NONPROLIFERATION TREATY
SAFEGUARDS AND THE SPREAD
OF NUCLEAR TECHNOLOGY

V. Gilinsky and W. Hoehn
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PREFACE

The Rand Corporation since 1965 has been conducting research under the sponsorship of various governmental agencies on aspects of the proliferation of nuclear weapons; earlier studies emphasized scientific, technical, and economic aspects of the development of independent national weapons programs, while recent efforts have focused on various issues related to the development of effective U.S. antiproliferation policies. As these research activities have led to the publication of several dozen reports to date, it is no longer practicable to list them herein; some are cited in the main body of the report, and a complete listing can be obtained from the Index of Rand Publications.

This report explores some aspects of the relationships between the form of NPT safeguards to be established in future negotiations, and the prospects for developing means of controlling the spread of various technological innovations having significant military potential. A common view, with which this report takes issue, is that international safeguards on peaceful nuclear materials and facilities obviate the need for further technology controls. The Non-Proliferation Treaty provides that formal negotiations between the IAEA and the parties to the Treaty over the form and extent of safeguards must begin no later than September 1970, and that such safeguards as are agreed upon must go into effect by March 1972; informal discussions among several parties and the IAEA have already begun.

The United States, despite the fact it is not a nonnuclear weapons state, has become entangled in the safeguards issue and, indeed, appears to be in a position of prominence in negotiations with the IAEA. This report explores the extent to which accommodation to some limitations of aspects of current IAEA safeguards systems could be employed to advance U.S. policy interests on various technology control issues.
SUMMARY

Present U.S. policy on preventing the further spread of nuclear weapons accords a major role to international safeguards on civilian nuclear facilities, particularly safeguards administered by the International Atomic Energy Agency (IAEA), whose object is to ensure that no non-nuclear weapons state can secretly divert its civilian nuclear materials and facilities to military purposes. Article III of the Non-Proliferation Treaty (NPT) requires non-nuclear parties to the Treaty to begin negotiations with the IAEA on safeguards by September 1, 1970; the treaty safeguards must be in effect by March 1972.

A number of important countries have signed but have not ratified, in some cases, with explicit reservations concerning safeguards attached to their signatures. Since there will be strong pressures to compromise for a reduced system of safeguards, it is important to re-examine the value of international safeguards.

Safeguards cannot, of course, cope with withdrawals from the Treaty after acquisition of civilian facilities and materials transferable to military use; they can only serve to give warning of clandestine weapons programs undertaken by governments under cover of the Treaty. The effectiveness of safeguards in deterring clandestine diversion is in providing "early warning" in time to permit some preventive action to be taken. There is little reason to be confident that presently envisioned safeguards will be effective in providing such timely warning. Since they also create resistance to the application of what may be more useful control measures, an excessive concern with safeguards threatens to weaken the avowed policy of restricting proliferation.

The authors of this report argue that antiproliferation efforts may be most effective when directed at inhibiting the preconditions for rapid development of nuclear weapons programs. A major difficulty is that a literal interpretation of the NPT, particularly Article IV, would appear to promote the spread of all types of nuclear technology to all parties to the Treaty. This was, in effect, the price of safeguards. Some way needs to be found to restore the balance between safeguards and technology transfer control.
During the 1950's a liberal nuclear technology transfer policy under the Atoms for Peace program was not immediately dangerous because it was largely self-policing—the research reactors that were distributed were too small to be of military importance. Now, however, the problem is one of much larger facilities. In addition, the U.S. has lost its monopoly on commercial nuclear facilities and materials, and hence its earlier unilateral control.

There has been excessive concern with the possibility of long-term small-scale diversion by national governments. A more disturbing and dangerous possibility for a weapons development program is the acquisition and development of facilities, materials, and technology—all in strict compliance with the NPT safeguards provisions—until the lead time for production of weapons in quantity can be reduced to a matter of months. From then on, a weapons program could be undertaken at any time, with some confidence that, by the time of discovery, a weapons stockpile would already be in hand.

When one considers a weapons program that would be largely completed before the safeguard system could react, it seems clear that antiproliferation effort should aim, insofar as possible, at preventing the accumulation of critical materials and facilities rather than at discovering the existence of a weapons program at the last moment. The longer it takes to produce nuclear weapons, the more narrow the options, the greater the risk, and the less likely the decision to make them.

