article IV of the NPT, which calls for contributions "to the further development of the applications of nuclear energy for peaceful purposes," holds that due consideration should be given to "the needs of the developing areas of the world." If those needs are not appropriately served by nuclear technology, Article IV would not seem to require nuclear solutions.

  Despite these questions, the linkage between safeguards and technical cooperation will be difficult, if not impossible, to break. Without the provision of technical assistance in nuclear fields, many states would never have agreed to submit to the safeguards regime at all. *International organizations whose very existence depends on compromises that were made years ago will not have an easy time reformulating those compromises.*

  One possible solution would be to find some mechanism to provide technical assistance in energy technologies, medical technologies, or agricultural technologies generally to supplement the narrower assistance provided by the IAEA in the nuclear-related aspects of these fields. The IAEA would probably not be the appropriate vehicle to provide this type of general assistance, since its expertise and mission specifically involve nuclear technology. Moreover, the total amount of technical assistance the IAEA can provide is very small compared with funding available for development assistance in general. However, political agreements or understandings might be made between donor and recipient states in which non-IAEA sources of technical assistance would be increased at the same time that pressures that tied the IAEA's safeguards budget directly to technical assistance were relaxed.

Reallocation of Inspection Effort

Whether or not overall resources devoted to safeguards are increased, it is important to use the

[43]United States General Accounting Office, *Nuclear Nonproliferation and Safety: Challenges Facing the International Atomic Energy Agency,* GAO/NSIAD/RCED-93-284 (Washington, DC: U.S. General Accounting Office, September 1993).

[44]The total value of the Technical Assistance and Co-operation Funds contributions delivered in 1993 amounted to $36.7 million. Total assistance provided that year, including U.N. Development Program funds, member state extrabudgetary contributions, and member-state "in-kind" contributions, totaled $45.3 million.

available resources efficiently. In the case of safeguards, efficiency means getting the most value toward detecting safeguards violations and thereby deterring-or providing warning of—proliferation. Since IAEA inspection efforts depend on the amount and type of nuclear material under safeguards and the size of the facilities processing it, a large portion of the total IAEA safeguards budget (some 46 percent at present) is spent on Germany, Japan, and Canada, the states with the largest and most advanced nuclear programs under safeguards.[45] None of these countries is regarded by most observers as a current proliferation risk, especially with respect to cheating on safeguards or attempting to divert material from civilian fuel cycles.[46] In addition, the majority of the safeguards effort is applied to facilities involving the greatest amount of material—those associated with civilian nuclear power production—rather than to other nuclear activities, such as research reactors, that are more likely to benefit a weapon program. Various proposals for saving money within the IAEA have thus focused on redirecting effort to countries that are thought to pose a greater risk.

OPTION: *Reallocate inspection effort toward problem states.*

Many feel that, given the constraints of a zero-real-growth budget, there is a need to focus greater safeguards efforts (including environmental monitoring to look for undeclared facilities) toward states either in regions of political tension or with only marginal nonproliferation records.

There is already some authority within INFCIRC/153 to adjust routine inspection requirements (subject to certain limits) based on a country's overall fuel-cycle characteristics (see box 3-4).[47] **This authority might be exploited more fully, especially for *future* safeguards agreements,** although renegotiating safeguards agreements already in force would be much more difficult. For instance, more emphasis could be placed on a country's overall amount of "direct-use" fissile material (e.g., material containing highly enriched uranium or plutonium). If a country possesses enrichment or (especially) reprocessing facilities, additional inspection efforts might be justifiable even if amounts of fuel being irradiated in various reactors were small. (See the following option for discussion of the converse approach of reducing inspection effort in states that offer the IAEA widespread access and technical visits, with the aim of providing assurance that they do not possess undeclared facilities.) Some have taken this argument even further, suggesting that several measures in addition to the INFCIRC/153 provisions mentioned above be used in determining a country's level of inspection effort. These measures might include the size or growth of a state's military forces, its possession or development of vehicles suitable for delivering weapons of mass destruction, its import of key dual-use technologies, its involvement in regional tensions, or even its human-rights record.[48]

However, the IAEA is forbidden by its statute to discriminate against member states. Therefore, **unless a reallocation of inspection effort could**

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[45] The 46 peercent share is stated in the Jan. 17, 1995 letter from Jan Priest, IAEA, in response to Office of Technology Assessment questions, op. cit., footnote 34, p. 3. Earlier estimates of the fraction of safeguards resources devoted to Japan, Germany and Canada had been higher; it was given as 55 percent in Scheinman, op. cit., footnote 3, p. 20.

[46] Even if governments seekking nuclear weapons were to come to power in such countries, they would probably be more likely to withdraw from the NPT, which would permit the development of a large arsenal, than mount an expensive, difficult, and risky attempt to divert as little as one bomb's worth of fissionable material per year from safeguarded facilities.

[47] See paragraph 81, INFCIRC/153.

48 For example, see David Kay, "The IAEA—How can It Be Strengthened?" paper presented at the conference *Nuclear Proliferation in the 1990s: Challenges and Opportunities,* Woodrow Wilson Center, Washington, DC, Dec. 1-2, 1992, p. 16.

BOX 3-4: Legal Limits on IAEA Routine Inspection Effort[1]

The model safeguards agreement for NPT states, INFCIRC/153, lays out general guidelines for the routine inspection effort that should be applied to various types of facilities, based on the type and amount of nuclear material they use. Such guidelines are primarily in the form of ceilings on inspector effort, called "maximum routine inspection effort" or MRIE (see definitions below).

The *actual* routine inspection effort (ARIE) for a given facility is negotiated by IAEA and the state separately for each safeguarded facility.[2] In practice, inspection frequencies are then chosen so that the IAEA can meet its goals for detection times—i.e., so that it can detect the diversion of nuclear material on a time scale roughly comparable to what it would take to fabricate that material into a weapon—according to the following:

Unirradiated direct-use material:	one month
Irradiated direct-use material:	three months
Indirect-use material:	one year

MRIE. As specified in paragraphs 79 and 80 of INFCIRC/153, the "maximum routine inspection effort (MRIE)" is the maximum number of person-days of inspection work (up to 8 hours of access to a facility during one day) per annum allowable for a given facility. This limit depends on the larger of its inventory, annual throughput, or maximum potential annual production of nuclear material, which is denoted L and expressed in effective kilograms (see definition below).

L <5 effective kilogram (ekg): one routine inspection per year

L >5 ekg:

Reactors and sealed stores: 50 Person-Days-Inspection (PDI)/year[3]

Facilities containing Pu or U enriched to more than 5 percent:

$MRIE = 30x\ L^{1/2} PD1/y$, but not less than 450 PDI/y

All other cases: MRIE = (100 + 0.4L) PDI/y.

ARIE. "Actual routine inspection effort" is the estimated annual inspection effort under an INFCIRC/153 agreement, based on a plant operating fully according to its design data The ARIE is negotiated and included in the facility attachment. It cannot exceed the MRIE above. In accordance with paragraph 81 of INFCIRC/153, due consideration of the following factors should be given to the following when the ARIE is being established:

1. The form and accessibility of the nuclear material (bulk form v. discrete items, chemical composition, enrichment);
2. The effectiveness of the State System of Accounting and Control (SSAC), the extent to which the operator is functionally independent of the SSAC, the promptness and consistency of the State's reports, and the value and accuracy of the MUF as verified by the Agency;
3. The characteristics of the State's nuclear fuel cycle, in particular the number and types of facilities and the characteristics of such facilities relevant to safeguards (e.g., containment and ability to correlate information from different material balance areas);

[1] *IAEA Safeguards Glossary,* 1987 *Edition,* op. cit , PP. 65-66

[2] The ARIE is usually significantly less than the MRIE for some types of facility, but facility-specific values are safeguards-confidential.

[3] Small research reactors typically contain less than 5 effective kilograms of HEU, but larger ones, such as the approximately 40 MW(th) Osirak reactor in Iraq, can contain more. The latter was being inspected 3 times per year prior to its being attacked by Israel in 1981, and inspection efforts would have increased had it become operational.

(continued)

BOX 3-4 (Cont'd.): Legal Limits on IAEA Routine Inspection Effort

4. The international interdependence of nuclear activities involved and any relevant IAEA verification activities; and

5. Technical developments in the field of safeguards (e.g., statistical and random sampling techniques).

In practice, since the ARIE cannot exceed the MRIE, these factors can only be used to reduce the inspection effort, not to increase it. For instance, agreed ARIE person-days of inspection at reactors vary and can be set at levels up to 50, but normally do not exceed an upper limit of 10 or 15.[4] In addition, actual person-days of inspection can be less than the ARIE if there are extended shutdowns of the facility,

Effective kilograms (ekg). The number of "effective kilograms (ekg)" for plutonium and uranium-233 is equal to their mass in kilograms. For uranium enriched to at least 1 percent uranium-235, the ekg is the total amount of uranium times the square of the enrichment level. Thus 10 kilograms of 90 percent uranium-235 is 8.1 ekg, 10 kg of 20 percent uranium-235 is 0.4 ekg, and 10 kg of 5 percent uranium-235 is 0.025 ekg. Thus, the actual mass of uranium-235 present at lower enrichments is considerably more than the ekg value.

Time Allowed Before Safeguards Must Come into Effect. Article Ill of the NPT requires a state's safeguards agreement to "enter into force" within 18 months of its ratification or accession to the NPT. INFCIRC/153, paragraph 40, requires that Subsidiary Arrangements, which include Facility Attachments specifying actual inspection procedures for each safeguarded installation, enter into force within 90 days of entry into force of a state's safeguards agreement. Thus, there is no legal requirement for routine inspections to begin until 21 months after a state joins the NPT. However, the IAEA may conduct ad hoc inspections of any facilities declared in a state's safeguards agreement before, during, or after Subsidiary Arrangements are completed. Thus, inspections usually begin no later than up to about 18 months after a state joins the NPT.

[4] J.E. Lovett, "Nuclear Materials Safeguards for Reprocessing," International Atomic Energy Agency Report STR-151/152 (December 1987), pp. 208. Lovett also asserts that verification and sealing of spent fuel shipping casks at reactors would require levels of effort that are neither possible within agreed ARIE levels nor feasible with currently available inspector staff levels

be justified under some objective criteria, the IAEA would face serious institutional difficulties in making what would be perceived to be a political determination that some states are more trustworthy than others. Moreover, subjective criteria would be considered vulnerable to political distortions, making them nearly impossible for the IAEA to use when negotiating safeguards agreements. Certain member states might feel that they were being unjustly singled out. For instance, some states represented on the Board of Governors have been known to take a very conservative approach to such matters, fearing that any more stringent requirements that they allowed in another state might eventually come back and be applied to them. Adding another discriminatory practice on top of the already-existing distinction in the NPT between nuclear "haves" and "have nets" might damage the political consensus behind that treaty itself.

If reallocating safeguards effort away from states not thought to pose near-term proliferation threats had the effect of relaxing safeguards standards there, long-term risks could arise-particularly for states with extensive nuclear fuel-cycle infrastructures involving enrichment or reprocessing. If the continuity of safeguards were lost in one of these countries and a new government that sought nuclear weapons came to power, the IAEA could have a great deal of difficulty reestablishing a strict full-scope safeguards regime.

It remains to be seen how far the IAEA can push already existing authority to focus more of its resources on states of greater proliferation concern, especially in countries whose safeguards agreements have been in force for some time. However, the United States, being one of the most influential members of the IAEA, could try to push the agency in this direction, if it chose. INFCIRC/153 also gives the IAEA authority to conduct "special inspections" if reasonably justified to carry out its safeguards obligations, and these could also be used more effectively in problem countries. Some increased efforts along these lines have already been taken in North Korea and South Africa, two countries that have recently completed their safeguards agreements (albeit under extremely different circumstances).[49] Since special inspections can be requested "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 [safeguards] Agreement," some flexibility would certainly seem authorized in invoking this provision, and greater use could probably be justified in less cooperative states without overstepping this authority.

■ Expansion of Safeguards via "Enhanced Transparency"

Transparency measures refer to actions taken by a state to enhance the visibility and openness of its own activities in order to reassure others that it is not threatening their security, or in order to make it more difficult for other states to hide their own activities. In the area of nuclear safeguards, such measures might include providing access to IAEA inspectors above and beyond what is required by a state's safeguards agreement. Making *transparency* a norm of international behavior might enable the IAEA-or the world community-to become aware more easily of undeclared nuclear facilities or other state practices that could indicate the existence of a nuclear weapon program. As a result, IAEA safeguards would be bolstered, and states would gain added assurance that their neighbors were not mounting nuclear weapon programs. Increased transparency might also be associated with reduced routine inspection effort, permitting more efficient application of the IAEA's limited safeguards resources.[50]

One technique that can take advantage of additional transparency is the taking and analysis of environmental samples, which the IAEA is exploring as a means for detecting and/or characterizing undeclared nuclear facilities. The IAEA is also accepting invitations by states such as Iran and South Africa to conduct "visits' '-rather than formal inspections—to sites where questions may have been raised.

OPTION: *The United States could encourage states to make, and the IAEA to accept, offers to provide information and accept inspections not specifically required by safeguards agreements.*

If greater transparency by inspected states can help the IAEA satisfy itself that all facilities capable of processing or producing fissile material are safeguarded (i.e., that a given state lacks even the potential to operate any undeclared facilities and does not have access to such facilities anywhere else), then the agency can have confidence that nuclear material at reactors and in storage has not been diverted for weapon use-even if it has not been accounted for with the high statistical confidence levels and timelines now required.[51] The idea would be to move away from the traditional

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[49] Since South Africa volunteered very broad access to its territory, the IAEA was able to make so-called ad hoc visits to all the sites it wanted to see without having to invoke the "special inspection" machinery of its safeguards agreement with that country. Lack of North Korean cooperation, on the other hand, forced the IAEA to demand special inspections there. As of this writing, these requests have not been granted.

[50] See, e.g., David Fischer, op. cit., footnote 36, and Scheinman, op. cit., footnote 3.

[51] Scheinman, op. cit., footnote 3, p. 41.

focus on strictly quantitative material accountancy methods (which are increasingly difficult to apply rigorously as facility throughputs get larger) toward an approach that can also utilize the less quantitative types of information that are volunteered through transparency measures. For instance, the requirement for inspections every three months of spent fuel containing significant amounts of irradiated plutonium might be relaxed, perhaps in conjunction with real-time, automated monitoring of the spent fuel pond, if the IAEA could be assured that a country had no reprocessing facilities nor access to any. As Scheinman explains,

> [The value of these measures] lies not in the ability of the agency to draw conclusions identical to those drawn from the system of material accountancy—which it well may not be able to do. Rather, [it] lie[s] in the contribution that a flexible verification system makes to the **perception** of both the inspected party and outside states about the risk of detection, and, consequently, the willingness of a would-be proliferator to take the risk in the first place.[52]

The right to tailor safeguards procedures to an individual state's facilities, control systems, and behavior is implicitly incorporated into the original model safeguards agreement. Provisions for modifying the frequency and notification requirements for safeguards inspections based on various qualitative and quantitative aspects of a state's fuel cycle and reporting practices, as well as on developments in statistical techniques and random sampling, are contained in INFCIRC/153 (paragraphs 81 and 84). Nevertheless, such safeguards modifications have never been fully exploited, since the factors upon which they would be justified are not easily quantifiable.

Apart from seeking to reduce their inspection burden, states with nothing to hide may be willing to accept inspections and volunteer information not specifically required by their safeguards agreements. In so doing, they not only provide added assurance that they are complying with their own commitments, but also encourage others to do likewise. However, they may also need to balance such transparency against security, proprietary, or constitutional concerns that could argue against providing unlimited access. During the negotiation of the Chemical Weapons Convention (CWC), which provides for quite intrusive "challenge inspections" of suspect sites, such concerns led to the development of "managed access" provisions. These provisions specify negotiation procedures and timeliness by which inspectors must be granted some access to the requested site, and they obligate the inspected state to address whatever concerns have motivated an inspection request. However, they ultimately give the inspected state the right to limit access (see box 3-5). Similar protections would probably be associated, implicitly or explicitly, with any offers of additional access to the IAEA.

In principle, the signature of the Chemical Weapons Convention by 159 countries (as of this writing) indicates widespread international acceptance of its monitoring and inspection provisions, offering the prospect that CWC signatories may be willing to grant the IAEA a corresponding degree of openness. However, this apparent acceptance is tempered by the much slower rate at which the CWC signatories are ratifying it. (As of the same date, only 27 countries had deposited their instruments of ratification.) Moreover, since the convention has not yet entered into force, no inspections have been carried out, and nobody can tell how its commitment to transparency will be realized in practice.

By providing additional information, voluntary offers of openness improve the IAEA's ability to do its job. However, they can also pose some risk to the IAEA. First of all, acting on them will require additional resources, exacerbating the IAEA's financial difficulties. Second, voluntary

[52]Ibid., p. 23. Emphasis in original.

BOX 3-5: Challenge Inspections Under the Chemical Weapons Convention[1]

Under the Chemical Weapons Convention (CWC), a state party that suspects another party of violating the treaty's provisions can call for a *challenge inspection* of any site within the suspected violator's territory. The treaty and its associated Verification Annex specify a sequence of procedures and timelines under which the inspected state must give international inspectors access to the suspect site, and they also provide for a series of negotiations to determine how much access the inspected country must provide. The fact that 159 countries have signed the Chemical Weapons Convention (as of February 1995) shows that these provisions have gained widespread international acceptance, and it *may* indicate-although does not guarantee-that states would be willing to grant equivalent access to IAEA inspectors. On the other hand, the true commitment of states to these provisions has not been tested; as of the same date, over 25 countries had deposited their instruments of ratification for the CWC, but well short of the 65 ratifications needed to bring the treaty into force. Therefore, no experience has yet been gathered in conducting such inspections or in gauging states' reactions to them.

CWC Challenge Inspections

The Chemical Weapons Convention creates a new international organization, the Organization for the Prohibition of Chemical Weapons (OPCW), to implement the CWC's provisions. In a role somewhat analogous to the IAEA, the OPCW will contain a Technical Secretariat to compile the data that member states must submit under the CWC, and to conduct routine and challenge inspections. Any treaty party can initiate a challenge inspection by providing specific information about the site in question to the Director General of the OPCW's Technical Secretariat, who then passes it to the OPCW's Executive Council. To prevent abuses of the challenge inspection provisions, a 3/4 vote of the Executive Council can block an inspection request judged to be "frivolous, abusive, or beyond the scope of the treaty."[2] Otherwise, the Director-General is obligated to conduct the inspection without delay. Unlike an IAEA special inspection, which must be negotiated with the state to be inspected and therefore can at least be delayed, if not stalled indefinitely, a challenge inspection under the CWC cannot legitimatly be delayed or blocked by state being challenged. The inspected state must be notified of the location of the site to be inspected at least 12 hours before an inspection team is to arrive at a point of entry.

Within 36 hours of the team's arrival, the host state must transport it to the perimeter of the suspect site, where it will be allowed to examine traffic logs, take photographs and videos, and visit other portions of the perimeter. If the site perimeter requested by the inspection team is not acceptable to the host nation, the host (with some conditions) can propose an alternate. Negotiations over the final perimeter can continue for up to 72 hours from the team's arrival at the perimeter, at which point—if agreement has not been reached—the alternate perimeter will become the final perimeter. When the final perimeter is determined, the inspection team will be allowed to take air, water, and effluent samples, and use monitoring instruments.

Managed Access

Within 108 hours of the inspection team's arrival at the host nation's point of entry, it must be allowed access within the perimeter of the suspect site. The degree of access granted is to be negotiated between inspectors and host under the principle of "managed access," by which the host state is obligated to allow the "greatest degree of access" consistent with any "constitutional obligations it may have with regard to

(continued)

[1] This box is based on U.S. Congress, Office of Technology Assessment, *The Chemical Weapons Convention: Effects on the U.S. Chemical Industry,* OTA-BP-ISC-106 (Washington, DC: U.S. Government Printing Office, August 1993), pp. 5-6 and 27-28; on Amy Smithson (cd.), *The Chemical Weapons Convention Handbook,* Handbook No. 2 (Washington, DC: The Henry L. Stimson Center, September 1993), pp. 31-34; and on the Chemical Weapons Convention itself, formally known as the *Convention on the Prohibition of the Development, Production, Stockpiling, and Use of Chemical Weapons and on Their Destruction* (denoted here as *CWC),* United Nations, 1993.

[2] CWC, Article IX ("Consultations, Cooperation, and Fact-Finding"), paragraph 17.

BOX 3-5 (Cont'd.): Challenge Inspections Under the Chemical Weapons Convention

proprietary rights or searches and seizures" and with the protection of national security information.[3] The inspection team is required to conduct its inspection "in the least intrusive manner possible" that will permit it to accomplish its mission.[4] To protect sensitive installations or information, the host state may take measures such as removing sensitive papers from offices, shrouding displays or equipment, turning off computer systems, restricting sample analysis to determining the presence or absence of compounds indicative of treaty violation, or permitting access to a randomly selected fraction of buildings or rooms. In those areas where full access is not granted, the host nation is obligated to make "every reasonable effort" to provide alternate means to address the concerns that prompted the challenge inspection request.[5] The inspection itself may not last more than 84 hours, unless extended by agreement with the host.

After review by the inspected state, the inspection team's report will be transmitted to the Executive Council and to all other CWC members, with the provision that certain sensitive information may be retained within the Technical Secretariat. The inspection report is to include "an assessment by the inspection team of the degree and nature of access and cooperation granted to the inspectors,"[6] Consequently, the Executive Council and member states can draw their own conclusions from a determined effort by the inspected party to frustrate the inspection, even if no overt evidence of violation is found.

[3] CWC, Annex on Implementation and Verification, Part X ("Challenge Inspections Pursuant to Article IX"), paragraph 41,
[4] Ibid., paragraph 45.
[5] Ibid., paragraph **42.**
[6] Ibid., paragraph 59.

invitations to conduct such visits can be retracted at any time, as was demonstrated in North Korea (see box 3-6). Finally, and perhaps most seriously, visits that do not uncover suspicious activities might be overinterpreted to give the inspected state a "clean bill of health." All that such a visit should imply is that nothing untoward was discovered at that site at that time.

OPTION: *Encourage the IAEA to support bilateral nuclear inspection regimes and regional arms-control and confidence-building measures.*

In addition to accepting offers by individual states to make their nuclear activities more transparent, the IAEA can also work with groups of nations in tense regions of the world to encourage confidence-building measures and promote regional arms control agreements. The model for such regional nuclear inspection regimes has been established by Argentina and Brazil, which have implemented a quadripartite inspection agreement involving themselves, the IAEA, and the newly established bilateral agency ABACC. Both countries have completed the steps necessary to bring into force the Treaty of Tlatelolco, a regional agreement banning nuclear weapons in Latin America and imposing the same constraints on nuclear weapon ambitions as does the NPT.[53] Largely due to the change from military to civilian regimes in these two countries, both seem to have renounced any nuclear weapon ambitions, making such disarmament measures possible.

On the Korean peninsula, arrangements involving mutual visits to military and nuclear installa-

[53] For discussion of how a nuclear-free zone in the Middle East might be implemented and verified, see United Nations, "Establishment of a Nuclear Weapons-Free Zone in the Region of the Middle East," Report of the Secretary-General, A/45/435, October 1990. Note that the verification requirements insisted on by states in the region would go likely go beyond those provided by the IAEA's model full-scope safeguards agreement, INFCIRC/153.

BOX 3-6: Safeguards Transparency[1]

In considering ways to improve the effectiveness of safeguards while reducing overall inspection efforts, tradeoffs are often discussed between increased transparency and reduced (and possibly more randomized) inspection frequency, The rationale for such an approach is that a state that has no access to undeclared enrichment or reprocessing plants has no way to process some types of safeguarded nuclear material (e.g., low-enriched uranium or spent fuel) to the point where it could be used in a weapon, Therefore, diversion of such materials becomes less important, and inspection effort devoted to ensuring its lack of diversion can be somewhat relaxed. For example, a possible regime could provide that a state that agreed in advance to some or all of the following measures could be a candidate for substantial reductions in routine safeguards inspections:

- Giving the IAEA the unrestricted right to carry out inspections and technical visits at short notice and at any location at which the IAEA has reason to believe that there may be undeclared nuclear material. (The state would be informed of such an inspection, but its prior right of consent would not be sought.) **From the IAEA's perspective, a state would be much more persuasive in demonstrating the absence of undeclared facilities by giving the IAEA such an unlimited right of access than by simply allowing a finite number of "special inspections" when requested.** Special inspections are a specific provision within IAEA authority, but frequent special inspections that failed to find anything suspicious could have serious repercussions on the credibility of the safeguards regime. Pre-accepted inspection provisions could be used more freely, resulting in stronger assurances overall. As many IAEA officials stress, improving access would be the single biggest help in strengthening safeguards.[2]
- Inviting the IAEA to utilize a similar, unrestricted right to make "surprise" (unannounced) inspections at any facility that contains safeguarded nuclear material.[3]
- Permitting the IAEA to take environmental samples at locations of its choosing in the inspected state.
- Providing the IAEA with full information in advance about its nuclear program and, in particular, about plans for the construction or export of any new nuclear plant, and consulting with the IAEA before taking action so that any such plant may be designed in an easily safeguardable manner.
- Permitting IAEA inspection of all nuclear facilities during construction.
- Waiving visa requirements (or issuing long-term, multiple-entry visas) to IAEA inspectors carrying appropriate travel documents or, in appropriate cases, accepting resident inspectors.

Such a package of concessions in a given country could be met with a reduced inspection effort, possibly combined with more randomized routine inspections.[4] In principle, this may significantly reduce the overall costs of applying safeguards in countries willing to be extremely cooperative with the IAEA. It might be particularly attractive for states that have substantial nuclear programs, but that lack

(continued)

[1]Material in this section is drawn from 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, U. K.: Programme for Promoting Nuclear Non-Proliferation, Sept. 1992), pp. 32-33.

[2]Some within the IAEA advocate widening the safeguards net to include uranium mines, which now fall outside the legal domain of safeguards. It is claimed that such access would significantly help in ruling out undeclared facilities and, as an example, would have helped in determining the extent of Iraq's nuclear program. Placing mines under safeguards could also allow the IAEA to use isotopic techniques to trace the origin of nuclear materials back to individual mines, aiding in the verification of certain types of material transfers within a country's fuel cycle

[3]INFCIRC/153, paragraph 84 already provides the IAEA the authority to "carry out without notification a portion of the routine insections," and such unannounced inspections are now part of the system of procedures known as the Hexapartite agreement for safeguarding gas centrifuge enrichment facilities. Although not implemented, unannounced inspections have also been included as an option in the Safeguards Criteria for low-enrichment fuel fabrication plants. Afield test of such inspections has been completed, preliminary results may be found in L.G. Fishbone et al., "Field Test of Short Notice Random Inspections for Inventory Change Verification at a Low Enriched Fuel Fabrication Plant. Preliminary Summary," Symposium Proceedings (IAEA-SM-334/164), International Nuclear Safeguards 1994, 14-18 March 1994.