It is important to recognize that possibilities for control depend strongly on the incentives and options of the major industrialized non-nuclear countries. The most advanced non-nuclear countries are both producers and consumers of nuclear technology. Most less developed countries are merely potential consumers.

There is little that can be done directly to slow the development of nuclear technology in the advanced countries, although it can perhaps be channeled to some extent through cooperative U.S. actions. We should, of course, like to see civilian nuclear programs closely interdependent and based in critical areas on multinational facilities so as to reduce opportunities for transfer of civilian nuclear materials and facilities to military purposes.
To effect significant control over the distribution of potentially dangerous nuclear technology to the less developed countries, the U.S. needs the help of the most advanced non-nuclear countries. These are important suppliers of nuclear technology and the very countries most concerned about the interpretation of safeguards systems to be established under Article III of the NPT.

Early U.S. agreement on a scaled-down system for the advanced countries, particularly the Euratom countries and Japan, might gain their cooperation in controlling the flow of nuclear technology to the less developed countries without significantly reducing the degree of assurance provided by the presence of international safeguards.

The basis of a scaled-down safeguards system could be IAEA monitoring of IAEA-approved national or multinational safeguards system. The IAEA could first set standards and procedures for national inspection systems. Countries or multinational groupings (for the moment, Euratom) that met the standards would then inspect themselves. The authors envision a system whereby the principal industrial countries, mainly Euratom and Japan and of course the U.S. and U.K., would immediately acquire certification. This should meet the principal objections of Euratom; the concern of Japan that it will be at a disadvantage compared with Euratom countries; and the problem of equalizing inspection between the U.S. and U.K. and the other non-nuclear countries, a point particularly emphasized by Japan. The limited nature of direct IAEA involvement should also meet the objections, coming mainly from advanced countries, to the intrusiveness of existing IAEA safeguards.

A scaled-down version of IAEA safeguards would also relieve the U.S. of some of the obligations presumably incurred when President Johnson agreed to IAEA safeguards on all U.S. peaceful facilities. His proposal was apparently not meant to be taken literally, but it may be so taken if the U.S. insists on imposing the present IAEA system on the advanced non-nuclear countries.

Finally, despite the present ineffectiveness of safeguards, and relatively poor prospects for effectiveness in the near future, say, in this decade, the principle of international safeguards is important. The presence of safeguards sets useful precedents and keeps the door
open for introduction of more effective inspection techniques in the future. Some international safeguards are much better than none at all.
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I. INTRODUCTION

Present U.S. policy on preventing the further spread of nuclear weapons, as expressed, for example, in the negotiation of the Non-Proliferation Treaty (NPT), accords a major role to international safeguards on civilian nuclear facilities, particularly safeguards administered by the International Atomic Energy Agency (IAEA). The object of these safeguards is to assure all states, but especially those without nuclear weapons that no non-nuclear state* will divert its civilian nuclear materials and facilities to military purposes. To this end, considerable efforts by the United States and the IAEA have been directed at developing and perfecting the technical features of safeguard systems. The purpose of this report is to suggest that, despite these efforts, presently envisioned safeguards appear to have limited practical value and may even create resistance to the application of more useful control measures. Perhaps paradoxically, an excessive concern with safeguards threatens to weaken the avowed policy of restricting proliferation.

Although the NPT has now gone into effect, and outright rejection by industrial countries of NPT safeguards has been averted by means of a number of compromises—among them the U.S. promise to accept IAEA safeguards over its peaceful nuclear facilities—the safeguards issue is by no means settled. As finally drafted, the Treaty's Article III requires signatory countries to permit international inspection of their civilian nuclear facilities but in a manner to be agreed upon in subsequent negotiation with the IAEA. Although the inspection must start within specified time limits, there are no provisions for dealing with the situation in which negotiations remain incomplete. The NPT could easily become stalled if agreement is not reached on these issues. As a result, the United States has an obvious interest in the outcome of the various negotiations with the IAEA over safeguards.

* We prefer this older terminology to the more precise but clumsy "non-nuclear weapon states."

** Eighteen months from March 5, 1970, or eighteen months from the date of ratification by a country that ratifies after March 5, 1970.
In addition, it appears that many of the industrial signatories may delay final agreement with the IAEA until the form of the U.S.-IAEA agreement becomes clear.