[4]Such a system is currently being discussed within the IAEA, and Sweden has volunteered to serve as a test case.

BOX 3-6 (Cont'd.): Safeguards Transparency

facilities for producing unirradiated direct-use nuclear materials (separated plutonium or highly-enriched uranium), such as Canada, Sweden, Switzerland, and the Czech and Slovak Republics. It might also provide a framework for eventually subjecting the nuclear facilities of *nuclear-weapon states* to safeguards, without putting undue burden on the safeguards budget. The drawback to such proposals, however, is that relaxation of routine inspection effort will translate, in quantitative terms, to lower confidence that an SQ or more of materials has not been diverted. Unless these transparency measures actually provide the IAEA with high confidence that the inspected states have not built and do not have access to covert enrichment or reprocessing facilities with which to process any diverted materials, diversion could still pose a proliferation risk.

Transparency measures have precedents in a number of other arms control agreements and proposals, including the treaty on Conventional Forces in Europe (CFE), "Open Skies, " and the Chemical Weapons Convention.

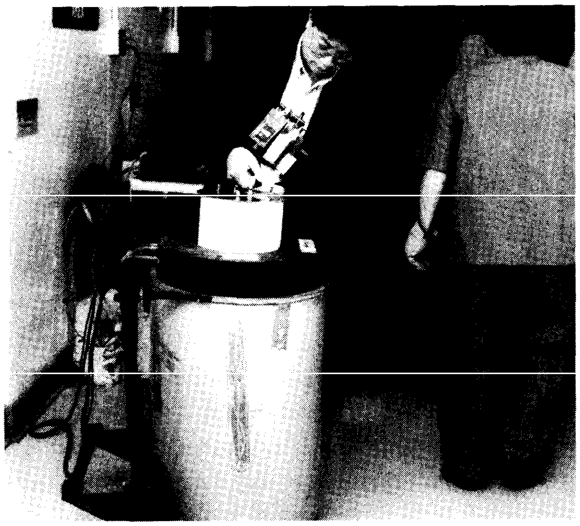
Nevertheless, details would have to be worked out to determine an equitable means of reducing the inspection effort in any given country. Objections over fairness might be raised by countries with only rudimentary fuel cycles if benefits were seen to favor the larger industrialized states in Europe. An approach that reduced overall inspection effort might also be inappropriate for Japan, since it is the only NPT non-nuclear-weapon state operating a reprocessing plant that produces significant quantities of separated plutonium (and is building a second very large plant).

Iran, South Africa, Libya, North Korea, and other states have made statements at one time or other volunteering to accept IAEA visits more intrusive than required by NPT safeguards (in some cases, practically amounting to "anytime/anywhere" inspections). The IAEA has taken advantage of these offers in Iran and South Africa and, and, prior to March 1993, it had been permitted to visit undeclared sites in North Korea. However, as the North Korean example shows, behavior and intentions can change, and such promises must be born out in practice. Despite its pledge, North Korea threatened withdrawal from the NPT when the IAEA pressed for access to two undeclared sites suspected of storing nuclear waste. Iran poses another sort of problem. Its fuel cycle is still in its early stages, and even if it were planning to develop nuclear weapons, as the United States and other countries allege, it might not have reached the point where it had built facilities it would wish to hide. Some countries, particularly the United States, would probably remain skeptical of Iran's long-term commitment to nonproliferation even if it allowed greatly expanded rights of inspection in the near term.[5]

Many in the IAEA feel that additional voluntary offers by states allowing relatively unrestricted '(technical visits" of their facilities would be beneficial and should thus be encouraged in a number of countries, including countries such as South Korea, Sweden, Switzerland, and Taiwan, which have admitted or have at one time been suspected by other nations to have considered nuclear options. Visits to a variety of facilities, such as production facilities for armor-piercing shaped-charges or nuclear research centers based at universities, could help add needed transparency to a country's overall activities.

On the other hand, the IAEA's Standing Advisory Group on Safeguards Implementation (SAGSI), in informal comments, has strongly opposed placing substantial emphasis on such visits (although not to them per se), since they can be manipulated by the country for propaganda purposes. In any case, such offers should probably not be accepted unless made unconditionally and accompanied by a waiver of a country's right to reject IAEA designated inspectors, if not a waiver as well of the right to reject additional personnel that the IAEA might like to include in such delegations, The latter could be particularly important for technical visits to any undeclared facilities, including those for nonnuclear activities, since it could be advantageous for the IAEA to include experts (perhaps with some nuclear weapon knowledge) not regularly assigned to inspections in those countries.

[5] This does not imply however, that the United States would oppose such transparency by Iran; on the contrary, it could be expected to welcome it.



MARTIN MARIETTA ENERGY SYSTEMS

IAEA inspectors making measurements on some of the highly enriched uranium that the United States has placed under safeguards at the Y-12 facility in Oak Ridge, Tennessee.

U.S. DEPARTMENT OF ENERGY, RICHLAND OPERATIONS OFFICE

IAEA inspector and Hanford employee handle a canister of plutonium oxide during an IAEA safeguards inspection at the Hanford plutonium storage facility Hanford, Washington.

tions have been discussed bilaterally, but progress remains stalled so long as North Korea continues to violate its safeguards obligations to the IAEA.

OPTION: *Expand the scope of the nuclear facilities subject to the United States' "voluntary offer" to accept safeguards not required by the Non-Proliferation Treaty and encourage other nuclear-weapon states to do the same.*

The United States is taking a number of steps to increase safeguards transparency. Since 1968, it has volunteered to accept safeguards at its own civil nuclear facilities, even though it is not required to do so under the Non-Proliferation Treaty.[54] In the past, however, due to both resource constraints and lack of urgency, the IAEA has chosen to place only a few U.S. nuclear facilities under safeguards, and very few inspections had been conducted in recent years.

In 1993, the United States for the first time agreed to place under safeguards nuclear material determined to be excess to its nuclear weapon program, and in 1994 it invited the IAEA to monitor some highly enriched uranium stored at Oak Ridge, Tennessee, and plutonium stored at Hanford, Washington. The IAEA agreed to do so, and monthly inspections began in January 1995. Through its extrabudgetary contribution to the IAEA, the United States is providing resources to conduct these additional inspections so that they do not detract from safeguards activities elsewhere in the world.

The United States could increase the scope of its nuclear facilities and materials subject to its voluntary safeguards offer, urge the IAEA to inspect a greater number of them, provide the resources to do so, and encourage other nuclear weapon states to follow its lead. If a convention to freeze the production of fissile material were implemented, the United States and other weapon states could allow the IAEA to have access to former weapon-material-production facilities. Such steps would reinforce the spirit of Article VI of the

[54] As a nuclear-weapon state, the United States is not obligated by the NIT to place its nuclear facilities under IAEA safeguards. However, to assuage concerns from non-nuclear-weapon states that this exemption placed the U.S. nuclear industry at an unfair advantage, the United States has voluntarily offered to place any of its civil nuclear facilities under safeguards. (The other nuclear-weapon states have since made similar offers, although sometimes—as in the case of China and Russia—to a much more limited extent.) From the list of civil facilities that the United States offers, the IAEA decides which to accept for application of safeguards.

NPT that calls for progress toward nuclear disarmament, making it harder for other states to refuse to follow suit.

OPTION: *The IAEA could expand the use of import and export information submitted by member states.*

As part of the enhanced safeguards activities initiated after the Gulf War, the IAEA has established a registry of imports and exports of certain equipment and non-nuclear material, and of imports, exports, production, and inventories of nuclear material. States supplying such information make it harder for their trading partners to mount covert nuclear activities. The IAEA could attempt to cross-check and verify these submissions. Other options include broadening the scope of information to be reported to the IAEA, encouraging states more strongly to participate, and making the information more widely available than just within the IAEA. However, this last point would likely raise proprietary concerns among the reporting parties.[55] Moreover, if such reporting were not mandatory and universal, those states choosing to report might suffer a disadvantage with respect to those who do not.

OPTION: *Expand the scope of safeguards to include uranium mining and milling activities that are not now subject to safeguards.*

Some observers have proposed expanding the domain of safeguards to include monitoring a state's uranium mining and milling activities. Currently, these activities fall outside of the IAEA's responsibility (see box 3-7), and they are not addressed in existing full-scope safeguards agreements. Further, while non-nuclear-weapon states party to the NPT are required to inform the IAEA of the export of yellowcake (U_3O_8, produced when uranium ore is refined), there is no requirement to verify or keep track of the shipment after its importation. Placing uranium ore and yellowcake under safeguards would require either the renegotiation of safeguards agreements or the voluntary acceptance of such safeguards on the part of states conducting mining and milling activities.

Since it is very difficult to monitor and keep track of the exact quantity of nuclear material produced by these activities (quantities of ore, in particular, can be very large), this concept might be limited to mandatory reporting of all production and transfers, perhaps with spot checks but without attempting to account rigorously for all mined materials. While such measures would not satisfy material accountancy requirements, they would at least add transparency to the entirety of a state's nuclear activities and provide a rough idea of the amount of uranium available from domestic sources, thereby making it more difficult in some cases for a clandestine program to be developed. The cost of such an addition to safeguards efforts would have to be weighed against whatever improvement in effectiveness was thereby achieved.

■ Improving the IAEA's Technical Capability

Lowering "SQ" or Timeliness Thresholds

OPTION: *The United States could encourage and support the IAEA to lower "significant quantity" thresholds.*

The IAEA significant quantity thresholds-the amount of fissile material whose diversion the IAEA safeguards system is designed to detect (e.g., 8 kilograms of plutonium, or 25 kilograms of uranium-235 in a form enriched to 20 percent or more)—represent the approximate amounts that the IAEA considers to be needed for a state to make its first nuclear explosive.

Many analysts have stated that these quantities are probably too high, and that even states attempting to make their first nuclear explosive

[55] See U.S. Congress, Office of Technology Assessment, *Export Controls and Nonproliferation* Policy, OTA-ISS-596 (Washington, DC: U.S. Government Printing Office, May 1994), especially pp. 34-35, for discussion of some of the issues involved with making export data public.

BOX 3-7: What Is Exempted from Safeguards?

- Uranium mining and milling activities, including active mines, uranium-bearing ore, and (from inspection, but not from reporting exports) yellowcake before it is in a form suitable for further enrichment or fuel fabrication (INFCIRC/153, paragraphs 33-34).
- Nuclear material for use in non-nuclear activities (such as production of alloys or ceramics) or in military non-explosive uses (such as naval propulsion, although only when actually in the ship's reactor), provided its removal from the nuclear fuel cycle is declared and specified in advance (paragraphs 13-14).[1]
- Special fissionable material in gram quantities for use in sensing instruments, or plutonium containing more than 80 percent Pu-238 (paragraph 36 of INFCIRC/153).
- Up to 1 kg total of plutonium or highly enriched uranium (by uranium-235 content) or greater amounts of low-enriched, natural, or depleted uranium, as specified by paragraph 37 of INFCIRC/153, if requested by the state to be exempted from safeguards.
- Records of plant operation and inventories more than 5 years old (paragraph 53). The IAEA would therefore normally be prevented from examining or re-checking records of production more than five years into the past (although South Africa voluntarily provided operating records as far back as 15 years in order to help the IAEA verify the accuracy and completion of its initial inventories of nuclear material).
- Detailed knowledge of the capabilities of equipment within material balance areas (such as centrifuge design information) and *access* to such areas (implied by paragraphs 5, 8, and 76c, calling for protection of commercial and industrial secrets, for using only minimum information required for carrying out purposes of safeguards, and for carrying out routine inspections only at predetermined strategic points).

[1]On this issue, INFCIRC/66 is more restrictive than INFCIRC/153, since the former does not allow any military use of nuclear materials,

might be able to do so with less.[56] Indeed, the U.S. Department of Energy has all but confirmed this view, at least in the case of plutonium, in its recent declaration that 4 kilograms of plutonium is sufficient to make a nuclear weapon.[57] Lowering these thresholds would call for increased inspection effort and correspondingly greater inspection resources, and it would make it harder for the IAEA to meet its inspection goals—particularly at bulk-handling facilities. (Large bulk-handling facilities are difficult to safeguard even under the existing definition of the SQ; see discussion below). Lowering the SQ would also require increased inspection frequency at several small facilities in states not yet in possession of 1 SQ under the present definition. If the IAEA could not meet its inspection goals with a lowered SQ, and if it were unable to demonstrate that other safeguards techniques could compensate for that inability, the agency might have to "sound the alarm" more frequently

[56]See, e.g., Fischer, op. cit. footnote 36, p. 39; and Brian G. Chow and Kenneth A. Solomon, *Limiting the Spread of Weapon-Usable Fissile Materials* (Santa Monica, CA: Rand Corp., 1993), p. xiv. Note, however, that the SQ has never been meant to correspond to the minimum amount of fissionable material needed in a weapon, since: 1) it includes provision for estimated material losses during manufacture (even though much of this processing loss can be recovered), and 2) advanced weapon states with considerable experience and sophisticated designs might be expected to get the same results with less material. See Fischer and Szasz, op. cit., footnote 2, p. xix.

[57]U.S. Department of Energy, classification Bulletin WNP-86, February 8, 1994, states that "Hypothetically, a mass of 4 kilograms of Plutonium or uranium-233 is sufficient for one nuclear explosive device." (Although this sentence is unclassified, the full text of the Bulletin is classified.) No such statement has been issued with respect to uranium-235.

that it is unable to assure the nondiversion of an SQ of materials—even if no diversion had actually taken place.

To the extent that the SQ overstates the amount of nuclear material needed for a weapon, the actual diversion of even a fraction of an SQ should warrant a loud alarm-yet the IAEA might not readily notice such a diversion today. (Diversion of less than 1 SQ can still be detected, but with a lower probability than diversion of larger amounts.) The possibility of a state's obtaining 1 SQ or more by diverting lesser quantities from multiple facilities must also be considered, since such a scenario is in general more difficult to safeguard against. Indeed, new statements by the IAEA in 1993 asserted the goal of detecting a cumulative diversion of an SQ or more from all of a state's facilities taken collectively. As a result, the IAEA increased the inspection frequency from once to four times per year for sites containing less than 1 SQ of "direct-use" material (e.g., material containing highly enriched uranium or plutonium) in states where the total amount of material in such facilities exceeds 0.5 SQ. Otherwise, however, the safeguards criteria and approaches used to achieve safeguards goals are still based on individual facilities and thresholds of 1 SQ for each of the material balance areas within them.

Since the IAEA has no direct nuclear weapon expertise, it relies on the nuclear-weapon states for technical advice on matters such as the appropriate definition of an SQ. Existing definitions date back to information provided by the nuclear-weapon states in the mid- 1960s; in the absence of subsequent guidance, the IAEA had no basis to revise them. In recent years, however, the IAEA has become more concerned about this issue. In 1990, Director General Blix asked the nuclear-weapon states to provide updated guidance on whether the definitions should be revised. He received no response.

This question is also being examined to some extent within the 93+2 program. Now that the United States has declassified the fact that 4 kilograms of plutonium could be sufficient for a nuclear weapon, it may be easier for the United States to engage in a discussion with the IAEA on lowering the SQ. However, the United States has been reluctant to contemplate this step in the past, at least in part because doing so would place yet additional demands on a safeguards system that is already squeezed between increased responsibilities and fixed resources. Even if safeguards resources were to be increased, it is not clear that lowering the SQ would be the most effective way to use them.

OPTION: *The United States could encourage and support the IAEA to reexamine timeliness thresholds.*

The IAEA's timeliness criteria are based on estimates of the time it would take a state to convert a given safeguarded material into a finished metal weapon component, once such material were diverted (see table 3-l). These conversion times range from about a week for plutonium, uranium-235, or uranium-233 already in metal form, to months for such material in irradiated fuel, to about a year for thorium or uranium enriched to less than 20 percent.[58] Based on these conversion times, the IAEA has established timeliness goals for the maximum amount of time that may elapse between diversion and its detection.

To detect diversion before the diverted material could be fabricated into a weapon, timeliness goals for various types of nuclear material would have to be less than their corresponding conversion times. However, the only requirement be-

[58] International Atomic Energy Agency, *IAEA Safeguards Glossary,* op cit., footnote 2, paragraph 105, p. 23, and table II, p. 24. Conversion time estimates do not include the time needed to accomplish the diversion or to move the diverted material to the site(s) where it is further processed. The estimates also assume that all facilities needed to produce weapons from the diverted material exist and that all non-nuclear components of such weapons have been made or can be completed in less time than it will take to process the nuclear materials into weapon components.

TABLE 3-1: Estimated Material Conversion Times for Finished Plutonium or Highly Enriched Uranium Metal Components

Conversion time	Beginning material form
Order of days (7-10)	Plutonium (Pu), highly enriched uranium (HEU), or uranium-233 metal
Order of weeks (1-3)[a]	PuO_2, $Pu(NO_3)_4$, or other pure plutonium compounds
	HEU or uranium-233 oxide or other pure uranium compounds
	Mixed-oxide fuel (MOX, consisting of plutonium and uranium oxides) or other unirradiated pure mixtures containing plutonium and uranium (uranium-233 or highly enriched uranium); or
	Pu, HEU, and/or uranium-233 in scrap or other miscellaneous impure compounds
Order of months (1 -3)	Pu, HEU, or uranium-233 in irradiated fuel
Order of one year	Uranium containing <20 percent uranium-235 and uranium-233, or thorium

[a]This range is not determined by any single factor, but the pure plutonium and uranium compounds will tend to be at the lower end of the range and the mixtures and scrap at the higher end.

SOURCE: *IAEA Safeguards Glossary, 1987* Ed., IAEA/SG/INF/1 (Rev. 1) (Vienna, Austria: International Atomic Energy Agency, December 1987), P. 24.

tween the two is that they should correspond "in order of magnitude," meaning they should be within about a factor of 3 of each other.[59] In practice, timeliness goals can exceed conversion times. For example, according to the IAEA, fresh reactor fuel containing plutonium or highly enriched uranium can be converted into weapon components in one to three weeks (for highly enriched uranium [HEU] or plutonium oxides or other chemical compounds) or seven to ten days (for HEU or plutonium metal). However, the timeliness goal for such material is one month. Spent (irradiated) fuel containing plutonium or HEU, which would have to be chemically reprocessed to yield HEU or plutonium, could be converted to weapon components in one to three months, but the timeliness goal for spent fuel is at the upper end of this range, at three months. Therefore, in some cases, the IAEA's timeliness goals for detecting diversion of nuclear material can exceed the amount of time it would take to convert that diverted material into weapon components.

Some argue that it is not even sufficient for the IAEA to be able to announce the diversion (or the inability to certify nondiversion) of nuclear materials before that material could be made into a bomb. Instead, they state that the international community must be warned of a potential diversion *far enough in advance so* that pressure could be applied to prevent the diverting state from making the weapon in the first place.[60] Such a requirement is impossible to achieve in any safeguards regime that permits nations to produce,

[59]Ibid., paragraphs 108 and 109, P. 25, and paragraph 123, p. 29.

[60]This more restrictive definition is the one adopted by the ''timely warning''language in the U.S. Nuclear Non-Proliferation Act (NNPA) of 1978, which governs United States nuclear cooperation with other countries. In particular, the NNPA sets the conditions under which U.S.-supplied nuclear material can be reprocessed. See, e.g., Leonard Weiss, "The Concept of 'Timely Warning' in the Nuclear Nonproliferation Act of 1978," unpublished paper distributed by the Senate Governmental Affairs Committee, Apr. 1, 1985.

stockpile, and use nuclear materials, such as plutonium or HEU, that can be converted into weapon components in less time than almost any conceivable international response could be mounted. Formulating, deliberating, approving, and implementing such a response would almost certainly take weeks to months, if not longer. In such cases, detecting the diversion of nuclear materials the instant it happened would not provide sufficient notice.

To make possible the degree of warning that this definition would require, a much stronger system of international control would be required that prohibited individual nations from producing or stockpiling any nuclear materials that could be converted to weapons on short notice. Such a system would resemble the Acheson-Lilienthal plan more than it would the present system of IAEA safeguards.

It might also be argued that the international community does not possess—or at least would never be willing to use-diplomatic, economic, or military measures strong enough to prevent a state from making a weapon out of diverted nuclear material. If this were indeed the case, no amount of notice would suffice, and the only way to guarantee that proliferation could not occur would be to prevent non-nuclear-weapon states from pursuing certain elements of the nuclear fuel cycle. These activities would have to be either banned completely, reserved for nuclear-weapon states alone, or internationalized. Although some indeed urge the banning of spent fuel reprocessing, enrichment could not be banned without shutting down most civil nuclear power plants. **Reserving enrichment and reprocessing for the nuclear-weapon states would so badly aggravate the existing discriminatory nature of the international nonproliferation regime that this option must be considered politically untenable.** Internationalization is addressed in chapter 4.

Unlike changes in the definition of significant quantities, which generally affect only the *intensio* of each individual inspection (e.g., the number of samples taken or measurements conducted on a certain batch of material stored in many containers), changes in the timeliness criteria require increased inspection *frequency.* Shorter timeliness criteria, therefore, would have a large effect on the safeguards efforts needed to achieve them.[61] **Moreover, achieving the existing timeliness criteria uniformly and comprehensively for all facilities-particularly those containing direct-use materials-is probably much more important than adopting even more stringent criteria as goals.** For example, in 1993, the timeliness goal for direct-use material was fully met at only 63 percent of the facilities containing such material, and either partially met or not met at 37 percent.[62] (See also the discussion of near-real-time accountancy, below).

Safeguards Uncertainties at Nuclear Material Bulk-Handling Facilities

OPTION: *The United States could encourage and support efforts to decrease uncertainty limits at bulk-handling facilities.*

Facilities that process nuclear material in bulk form include those for enrichment, fuel fabrication, and reprocessing. Though each type of facility poses unique challenges for safeguards, enrichment safeguards are probably the most developed and easiest to implement of the three (see box 3-8). One of the most difficult types of facility to safeguard effectively is the spent fuel reprocessing plant, because:

1. the plutonium produced is directly usable in nuclear weapons;
2. plutonium in a reprocessing plant is somewhat more difficult to assay accurately (on a kilo-

[61] Lowering the definition of the significant quantity (SQ) will increase the inspection frequency for facilities that have less than 1 SQ under the old definition but more than one under the new one.

[62] Letter of Jan. 17, 1995 from Jan West, IAEA, in response to Office of Technology Assessment questions, op. cit., footnote 34, p. 2.

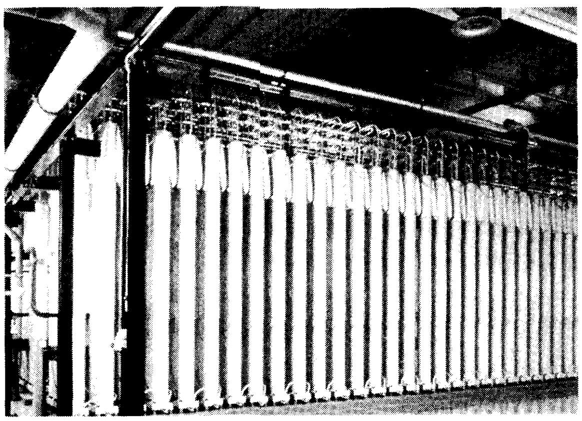
BOX 3-8: Enrichment Plant Safeguards

Enrichment plants, like reprocessing facilities, are bulk-handling facilities that can potentially produce material directly usable in weapons: in this case, highly enriched uranium.[1] Currently, the IAEA applies safeguards only to the following 7 enrichment facilities: Brazil (Resende)[2]; Germany (URENCO, Gronau); Japan (Ningyo, and Rokkasho-mura enrichment plants); Netherlands (URENCO, Almelo); South Africa (Pelindaba); and the United Kingdom (BNFL centrifuge plant at Capenhurst).[3] Of these, the Resende enrichment facility (using Becker nozzle technology) is unlikely to operate in the future. However, Brazil's Ipero gas centrifuge plant will be coming under safeguards now that Brazil has agreed to apply safeguards to all its nuclear fuel cycle facilities. Since the United Kingdom is a weapon state, its facilities are safeguarded under voluntary agreements. Of the remaining facilities, Germany, the Netherlands, and Japan operate centrifuge plants and South Africa operates an aerodynamic separation process called Helikon. The latter technology had never been safeguarded by the IAEA prior to South Africa's accession to the NPT, but it shares some characteristics with gas centrifuge and some with gaseous diffusion technology.

Gas Centrifuge Enrichment Plant Safeguards

If covert reconfiguration of gas centrifuge plants can be detected, such plants can be safeguarded with high confidence. Using well-established measurement techniques, input and output quantities of uranium hexafluoride can be assayed very accurately, both for amount and for isotopic content.[4] It is harder to measure the amount of uranium hexafluoride contained in gas form within the centrifuge cascade than it is to determine inputs and outputs, but this "gas phase inventory" is relatively small, Given present measurement uncertainties, plants with up to *2,000,000* separative work units per year enrichment capacity (which contain roughly 75 kilograms of uranium-235 in the process stream at any given moment) appear safeguardable using current practices. A plant this size can produce enough low-enriched uranium to fuel some 20 large commercial power reactors. Urenco plants are half this size, although Russian centrifuge plants are of this scale or slightly larger.

URENCO



Gas centrifuge cascade at a URENCO uranium enrichment plant. URENCO operates enrichment facilities in Almelo in the Netherlands, Capenhurst in the United Kingdom, and Gronau in Germany.

(continued)

1 For discussion of different types of enrichment technologies, see US. Congress, Office of Technology Assessment, *Technologies Underlying Weapons of Mass Destruction,* OTA-BP-ISC-115 (Washington, DC: Government Printing Office, December 1993), appendix 4-B.

2 This facility had been covered by an INFCIRC/66 safeguards agreement prior to implementation of full-scope safeguards under the ABACC agreement and the Treaty of Tlatelolco.

3 *IAEA Annual Report for* 1992, op. cit., p. 161.

4 2.5 ton (t) cylinders of UF_6 gas are routinely measured to within +/-0,5 kilogram (kg), and 14 t cylinders to within +/- 1 kg. Uranium purity (grams uranium per grams material) has a 1-σ uncertainty of only 0.05 percent, and isotopic assay for low-enriched uranium at IAEA's Seibersdorf Analytical Laboratory (based on the characteristic 186-keV gamma emission) has an uncertainty of 0.2 to 0.3 percent. David Gordon, group leader, Arms Control and Nonproliferation division, Brookhaven National Laboratory, private communication, 1993.