Pressing for what may seem to be a technically superior system may further reduce the political acceptability of the NPT for the industrially advanced countries, for the threatened application of intrusive safeguards leads immediately to charges (real and imagined) of technological discrimination, particularly by those industrial countries that see themselves as commercial competitors of the U.S. Beyond this objection is yet another, namely, that a comprehensive system might not significantly improve the assurance that safeguards are intended to provide. Whatever values safeguards have, they can be had for the most part by a system that is less technically complex and cumbersome than the existing U.S. and IAEA systems approach.

There are further dangers in an anti-proliferation policy strongly tied to safeguards. To restore political acceptability to NPT safeguards, at least in principle, it was found expedient to add Articles IV and V, which, on paper, obligate the nuclear powers to promote and aid all aspects of the civilian nuclear programs in the non-nuclear countries. This issue has been seized upon by the less developed countries (LDC's), who want various forms of assistance so that they can afford nuclear energy, which they tend to view as a magic key to progress. If the nuclear aid provisions in the NPT are taken seriously—and there are many indications that the non-nuclear countries, both advanced and less developed, intend to exploit them—they could lead to a widely increased level of technical nuclear capabilities in otherwise less-advanced countries, the dangers of which would far outweigh any beneficial effects of safeguards. From the point of view of controlling proliferation, one would naturally prefer, if possible, no potentially dangerous facilities and (therefore) no safeguards.*

* One would certainly want to avoid the absurd, though perhaps not sufficiently improbable, "worst case" in which the United States would assist in distributing large numbers of nuclear facilities to countries that could not otherwise obtain them in return for the recipient's pledge that the facilities would be inspected.
It now appears that final agreement on the inspection provisions of Article III will involve not only compromises on the form and extent of international safeguards on peaceful nuclear activities,* but also some further concessions, primarily by the United States, concerning the obligations of the nuclear powers toward the non-nuclear countries, as outlined in Articles IV and V. It is thus important that an assessment be made soon of the proper balance in U.S. policy between international safeguards and the extent of nuclear technical assistance and controls.

*Note that the NPT does not forbid non-nuclear countries from engaging in military nuclear activities other than explosive devices. Such activities would not be subject to international inspection. See Mason Willrich, The Non-Proliferation Treaty, The Michie Co., Charlottesville, p. 93, 1969.
II. BACKGROUND OF NEGOTIATIONS OVER IAEA SAFEGUARDS

Negotiations over safeguards are made difficult because many of the non-nuclear countries, especially those whose accession is generally considered essential for the effectiveness of the Treaty, are clearly unenthusiastic about many aspects of the NPT. The reasons for their reluctance to accept the Treaty are varied. Some countries are reluctant to formally forswear nuclear weapons; some want security assurances; some are genuinely concerned about the possible adverse effect on their peaceful nuclear programs. Others feign this concern because they see an opportunity to obtain technical assistance, and still others are unhappy because their views were not sought during the Treaty's formulation. Since the Treaty is now in effect, and no further security guarantees are likely to be forthcoming, one might add that it is considered in poor taste to profess any interest in becoming a nuclear power. The negotiations over the implementation of Article III safeguards must accordingly bear the brunt of the discontent among the non-nuclear countries, at least among those not prepared to reject the Treaty initially and immediately.**

*The joint U.S.-USSR-U.K. security guarantees expressed in the U.N. Security Council Resolution of 19 June 1968 appear to have essentially no content. See Hearings before the Committee on Foreign Relations, Ninetieth Congress, Second Session, on Treaty on the Non-proliferation of Nuclear Weapons, July 10, 11, 12, and 17, 1968. For example, on p. 15:

Senator Sparkman. Let me ask you this question: Does the Security Council resolution and the U.S. declaration commit the United States to any additional responsibilities other than those already assumed under the United Nations Charter? Secretary Rusk. I would think not, Mr. Chairman, both as a matter of law and as a matter of policy.