BOX 3-8 (Cont'd.): Enrichment Plant Safeguards

The principal safeguards concerns associated with centrifuge plants involve the possibility of reconfiguring the cascade to produce higher enrichments, which is a particular concern because of the speed at which such plants would start producing the higher enrichments after such a conversion. Covert production of highly enriched uranium would require the use of unsafeguarded feedstock in addition to reconfiguration of the cascade. Material imbalances would result if safeguarded feedstock did not show up again as safeguarded, low-enriched output. To protect against either reconfiguration or operation of the plant with undeclared material or in an undeclared manner, a consortium of centrifuge technology holders in 1981 agreed with the IAEA and Euratom to implement a set of procedures for safeguards, known as the Hexapartite agreement. This agreement represented a compromise between protecting proprietary information relating to the technology and configuration of the cascade itself, and restricting the opportunities for altering plant operation between inspections. Its principal strength is its providing for short notice inspections *within* the cascade area of the plant, under guidelines called "limited frequency unannounced access" (LFUA),[5] and for portable assay equipment to be taken into the cascade area for determining whether the plant is producing HEU.[6] In addition, uranium flows in and out of the plant are monitored and controlled, with samples of the output measured for enrichment.

LFUA inspections inside the cascade area are allowed from 4 to 12 times per year, depending on the size of the facility, Their degree of surprise can range from a totally unannounced arrival of inspectors at the plant (at which point operators would be allowed no more than 2 hours to hide from view any proprietary equipment that might be exposed within the cascade) to unexpectedly calling for an inspection inside the cascade area during one of the routine monthly inspections at the plant. Although there is no explicit routine verification measurement that can guarantee detection of undeclared feed being introduced into the cascade, LFUA inspections area deterrent against such scenarios since they add a probabilistic chance of spotting such material.[7]

Gaseous Diffusion Enrichment Plant Safeguards

The principal difficulties of safeguarding gaseous diffusion enrichment plants involve the large amount of material normally present *within* the cascade (as much as 4 tonnes of uranium-235 in a large plant), and the occurrence of some of that material "plating out" on the inside surfaces of pipes due to small leaks.[8] Both factors involve holdup material and thus lead to measurement inaccuracies and uncertainties in MUF. Argentina has the only gaseous diffusion facility under safeguards outside the nuclear weapon states, and its small size should make it relatively easy to safeguard effectively.

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[5] Part of the agreed procedures involves safekeeping at the plant of original photographs Of the interior cascade area so that inspectors can compare them with the current layout. With the myriad of pipes, valves, and connections inside a cascade, however, the visual acuity of the inspector can limit the utility of such comparisons.

[6] This equipment involves gamma analysis and x-ray fluorescence equipment using a portable cobalt-57 source. The software for this instrument has been "blinded" so that it indicates only whether enrichment levels are greater than or less than 20 percent and does not reveal the actual enrichment As with the LFUA compromise, the decision to limit the measurement equipment to this simple HEU/LEU reading was made to protect sensitive plant information, such as the separative capacity of individual centrifuges or specific portions of the cascade.

[7] The IAEA also has the option during routine inspections to require that every feed, product, and tail cylinder be verified before it is fed into or shipped from the plant. A more reasonable plan would be a sampling program that would have a high probability of detecting a significant diversion.

[8] Unlike centrifuge plants, which run at low pressures and whose fast-spinning vacuum-encased rotors can easily crash if there are leaks, diffusion plants can tolerate small leaks without major damage. (Sampling, which can introduce leaks, is thus done at many places, whereas there are no inter-cascade sampling points in centrifuge plants.) Plating out is the result of water vapor reacting with the fluorine in UF_6 gas.

nium, yet is significant in quantities less than one-third that of HEU;
3. the material is in "bulk" form (e.g., in solution or in the form of powder) throughout plant operations; and
4. extremely large quantities of plutonium (up to 8 tonnes per year, or 1,000 significant quantities) can routinely be separated in large commercial plants.

Mixed-oxide fuel fabrication plants share many of the safeguards difficulties of plutonium reprocessing plants. However, MOX plants that are now under safeguards have considerably smaller plutonium inventories and throughputs than the large commercial reprocessing facilities built or under construction in England, France, and Japan. Moreover, the IAEA has amassed considerably more experience to date with MOX facilities than with reprocessing plants.

Up until about 1990, IAEA criteria for safeguarding reprocessing plants had used as their standard not the "significant quantity" but a quantity called the "accountancy verification goal" (AVG). The AVG, which might be several times larger than an SQ, was based on a realistic assessment of what then-current measurement techniques applied to a given facility could actually detect. As analytic techniques and safeguards practices have improved, however, the IAEA has phased out use of the AVG, and the revised Safeguards Criteria introduced in 1991 make no reference to the concept.

Even though the AVG is no longer in use, conventional material accountancy methods alone appear unable to verify the absence of diversion or loss of material from large reprocessing plants to within annual uncertainty levels of 1 significant quantity of plutonium. At present, this conclusion is moot, since the reprocessing plants that have come under full-time IAEA safeguards to date are relatively small. However, Japan is building a large reprocessing plant at Rokkasho-mura that, when completed, cannot be safeguarded with a simple extrapolation of techniques in use at smaller facilities. While several new methods being studied appear to hold promise and are likely to improve detection sensitivity by a significant amount, the IAEA has not been able to demonstrate that material accountancy methods at large reprocessing plants will be able to assure, say, a 90 percent probability of detecting the diversion of as little as one weapon's worth of plutonium per year.

Reprocessing plants of this scale, therefore, pose difficulties for the IAEA. Either the agency will need to demonstrate that safeguards methods *other than* the inventory measurements that form the core of its existing safeguards approach can be relied on to detect diversion with a high degree of confidence, or it will have to conclude that it cannot safeguard such a plant to the same standards it applies at smaller facilities. **To date, the IAEA has not considered the possibility that it cannot safeguard large facilities such as the Rokkasho-mura reprocessing plant, but neither has it been able to demonstrate that it can.[63]**

Various techniques to improve the capability of conventional material accountancy methods at large-scale reprocessing plants have been proposed and tested over the last 10 to 15 years. Many of these new techniques involve a concept known as "near-real-time" accountancy (NRTA—see next section), or the use of ongoing, continuous measurements to keep track of nuclear materials as opposed to the periodic taking of discrete inventories. Improved safeguards methods also apply various statistical models to the large amount of process data (e.g., flows and concentrations of nuclear materials and volumes of solutions in

[63]Rokkasho is the only reprocessing plant now envisioned to come under full-time IAEA safeguards with an annual plutonium production rate as large as a few tonnes per year. The only other civil reprocessing plants of this size now operating are in nuclear weapon states: the United Kingdom, France, and Russia.

tanks) available from such plants.[64] Other improvements to supplement material accountancy involve verification of design information and increased use of containment and surveillance (C/S) measures.[65] Application of these methods to safeguarding reprocessing plants is discussed in more detail in appendix A.

Part of the difficulty in safeguarding large reprocessing plants is that the IAEA has no real experience doing so (though it has safeguarded several smaller ones in the past, such as Tokai in Japan). Many of the measurement studies must therefore rely, at least in part, on assumptions about the actual plant operation and the obtainable measurement uncertainties. Another problem is that although the effectiveness of various safeguards techniques as applied to generic facilities is discussed in the open research literature, the effectiveness of the specific statistical tests the IAEA plans to use in a given case is facility-dependent. IAEA confidentiality would, therefore, prevent it from being shared even with member governments or the Board of Governors, let alone with the public. **Without knowing the specific characteristics of the data set on which statistical models are to be applied, however, the effectiveness of those models cannot be assessed by outside observers**.

Since the Office of Technology Assessment (OTA) last examined this issue in 1977, substantial improvements have been made in IAEA safeguards practices, including those at reprocessing facilities.[66] Moreover, the level of concern that should be attached to the material-accountancy limits at large bulk-handling plants depends on subjective judgments of what constitutes adequate deterrence against diversion. Many argue that the primary value of safeguards at a large reprocessing plant in a country such as Japan is to detect whether such a facility is being used to fuel a large nuclear weapon program with many weapons' worth of plutonium per year. No matter how effective they may or may not be at the margins, safeguards are well capable of detecting diversion of plutonium on that scale. It could be argued that the diversion of only a small amount of low-quality plutonium is very unlikely, given both the risks of detection with even an imperfect safeguards system and the political consequences for Japan of being caught developing nuclear weapons.

Those holding this view speculate that if Japan ever felt the need to develop a nuclear weapon option, it would be much more likely to: 1) build a small clandestine nuclear infrastructure outside of safeguards, 2) buy or steal the nuclear material, now that there may well be an active market in it,[67] or 3) simply withdraw from the NPT after announcing that the Treaty no longer served Japan's vital interests. Given the tremendous value that safeguards have in helping deny states a quick and direct way to produce large amounts of weapon-usable material during civil power program, the added value of tightening the threshold at which small diversions from a reprocessing plant would be detected with high confidence might be considered significantly less important. In other words,

[64]Near-real-time accountancy techniques are used at THORP in the United Kingdom and UP-3 in France.

[65]Containment and surveillance measures include items such as use of cameras and seals to ensure that a given storage location or piece of equipment has not been disturbed. For reprocessing plants, C/S measures are quite useful and can be used to block many diversion paths—perhaps all of them if the plant's flows are completely and correctly known by the inspectors. The IAEA has always considered, however, that C/S measures supplement—but do not replace—material control and accountancy, and that absence of diversion can only be positively demonstrated by the latter.

[66]See U.S. Congress, Office of Technology Assessment, *Nuclear Proliferation and Safeguards*, OTA-E-48 (Washington, DC: Office of Technology Assessment, July 1977); and B. Judson, "Needs and Obstacles in the International Safeguards of Large Reprocessing Plants," NTIS No. PB95-199170, OTA contractor report, December 1993.

[67]The German interception of 350 grams of apparently Russian-origin plutonium oxide in August 1994 and the Czech seizure of 3 kilograms of highly enriched uranium in December 1994 indicate that black market purchase of nuclear weapon material may be more realistic than previously thought.

safeguards might not eliminate the risk of diversion (see appendix A), **but those risks are nevertheless greatly reduced in both the probability of diversion of any kind and in the amount of material subject to diversion.**

Others, however, object to the above reasoning. First, even a very small nuclear arsenal can have a very large political and military effect. Second, even if Japan is judged very unlikely to skim a small amount of plutonium from a large reprocessing plant, the United States and other countries would probably be much less sanguine if a developing country in a politically unstable region of the world were to build a plant even a fraction the size of Rokkasho. Since the IAEA is required not to discriminate among its member states, it would have great difficulty in justifying more stringent safeguards in some places than in others.[68] Therefore, the existence of safeguarded reprocessing plants—even in countries not thought to pose proliferation risks—leaves the IAEA with few grounds on which to discourage the development of reprocessing plants in more questionable locations, or to require any additional safeguards measures to be applied there.

OPTION: *The United States could encourage and support the implementation of automated near-real-time accountancy and alarm capability by the IAEA at more facilities.*

The concept of near-real-time accountancy has traditionally been focused on reprocessing and fuel-fabrication facilities in which the amount of in-process inventory is large enough that timeliness goals are difficult to meet by conventional material control and accountancy (MC&A) methods. MC&A practice at reprocessing plants traditionally has required physical inventories to be taken and verified only once a year during a complete plant shutdown and cleanout. Monthly "interim inventories," which do not require plant shutdown, are less precise because of the difficulty in estimating in-process inventories. **In any case, interim inventories do not always meet the one-month timeliness goal for detecting diversion of material, including the investigation and resolution of anomalies.**

One facility already incorporating the NRTA approach is Japan's Tokai Plutonium Fuel Production Facility (PFPF), where MOX fuel has been fabricated for Japan's Joyo and Monju fast-breeder reactors at a rate of 5 tonnes per year since 1988.[69] Unattended, tamper-proof instruments, such as neutron coincidence counters in glove boxes, measure plutonium levels at various locations, even in the absence of human inspectors. Unmanned instrumentation allows safeguards measurements in areas where worker-safety regulations restrict manned inspections, such as between plutonium-storage and fuel-assembly areas in MOX plants. It is also intended to reduce manpower costs, although whether it will or not will depend on factors such as the details of the installation, its monitoring objectives, and so on.

Despite its use of NRTA, allegations questioning the adequacy of safeguards at the PFPF have been publicized, particularly concerning the

[68] Even though the IAEA cannot apply different safeguards standards to different nations, the rationale for pursuing reprocessing and the risk of plutonium diversion is not uniform around the world. Energy-poor Japan—a nation that traditionally has taken a very long-term view—argues that the plutonium fuel cycle is essential to achieving some measure of security for its energy supplies in the future, and that it is worth utilizing even if it generates electricity that is significantly more expensive than electricity from other sources. Further, having a domestic plutonium supply would eliminate the need to reprocess plutonium overseas and then return it to Japan via highly visible and politically contentious shipments. To ease concerns elsewhere, Japan has cooperated extensively with the IAEA in finding ways to make plants such as Rokkasho as safeguardable as possible. As noted earlier in the text, LASCAR was a Japanese initiative, financed by Japan. In less cooperative states, the IAEA's job could be made much more difficult.

[69] Power Reactor and Nuclear Fuel Development Corp. promotional brochure, Tokyo, Japan, August 1992, p. 7.

amount of plutonium—claimed to be 70 kilograms, or roughly 9 significant quantities-presumed to be held up in plant equipment.[70] One critic has concluded from this episode that this plant cannot be safeguarded effectively.[71] The IAEA responded that the plutonium in question has been measured in situ on a monthly basis, and that to improve the quality of these measurements the IAEA is discussing a schedule with Japanese authorities for the recovery of this material from this plant equipment where it is trapped.[72] The case does illustrate, however, the diffilculties of performing in-process measurements in bulk-handling facilities.

OPTION: *The United States could encourage and support the increased use of containment and surveillance techniques by the IAEA.*

Containment and surveillance techniques are used to supplement, rather than substitute for, the primary safeguards approach of material accountancy. Once the quantity of nuclear material stored in a particular location has been measured, for example, C/S measures such as cameras, motion detectors, or tamper-proof seals can be used to ensure that no material is added or removed, drastically reducing the need to repeat the measurements at a later date.

C/S techniques as applied in safeguards, however, should not be confused with similarly named methods to physically prevent material from being diverted by unauthorized intruders or seized, either at facilities or during transport between facilities (although such events would very likely be detected by C/S methods or by subsequent IAEA inspections). ***Prevention* of these activities falls within the domain of "physical protection," which is the responsibility of the state, not the IAEA.**[73] **C/S** techniques used by the IAEA are employed mainly to reduce the need for inspectors tore-assay material in storage or re-certify the integrity of previously inspected items—to maintain "continuity of knowledge."

C/S techniques are being improved. For example, videotape-based Modular Integrated Video Systems (MIVS) have already been installed to replace many of the older Minolta 8-mm cameras, which are movie cameras modified to take one frame every 10 to 20 minutes.[74] In addition, an improved, digital-based surveillance system called GEMINI is also being developed. New seals have already been developed that can be read

IAEA

Verification of seals using laser disk recording. With this equipment, IAEA inspectors can determine whether seals placed at safeguarded facilities have been tampered with.

70 Ppaul L. Leventhal, "The New Nuclear Threat," *The Wall Street Journal,* June 8, 1994, op-ed page, and Nuclear Control Institute, " 'Astounding' Discrepancy of 70 Kilograms of Plutonium Warrants Shutdown of Troubled Nuclear Fuel Plant in Japan, ''press release, May 9, 1994.

71 Ibid.

72 Intemational Atomic Energy Agency, "Japanese Material Under Full Safeguards," press release, PR 94/23, May 25, 1993. Specific safeguards-related data concerning PFPF-and all other safeguarded facilities—are considered "safeguards-confidential" by the IAEA and are not made public (see section on "Increase transparency within the IAEA itself," below).

73 General guidelines for such measures are published by the IAEA as INFCIRC/225/Rev.3, "The Physical Protection of Nuclear Material." These guidelines form the basis of the Convention on the Physical Protection of Nuclear Materials, which came into force on February 8,1987 and has a membership similar to that of the Nuclear Suppliers Group.

74 In 1990, for instance, 43 Modular Integrated Video system closed-circuit TV systems were being installed at 19 facilities.

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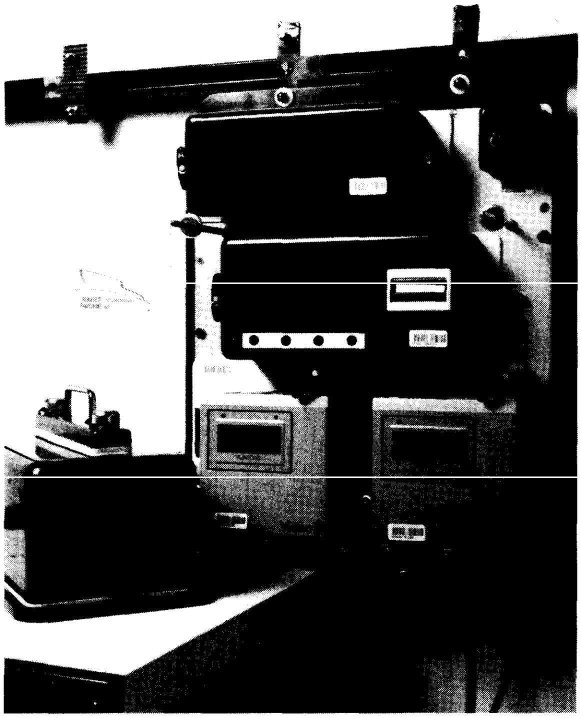
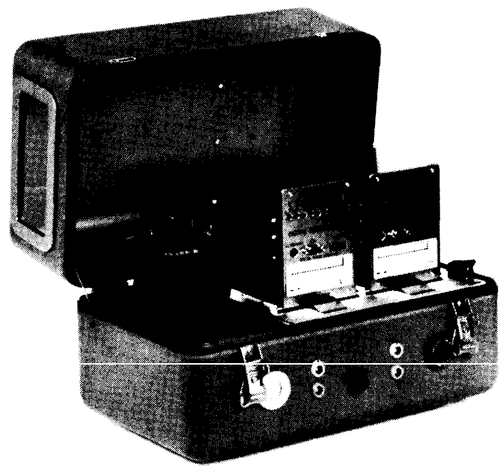


The Modular Integrated Video System (MIVS) surveillance unit now jn use by the IAEA.

AQUILA TECHNOLOGIES GROUP



The digital-based Gemini surveillance system, an improvement over the MIVS system.

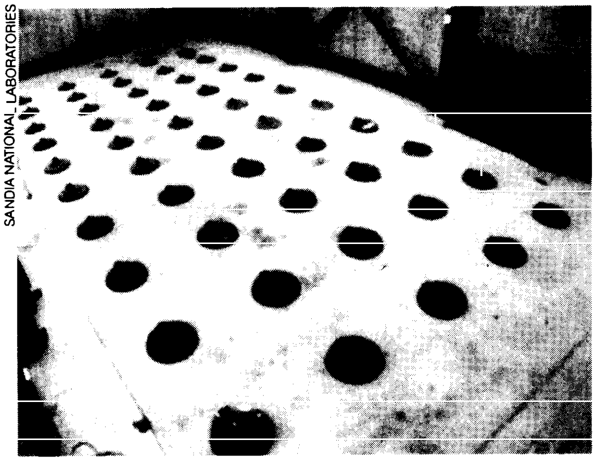
in the field for signs of tampering, rather than needing to be sent back to IAEA headquarters in Vienna.

Furthermore, there are several proposals for increasing the use of IAEA C/S techniques for nuclear facilities.[75] In the early 1980s, the RECOVER program tested the concept of transmitting information on the status of C/S equipment directly to Vienna by telephone lines, but the concept never gained IAEA acceptance.[76] More recently, the IAEA has conducted and is evaluating test operations in Sweden, Finland, and Hungary, in which state operators have been allowed to change videotape or film and send it to the IAEA, with special techniques used to prevent tampering or substitution. This procedure saves inspector effort in the collection of such tapes. A remote-monitoring project being developed at the U.S. Department of Energy's Sandia National Laboratories-originally designed to demonstrate remote monitoring of a deactivated chemical facility—is examining the use of cameras and satellite links for real-time C/S. A system has already been installed in Australia, and other sites are being examined. Private companies such as a Hughes-Canberra consortium and Unisys have also begun to examine concepts for remote-monitoring techniques using satellite links that could be used both for implementing better containment and surveillance and for enhancing near-real-time accountancy methods.

To improve the instrumentation available for remote monitoring of nuclear materials, Japan and the United States have been developing and testing the Containment and Surveillance Data Authenticated Communication System at Sandia Na-

[75] For a survey of ideas being discussed in the context of the European fuel cycle, see M. Cuypers and R. Haas, *"Can Containment and Surveillance Play a More Important Role in Safeguards?"* in *Proceedings of the Third International Conference on Facility Operations-Safeguards Interface,* San Diego, CA, Nov. 24-Dee. 4, 1987 (La Grange Park, IL: American Nuclear Society, 1988), pp. 341-348.

[76] The RECOVER system was not found to be cost-effective, among other reasons because it transmitted only status information about safeguards instrumentation, rather than the actual data from those instruments.



SANDIA NATIONAL LABORATORIES

Dry spent-fuel storage facilitu in Australia, monitored from Sandia National Laboratories, Albuquerque, New Mexico. Part of the International Remote Monitoring Project, this demonstration is a collaborative effort between the U.S. Department of Energy Sandia National Laboratories, and the Australian Safeguards Office.

tional Laboratories in New Mexico since mid-1992. The system uses advanced sensors to monitor flows of nuclear materials at various locations and then transmits this data by satellite to a control center in Japan. If such a system were used in a safeguarded facility, anomalous situations could immediately trigger alarms in a local control center, or back at IAEA headquarters. These alarms, in turn, could initiate a rapid response.

Such proposals face significant obstacles, not the least of which is a state's willingness to be subjected to measures going beyond the traditional requirements of safeguards, especially when data from one of their facilities is to be transmitted outside the country without the government right to vet the data first. Some of the techniques could even lead to an increase in safeguards effort, rather than a savings, through the need for site visits to resolve ambiguous indicators, such as unexpected motion, or to repair failed equipment.[77] On the other hand, to the extent that remote surveillance does eliminate the need for site visits, it will also lessen the opportunity to gain the "on-the-ground" presence that human inspectors provide. Many argue that this presence cannot be overestimated.

Containment and surveillance techniques also suffer from the fact that their usefulness is difficult to quantify. Unambiguous evidence of nondiversion can only be obtained for the material or area within a given camera's or motion detector's line of sight, and then only in the case of uninterrupted coverage. Nevertheless, initial reports **overall** have been promising. Further analysis of specific applications of enhanced C/S is, therefore, needed to determine whether it could result in cost-effective improvements in safeguards.

■ Improving the Ability To Detect Undeclared Facilities

OPTION: *The United States could encourage states to share intelligence information on potential safeguards violations with the IAEA.*

The IAEA has repeatedly stated that its activities will be significantly enhanced by increased access to information—both open source and national intelligence information. Before the Gulf War, member states neither pressed the IAEA to be aggressive in ferreting out clandestine facilities nor supplied the IAEA with information that would assist in such efforts. Nevertheless, successful precedents in providing such information have now been set with respect to Iraq, North Korea, South Africa, and other countries. The IAEA has also shown in South Africa that it has been

[77] The anomaly and false alarm rates with C/S measures are usually significantly higher than with material accountancy, but these anomalies would almost never be expected to give evidence of an actual diversion. Normally these false alarms can be appropriately resolved through further investigation, which in the extreme case can involve taking a special physical inventory. When that occurs, the C/S measures would in effect have contributed only to timely detection of the need for taking another material balance. J.E. Lovett, "Nuclear Materials Safeguards for Reprocessing," International Atomic Energy Agency Report STR-151/152 (December 1987), pp. 218-219.

able to independently verify the "completeness" of a state's declared inventory *without* being tied to conclusions reached by national sources.[78]

While it is generally agreed that sharing intelligence with the IAEA is a good idea, member states considering such sharing need to explore several overlapping issues:

- the form in which the information should be shared (e.g., photographs, written communications, informal briefings, or isolated tips),
- the means by which it can be assured that sensitive information is protected,
- the confidence that the IAEA can have in information that is provided to it, especially if the sources and methods by which it was derived are not shared with the agency,
- the mechanism for defending against planted disinformation directed against a particular state, and
- the use that the IAEA makes of the information once obtained.

Unlike national governments, which may agree to participate in reciprocal exchanges of information, the IAEA is required to maintain strict confidentiality and cannot offer any return flow of information. **As the recipient of information, the IAEA must develop policies for evaluating it as well as for shielding itself against charges of being manipulated for political purposes by being given information only selectively.** It must also be able to keep sensitive information about a state out of the hands of nationals or sympathizers of that state.

The fact that the IAEA is now receiving and using information supplied by member states, including the United States, represents a sea change in behavior that is absolutely necessary if the IAEA is to make a serious attempt to ensure that states have not built and are not using clandestine, undeclared nuclear facilities. The IAEA's best defense against charges of "selective provision" of intelligence is to accept information from any party, to balance these charges against the quality and implications of the information it is being provided, and to use its own judgment in coming to any conclusions before acting on them. **This will require the agency to develop some expertise in judging or in performing some analysis of the information presented to it.**

OPTION: *Increase the mandate and frequency of special inspections, to include "anytime, anywhere" inspections.*

In contrast to safeguards transparency measures, which would be completely voluntary, the IAEA also has some authority to demand "special inspections." Although no special inspections at undeclared facilities had ever been requested or carried out before the IAEA's investigations in North Korea, INFCIRC/153 provides for them if needed in order for the IAEA to obtain further information or to carry out its safeguards responsibilities.[79] The efficacy of this provision is limited by several factors, however. One is that special inspections must be carried out "in consultation" with the state, which as currently interpreted effectively precludes short-notice inspections such as those provided for in the Chemical Weapons Convention.[80] Without such consultation, many countries would consider that such inspections by the IAEA would violate their sovereignty. How-

[78] IAEA Officials have said that the agency's extensive verification activities have led to a high level of confidence that South Africa's declared HEU inventory is essentially correct and complete. This contrasts to the situation in North Korea, where lack of cooperation has increased the IAEA's need for national intelligence information to reconstruct that country's nuclear history.

[79] Note that the term *special inspection* as used in INFCIRC/ 153 can refer to inspections requested either by the IAEA (e.g., to reconcile differences or ambiguities it discovers during the course of routine inspections), or by the state. This discussion refers to the former.

[80] Short-notice inspections might be useful to preclude the inspected state from quickly hiding evidence of violation of its safeguards agreements or international commitments. An analogy is the attempt of Iraq to hide its "calutron" uranium enrichment equipment from the UNSCOM/IAEA inspection team by driving them out the back of a facility when the team was at the gate. If the team had not arrived on short notice, the removed calutrons might never have been found.

ever, states could agree to reinterpret or waive their rights of consultation under this article to give the IAEA more timely access.

Another limitation is that requests for special inspections are taken very seriously, require weighty political consideration, and, depending on their outcome, have considerable implications for IAEA credibility. Since they have to be justified to the country and possibly also to the Board of Governors, coming up empty-handed too many times could erode confidence in the IAEA's ability to identify suspect activities. False alarms might also call into question the reliability or appropriateness of national sources of information, if such had been used, and could preclude the IAEA from calling for and conducting further special inspections. As such, special inspections within the current IAEA framework are no panacea and cannot be expected to become significantly more frequent (see box 3-9). Most likely they will con-

BOX 3-9: Different Types of Inspections

Within the context of strengthening IAEA safeguards, several different types of inspection have been discussed. They differ according to several factors: who can request them; how much notification time (if any) is afforded the inspected site; the legal authority (i.e., whether the state can refuse them); and which facilities are covered. The following represent four principal types of inspection (summarized in the accompanying table):

- **Technical visits.** Totally voluntary inspections on the part of the state to demonstrate openness or allow the IAEA to observe activities at sites that mayor may not be related to safeguarded facilities.
- **Regular safeguards inspections.** Can be carried out by the IAEA in either routine or ad hoc modes under safeguards agreements negotiated between the IAEA and the state.
  - *Routine* inspections are limited to material in declared facilities (under INFCIRC/153, for NPT states), to declared facilities irrespective of their material content (under INFCIRC/66, for safeguarded facilities in non-NPT states), and to key "strategic" measurement points for specified material-balance areas. Once a safeguards agreement has been implemented, the state has only very limited rights to refuse any given inspection, but may freely reject individual inspectors when first selected by the IAEA.
  - *Ad hoc* inspections verify initial declarations, establish baselines for the routine inspections that follow, and verify design Information. They must be agreed to in advance by the state, but they can be carried out as soon as a safeguards agreement is in force, even if negotiations to produce the specific legal documents authorizing inspections (the Subsidiary Arrangements and Facility Attachments) have not yet been completed. To a certain extent and with reasonable justification, they can encompass undeclared facilities.
- **Special inspections.** AuthorizedbyINFCIRC/153 paragraphs 73 and 77 (for NPT non-nuclear weapon states) for the purpose of allowing the IAEA to verify or gather additional information needed to fulfill its safeguards responsibilities.[1] Special inspections can be requested by the Director General or by the Board of Governors, and can be aimed at declared or, with reasonable justification, undeclared facilities, but must be individually notified and, in practice, agreed to by the state before being carried out. If the state refuses, and the Board decides that the inspection is urgent to verify that no diversion is occurring, the dispute can ultimately be taken to the Security Council for resolution. The IAEA's first request for a special inspection at a nondeclared facility was presented to North Korea in early 1993 and was denied,

(continued)

[1]The United States, although not a non-nuclear-weapon state, has voluntarily offered to accept IAEA safeguards on a large number of selected civil nuclear facilities, and its safeguards agreement with the IAEA also contains language authorizing the IAEA to conduct special inspections. However, the United States is under no obligation to declare military nuclear facilities or permit inspections of them. Therefore, special inspections of the United States would be limited to resolving questions concerning only the nuclear material that was voluntarily put under safeguards, and they could not be used to investigate allegations of undeclared nuclear sites.

BOX 3-9 (Cont'd.): Different Types of Inspections

- **Challenge inspections.** The state would be notified, but would not be allowed to refuse. The IAEA has no right to conduct challenge inspections, They have been included in the Chemical Weapons Convention, however, which provides member states the opportunity to request challenge inspections at any locations or facilities in the territory of another member state. Requests for challenge inspections under the CWC maybe rejected by the Executive Council established by that treaty (somewhat analogous to the IAEA's Board of Governors) if it determines the request to be frivolous, abusive, or clearly beyond the scope of the Convention, However, once a challenge inspection has been approved by the Executive Council, the challenged state has no authority to refuse or delay it,

  CWC challenge inspections are based on the principle of "managed access, " in which the inspected state is required to provide some access to the inspected site but enters into negotiations—and ultimately has the last word—concerning the level of that access. However, the inspected state is obligated to demonstrate that those locations to which full access was not granted are not being used for prohibited activities. For more information on CWC challenge inspections, see box 3-5.

- **Surprise inspections.** Short-notice or unannounced inspections that would not recognize a state's right of refusal—so-called "anytime/anywhere" inspections, The first such inspections pertaining to weapons of mass destruction were directed at Iraq through U.N. Security Council Resolution 687 in February 1991, as part of the terms of the ceasefire ending the Persian Gulf War, These go well beyond the authority given by INFCIRC/153. In practice, they have proven difficult to carry out thereon a number of occasions, due to substantial Iraqi interference, but in other cases they were very successful in ferreting out equipment that Iraq was attempting to hide,

Characteristics of Different Types of Inspections

Inspection type	Characteristics	Model
Technical visit	▪ Volunteered by inspected state ▪ No formal safeguards role	No standard model
Regular inspection	▪ Routine or ad-hoc Routine inspections are agreed-to well in advance (with limited exceptions such as very short-notice inspections of aspects of centrifuge enrichment plants) ▪ Routine inspections look at declared facilities only ▪ Limited rights of refusal (e.g., can refuse individual inspectors)	INFCIRC/153
Special inspection	▪ Requested by IAEA Director General or Board of Governors ▪ Includes undeclared facilities (when justifiable) ▪ Consultation with state required ▪ Unresolved issues can be taken to U.N. Security Council	INFCIRC/153 paras, 73,77
Challenge inspection	▪ State is notified, but cannot refuse or delay ▪ Can be requested by any member state ▪ Includes undeclared facilities	CWC "managed access"
Surprise inspection	▪ Short-notice or unannounced ▪ No right of refusal • "Anytime/anywhere"	U.N. Security Council Resolution 687 (Iraq)

tinue to be invoked only in egregious circumstances, such as in North Korea.

Nevertheless, the authority to carry out special inspections, together with access to intelligence information, can constitute a powerful tool to detect clandestine activities. Given what has been discovered in Iraq and North Korea, it can be expected that special inspections, or even simply "technical visits," when combined with increased use of intelligence supplied by member states, may play a much greater role than they have in the past. Some precedent has also been set within the Chemical Weapons Convention regarding challenge inspections, using "managed access" to set the terms of those inspections (see box 3-5).[81] Once that Convention comes into force and some experience has been gained with its challenge inspections, the IAEA could seek to apply any lessons learned to its own inspection activities.

Though Iraq is indeed a special case, the success in implementing U.N. Security Council Resolution 687 depended on three factors, which are applicable to special inspections more generally:

- access to relevant information on suspect locations,
- the right to timely and unrestricted access to identified sites, and
- the assurance of predictable Security Council backing when support for implementation was necessary.

Although much of the information upon which special inspections or technical visits might be based will inevitably have to come from national intelligence sources, some could come from environmental sampling programs carried out by the IAEA itself. To persuade certain countries to allow or undertake environmental sampling programs on their territory, it might help if neighboring countries could be convinced to volunteer first. For instance, the United States might urge South Korea to allow for such sampling in an effort to persuade the North to follow suit. Of course, there is no guarantee that this would work, but such a tactic would further call into question the motives of the North if it refused to follow a South Korean lead.

In addition, special inspections will require advanced or new kinds of portable instruments for field inspectors (e.g., compact multichannel analyzers or environmental sampling kits) and additional training for inspectors to learn what they are looking for and how to react to unexpected information they might discover. Increased member state support along these lines in the form of voluntary contributions, equipment, and training would be beneficial.

Initiating Safeguards for States with Nuclear Infrastructures

When a state first comes under safeguards, for example upon acceding to the Non-Proliferation Treaty, it must declare to the IAEA all of its nuclear materials and the facilities where these materials are processed or stored. The IAEA has a responsibility to verify the completeness of this initial declaration. That is, it must ensure that the state is not hiding nuclear materials, particularly those capable of being used in weapons. This task is a challenging one whenever the state has a substantial nuclear infrastructure. According to IAEA Director General Hans Blix:

> There is an inherent difficulty in verifying the completeness of an original inventory in a country in which a substantial nuclear programme has been going on for a long time. It requires much effort both by the inspectorate and much openness and co-operation by the inspected party—extending beyond declared facilities and current records.[82]

Kazakhstan and Ukraine are in this category. Both states had nuclear facilities and nuclear materials while part of the Soviet Union, a nuclear-

[81] See U.S. Congress, Office of Technology Assessment, *The Chemical Weapons Convention: Effects on the U.S. Chemical Industry*, OTA-BP-ISC-106 (Washington, DC: U.S. Government Printing Office, August 1993).

[82] Hans Blix, Statement to the 36th Session of the General Conference of the IAEA, Sept. 21, 1992.

weapon state that was not required to put its facilities under safeguards. Now that these states are independent countries and parties to the NPT, all their nuclear materials and facilities must be safeguarded, and the IAEA must make sure that the initial declaration these states make is complete.

This task is particularly important if the state entering safeguards is suspected or known to have mounted a nuclear weapon program. Indeed, several such states have either come under or are about to come under full-scope IAEA safeguards, including Argentina, Brazil, South Africa, and North Korea. To help allay suspicions that a nuclear weapon program or capability might secretly continue after the state comes under safeguards, it is important to ensure that all nuclear materials that may have been produced in the past are fully accounted for, and that all activities that had been related to the weapon program have ceased.

OPTION: *IAEA verification of the termination of a nuclear weapon program.*

Several steps could be taken to help cement the nonproliferation commitments of states thought to have mounted nuclear weapon programs in the past. First, the United States and other NPT parties could reemphasize the original meaning of the NPT commitment not to manufacture nuclear weapons. From the Treaty negotiating record and from statements of William Foster, then-director of the U.S. Arms Control and Disarmament Agency, activities prohibited under this commitment include all related development, component fabrication, and testing activities specifically related to creating nuclear explosive devices.[83] Such a reaffirmation is especially important for former threshold states, since IAEA safeguards were originally set up to verify only one aspect of such activities—the nondiversion of nuclear material from declared peaceful purposes.

Since the discovery of the Iraqi weapon program, the world community has expected more of safeguards. The IAEA has accordingly placed much more emphasis on: 1) verifying the completeness of a state's initial inventory of nuclear materials, ensuring to the extent possible that it has not hidden a stockpile of weapon-capable materials, and 2) ensuring the absence of undeclared nuclear facilities, eliminating to the extent possible the concern that the state is preparing to secretly violate its NPT commitment.

It could be made clear by the United States, by the IAEA, or by the United Nations more broadly that former threshold states have a special obligation to declare any such prior activities and to provide assurances that they have ceased, as well as to accept full-scope safeguards. Such assurances could include demonstrating that scientific teams had been reassigned, that facilities had been dismantled or converted to non-weapon purposes, and that any prior manufactured components and materials had been destroyed. If agreed to by the states in question, technical visits could then be used to verify the completion of these steps (see box 3-10). Short-notice inspections could also be used to help guard against the possibility of a state's moving former bomb material or nuclear-related equipment in order to hide it from inspection, and thus enhance the confidence in determining initial inventories of previously unsafeguarded nuclear-weapon-usable material.[84] Such inventories are particularly important instates that are suspected of having gone very far down the path of developing nuclear weapons.

■ Procedural and Institutional Improvements to Safeguards

OPTION: *Make greater use of inspectors from nuclear-weapon states who have intimate knowledge of nuclear explosive technology*

[83] 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.

[84] Leonard S. Spector, "Repentant Nuclear Proliferants," *Foreign Policy,* fall 1992. p. 35.

BOX 3-10: IAEA Nonroutine Inspections in North Korea and South Africa

Subsequent to the Persian Gulf War and IAEA activities under Security Council Resolution 687, the IAEA has gained vital experience in at least two other countries of serious proliferation concern. In North Korea, inspections in the months following that country's signing of its first safeguards agreement revealed anomalies that led to the request for special inspections at two sites suitable for containing nuclear waste associated with reprocessing activities. In South Africa, the need to verify inventories of HEU that had been associated with nuclear weapons resulted in the IAEA undertaking an unprecedented level of "nuclear archeology" to understand and reconstruct uranium production levels and nuclear weapon development activities dating back well over a decade. As in Iraq, the IAEA has faced unique challenges in these two states and, as a result, has shown its capability for assertive actions and thorough analysis. In both cases, a new emphasis has been placed on verifying with the highest confidence possible that initial declarations be not only correct, but also *complete.*

North Korea delayed signing its safeguards agreement with the IAEA from 1985 until 1992. Partly through analysis of plutonium and other isotopes obtained from swipes taken around product handling areas, the IAEA's initial ad hoc inspections revealed evidence of inconsistencies in North Korea's declarations, For instance, it became clear that waste the IAEA was allowed to sample was inconsistent with the limited reprocessing that North Korea had declared, and that there must have been at least one other reprocessing campaign. Information supplied by the United States and shared with the IAEA Board of Governors showed that the North Koreans had concealed two sites probably containing nuclear waste, This information provided clear evidence of attempted deception on the part of the North Koreans and buttressed radiochemical evidence that the IAEA's own efforts had obtained. When the IAEA made a request to conduct "special inspections" at these sites, North Korea refused and threatened to withdraw from the NPT. It did not carry out this threat, but—as of this writing—it has not yet permitted the IAEA to inspect these sites and is therefore not in compliance with its safeguards agreement,

The South African program presented quite a different set of challenges. Here, the state was cooperating fully, but admitted to having run enrichment campaigns for over a decade producing substantial quantities of HEU, some at very high enrichments. Given the foreseen transition of the South African government from minority to majority rule, extreme political sensitivity surrounded the question of whether some of the highly enriched uranium produced by South Africa might have been hidden from

As an institution, the IAEA is not required to have nuclear weapon expertise. Indeed, since its membership and its technical staff draw from nuclear and non-nuclear states alike, the IAEA and its staff must not be permitted to acquire weapon information, lest the agency promote proliferation in the process of helping fight it. Nevertheless, inspectors with nuclear weapon expertise may be in a better position to detect weapon activities. Assigning them to inspection teams could bolster confidence in an enhanced IAEA agenda that sought to take a more vigorous approach toward exposing covert nuclear weapon programs and undeclared nuclear sites.

Such a proposal would be difficult to implement beyond the level of informally assigning particular individuals to inspection teams. The IAEA makes no formal distinction between inspectors from weapon states and nonweapon states. Weapon-state inspectors will face difficulty in sharing suspicions with other IAEA personnel—including their counterparts from other weapon states—if doing so would force them to reveal nuclear weapon information that is classified by their national governments.

The IAEA has already begun to grapple with some of these issues following its inspections of Iraq after the Gulf War. Since these inspections

BOX 3-10 (Cont'd.): IAEA Nonroutine Inspections in North Korea and South Africa

the IAEA and the incoming government. The Board of Governors therefore passed a special resolution calling attention to the importance of verifying the "completeness" of South Africa's initial declaration: had it produced more material than it declared? To find out, the IAEA determined that past enrichment history dating back almost 15 years needed to be fully understood. Operating records were gathered to reconstruct this history.

Two problems were evident. First, given their focus on producing material for weapons, South Africa had failed to keep detailed records of certain operating parameters that would have been useful for calculating material balances, but were less relevant for production, such as the enrichment levels of the waste product or "tails." Second, frequent plant shutdowns, one as long as 2 years, had occurred as a result of a peculiar problem with the South African Helikon process. Once these shutdowns were properly taken into account and the complete set of operating records was verified as authentic, the IAEA was finally able to conclude that the inventory estimates provided by South Africa were probably correct.

Several lessons can be drawn from these experiences: **the IAEA does its job best when the inspected country cooperates; the more difficult the inspection task, the more cooperation is needed. Second, intelligence data can significantly enhance the IAEA's ability to unravel inconsistencies when it discovers them, though such data is not necessarily required nor always the final word in explaining the nature of such anomalies.** Third, while the IAEA has never been tasked to verify any non-nuclear research or development activities associated with nuclear weapons, evidence of such activity can indeed be sufficient for it to ask for more information regarding the nuclear *material* inventory—which the IAEA does have ultimate responsibility for verifying. The Director General has emphasized this point in the context of states such as South Africa, where the IAEA verified dismantlement of parts of the weapon complex not involving nuclear material. Such a precedent could have important implications for other states having prior or suspected connections to nuclear weapon programs, such as Argentina, Brazil, and North Korea, and if they were accede to the NPT as non-nuclear-weapon states, India, Israel, and Pakistan.

SOURCE: Office of Technology Assessment, 1995

were conducted under the authority of U.N. Security Council Resolution 687, rather than a typical IAEA safeguards agreement, the IAEA was free to accept assistance from, and to share inspection results with, whomever it pleased. However, special procedures had to be developed to limit the access of non-nuclear-weapon state personnel to sensitive Iraqi nuclear weapon design information. It will be harder to make such a distinction in the context of routine safeguards activities.

OPTION: *Increase transparency within the IAEA itself.*

Just as the IAEA requires access to facilities and information to achieve its safeguards objectives, so do those attempting to assess the adequacy of IAEA safeguards need detailed information about the functioning of the IAEA to determine how robust those safeguards objectives are and how well they are being implemented. To its credit, the IAEA has earned the reputation of being able to keep proliferation-sensitive and proprietary information closely held within its ranks. In fact, it is mandated to do so by Article VII(F) of the IAEA statute, which instructs the Director General and his staff to "not disclose any industrial secrets or other confidential information coming to their knowledge by reason of their official duties for the Agency."

Nevertheless, the practice of restricting the dissemination of information appears to extend into areas and types of information that might, in fact, offer benefits in increased public confidence in the safeguards system if they were to be made available. In contrast to "safeguards-confidential" information, which is generally not shared with member states or the Board of Governors, many reports by the IAEA Secretariat *are* distributed to the member states, but are not released to the public. For instance, the 1991-1995 *Safeguards Criteria* document, which contains a detailed and updated description of the safeguards and inspection activities that must be carried out at any given type of facility, is not publicly available.[85] Neither are the annual *Safeguards Implementation Reports* (SIRS) available. These safeguards reports present an overall assessment of how well the IAEA has met its safeguards goals for the year, including problems it has encountered with C/S and other equipment. **Distribution of SIRS is restricted despite the efforts made to protect the identities of any specific country or facility discussed in them.** There are many IAEA technical papers and analyses on safeguards whose distribution is not explicitly restricted, but that are not widely publicized.[86] However, there is a large body of public literature, available in various conference proceedings and journal articles, to which IAEA and outside researchers both contribute.

Public confidence in the IAEA's effectiveness is difficult to earn in a closed environment. Greater openness on the part of the IAEA itself might also allow outside experts to formulate more informed proposals for its improvement, an outcome which could ultimately strengthen the overall safeguards regime.

OPTION: *The United States could encourage IAEA member states to accept the IAEA's proposed assignments of inspectors to their territories, and to issue inspectors long-duration, multiple-entry visas.*

Under INFCIRC/153, states are allowed to reject the IAEA's assignment, or "designation," of inspectors to their country for any reason they choose. (This provision is not unique to the IAEA; the 1993 Chemical Weapons Convention, for example, also permits states to exclude particular inspectors from their territory.) Although restricting which inspectors may visit which countries generates inefficiencies, and can even lessen the credibility of IAEA inspections in certain areas, the United States and almost every other IAEA member-state government have exercised this right to exclude individual inspectors or classes of inspector at some time.[87] Some of the restrictions imposed by states include requiring that inspectors

[85] It is difficult to argue that withholding this document from the public makes it significantly harder to identify and take advantages of weaknesses in the safeguards system. Plant operators-who, if anyone, would be the ones to take advantage of such weaknesses-become intimately familiar with this documents' requirements during the routine course of safeguards inspections.

[86] For instance, there are extremely few entries in the 1990-92 IAEA catalogue of publications under the heading of safeguards. Although the safeguards budget comprises over a third of the IAEA budget; only two pages of the catalogue's 170 pages list safeguards publications, and the majority of these are at least 10 years old. (The catalog lists publications that are for sale by the IAEA and does not include materials distributed free of charge.) According to the IAEA, the intention of the sales publications is to "compile state-of-the-art knowledge from the international nuclear community for dissemination to Member States to help them enhance their own abilities to apply peaceful, nuclear techniques in medicine, industry, agriculture, etc." Given the prominence that IAEA safeguards have attained due to the IAEA's involvement in Iraq and North Korea since 1991, the IAEA has made a conscious effort "to give corresponding weight to our technical assistance efforts that remain at the heart of the bargain implicit in the 'Atoms for Peace' philosophy and of central importance for our developing Member States that are numerically in the majority." Quotations are from letter in response to Office of Technology Assessment questions from Jan Priest, Division of External Relations, IAEA, January 17, 1995, op. cit., footnote 34, p. 3.

[87] Fischer and Szazs, op. cit., footnote 2, pp. 63-64. For instance, it has been reported that in the 5 years preceding the 1981 Israeli bombing of Iraq's Osirak reactor, Iraq had allowed only Soviet and Hungarian nationals to carry out inspections on its territory. One inspector from France-the country that had sold the reactor to Iraq—had also been accepted, but had yet to conduct an inspection (see Roger Richter, testimony before the Senate Foreign Relations Committee hearing on Nuclear Nonproliferation, June 19, 1981).

come from NPT states or from states that themselves are under IAEA safeguards; or requiring that they speak the language of the inspected state.[88] The United States excludes inspectors from states that do not accept U.S. inspectors, and those from states that do not have diplomatic relations with the United States. Like practically all other states, it also reserves the right to refuse to issue visas to particular individuals that it deems ineligible to enter the country (e.g., that are suspected of being terrorists).

Since few states will give up control over the entry of foreign nationals to their territory, few states will be willing to waive completely their right to exclude proposed inspectors. The IAEA can, however, discourage countries from abusing this procedure, or from taking an unreasonably long time to respond to lists of inspectors proposed for their territory. For example, it could publicize such rejections and their justifications, if any; impose the highest allowed inspection frequencies in states that have a history of refusing the bulk of inspector designations; or perhaps even call for a certain number of special inspections at *declared* sites while the state deliberates on accepting inspector designations.

To reduce bureaucratic delays, and to help make inspections more timely, countries could agree to provide long-duration, multiple-entry visas to inspectors. Requiring IAEA inspectors to obtain visas for each inspection visit makes it impossible for them to conduct short-notice inspections even if a state has agreed to accept such inspections as a transparency measure.

Director General Blix proposed in 1988 that states waive their right to approve the designation of individual inspectors for their territory, and instead accept inspectors as approved by the IAEA Board of Governors. It is understood that such a waiver may be subject to reservations, and may be withdrawn at any time. The United States has accepted this proposal, and it provides IAEA inspectors designated for the United States with one-year, multiple-entry visas.[89] In waiving the right to approve individual inspector designations, the United States is presumably assuming that the IAEA will not designate inspectors that the United States finds unacceptable. Alternatively, the United States may be relying on its ability to withdraw this waiver if necessary. The Director General also offered a modified proposal in which states that did not respond within a certain time to the list of inspectors that the IAEA proposed for their territory would be considered to have approved the list in its entirety. Under previous practice, if a state did not respond, the list was considered to be rejected.

OPTION: *Exclude non-NPT states or NPT states with dubious nonproliferation credentials from membership on the IAEA Board of Governors.*

The IAEA grew out of the "Atoms for Peace" era and was established more than a decade before the NPT was signed. Despite its having been assigned the responsibility for conducting the principal verification activities of the NPT, the IAEA is an independent institution that maintains certain inherent contradictions with respect to its role in nonproliferation policies. One is its promotional role for nuclear energy and research, elements of which arguably make it easier for certain states to develop a nuclear weapon program. An alternate view, however, is that the IAEA's promotional activities enhance the nonproliferation regime since: 1) without them, fewer states may have been willing to participate in the safeguards regime at all, and 2) promotional and technical cooperation activities conducted under IAEA auspices can provide considerable insight—if the information is shared between the IAEA's technical cooperation and safeguards divisions—as to the breadth and depth of a state's nuclear technology,

[88] Fischer and Szasz, op. cit., footnote 2, pp. 63-64.

[89] Letter in response to Office of Technology Assessment questions, from Jan Priest, Division of External Relations, IAEA, Jan. 17, 1995. op. cit., footnote 34, p. 2

including technology acquired independently of the IAEA.

Another mismatch between the IAEA as originally created and the new responsibilities given it by the NPT is the IAEA's membership, and particularly that of its 35-member Board of Governors.[90] In recent years, the Board has included representatives from a number of states that, at the time, were not NPT members: Argentina and Brazil (which were thought to have had nuclear weapon ambitions), India and Pakistan (both widely believed capable of fielding nuclear weapons on short notice), Algeria (whose imported research reactor from China had caused concern), Ukraine, and Cuba. The Board of Governors has also included NPT member Libya, which was widely reported to have sought to purchase nuclear weapons from China. Another NPT party on the Board with a less-than-perfect nonproliferation record is Romania, which as recently as 1992 admitted violating the terms of its NPT commitments under one of its previous political regimes.

It has been suggested that the IAEA's credibility is weakened by having non-NPT or would-be proliferant nations on its Board of Governors sitting in judgment of potential proliferants.[91] In this view, the IAEA would better serve the NPT if its Board of Governors could be restricted to NPT members, if not to NPT members with robust nonproliferation credentials. Admittedly, it would be difficult or impossible for the IAEA as an institution to make such a determination. As was demonstrated by the United Nations in the 1970s, the inclusion of countries with strongly contrasting approaches to security can polarize an institution, bogging it down with political infighting.

On the other hand, the Board—unlike the U.N. Security Council—is not subject to vetoes, and a small number of non-NPT states would not be able to subvert the Board's actions even if they wanted to. Some IAEA officials argue that involving states such as India and Pakistan directly in IAEA affairs actually has positive effects for nonproliferation by helping draw them into the circle of responsible nations. IAEA officials also claim that representatives of such countries have often been helpful in Board decisions, commanding influence with G-77 (nonaligned) states and bringing to the IAEA valuable perspectives on nonproliferation norms. On decisions involving Iraq and North Korea, the Board, including its NPT nonmembers, was able to act quite decisively once information was presented to it.

In any case, the IAEA Statute stipulates that "The Agency is based on the principle of sovereign equality of all its members....," making it very difficult to establish new criteria for selection for the Board of Governors that would exclude some of the IAEA's member states. The Statute can be amended by a two-thirds vote of the Board of Governors followed by two-thirds ratification of the state parties, but states not accepting the amendment are not bound to remain within the IAEA. Restricting the Board of Governors could thus push certain states to withdraw their membership altogether, along with their political, financial, and technical contributions. Perhaps more importantly, it might alienate states who are unlikely to join the NPT but whose participation would be desirable in future, related arms-control activities such as a global comprehensive nuclear test ban or a cutoff in the production of fissionable materials for nuclear weapons. On balance, attempts at restructuring Board membership appear to be fraught with significant obstacles and limited tangible benefits.

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[90]States serving on the IAEA Board of Governors for 1994-1995 are noted in appendix B.

[91]See, e.g., U.S. General Accounting Office, *Nuclear Nonproliferation and Safety,* op. cit., footnote 43, pp. 5, 22.