**We shall not discuss issues concerning security guarantees for non-nuclear countries despite the fact that these issues relate directly to the core of the Treaty—the promise on the part of non-nuclear countries not to resort to nuclear weapons development. Countries that find such a renunciation of nuclear self-defense threatening to their national security will not accept the NPT unless their security can be ensured in some other way. We shall also omit discussion of Plowshare assistance as covered by Article V of the Treaty. Plowshare relates to peaceful uses of nuclear energy, but it will be some time before it is commercially important, and it really forms a separate issue.
The possibilities for compromise are also limited by the history of Articles III and IV.* A detailed account would be out of place here,** but it is useful to recall a few facts. Safeguards on peaceful nuclear facilities did not become a significant issue for the NPT until the concluding stage of the negotiating process, which coincided with an upsurge in the prospects for civilian nuclear power in the advanced non-nuclear countries, most conspicuously in the Federal Republic

*The parts of Article III that are of principal concern to us here are in Paragraphs 1 and 4:

1. Each non-nuclear weapon State Party to the Treaty undertakes to accept safeguards, as set forth in an agreement to be negotiated and concluded with the International Atomic Energy Agency in accordance with the Statute of the International Atomic Energy Agency and the Agency's safeguards system, for the exclusive purpose of verification of the fulfillment of its obligations assumed under this Treaty with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices.

4. ...Negotiation of such agreements shall commence within 180 days from the original entry into force of this Treaty. For States depositing their instruments of ratification or accession after the 180-day period, negotiation of such agreements shall commence not later than the date of such deposit. Such agreements shall enter into force not later than eighteen months after the date of initiation of negotiations.

The relevant part of Article IV is in Paragraph 2:

2. All the parties to the Treaty undertake to facilitate, and have the right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy. Parties to the Treaty in a position to do so shall also cooperate in contributing alone or together with other States or international organizations to the further development of the applications of nuclear energy for peaceful purposes, especially in the territories of non-nuclear-weapon States Party to the Treaty, with due consideration for the needs of the developing areas of the world.

of Germany (FRG) and in Japan. * Forecasts of rapid progress in civilian nuclear development, in turn, led to a call, mainly by the United States, for comprehensive international safeguards, preferably under the International Atomic Energy Agency (IAEA), on nuclear materials and facilities in non-nuclear countries. At the same time, however, a growing awareness of the possible commercial importance of nuclear energy contributed materially to the difficulty of arriving at a general agreement on international inspection.

There followed the now-familiar series of charges and denials concerning whether or not the Treaty discriminated against the legitimate commercial interests of non-nuclear powers. The IAEA was finally accepted as the "official" agency for conducting safeguards inspections mainly because the Soviet Union would not accept Euratom inspection, especially in the FRG, and also to some extent because a number of unaffiliated countries objected to the prospect of the Euratom countries receiving preferred treatment under the Treaty. The more advanced industrial countries, however, did not find the solution entirely to their liking inasmuch as the extremely broad inspection rights vested in the IAEA ** encouraged the belief that inspection would be for them a commercial liability. ***

It was evident that little progress could be made on the Treaty unless the United States accepted IAEA inspection over its nonmilitary

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* The U.S. draft treaty of 17 August 1965 was vague about the obligations of signatories in regard to inspection. It required each of the parties to the Treaty to "cooperate in facilitating the application of International Atomic Energy Agency or equivalent international safeguards on all peaceful nuclear activities." The Soviets at that time showed no interest in inspection of peaceful activities in non-nuclear countries.

** Although in principle the rights granted to inspectors are broad, political realities of the international inspection system, together with limitations on the kinds of facilities subject to inspection and on the accuracy of measurements, render the effectiveness of the system open to question.

*** See, for example, W. Gmelin, D. Gupta, and W. Hafele, On Modern Safeguards in the Field of Peaceful Application of Nuclear Energy, KFK-800, (Ref. 9), pp. 6-9. Professor Hafele has expressed this point of view forcefully and effectively in numerous other writings.
nuclear facilities. In an address of 2 December 1967, President
Johnson announced that the United States would accept IAEA safeguards:

...when such safeguards are applied under the Treaty,
the United States will permit the International Atomic
Energy Agency to apply its safeguards to all nuclear activ-
ities in the United States--excluding only those with direct
national security significance.

He did not believe, he went on to say, that safeguards would interfere
with the peaceful activities of any country, and he wished to make it
clear to all that "the United States was not asking any country to
accept safeguards that it was unwilling to accept itself." Two days
later, British Disarmament Minister Mulley told the House of Commons
that the United Kingdom would take similar action. There seems no
prospect of similar acceptance of safeguards by the Soviet Union.

Discussion then centered on the possible concessions to the non-
nuclear countries which might compensate for the unavoidable liabili-
ties that remained. Since the Soviet Union was not a major supplier
of technical and financial assistance other than in the countries of
Eastern Europe and in Finland, the majority of the non-nuclear nations
looked (and still look) to the United States for technical and finan-
cial assistance. In many respects, this was not unreasonable since
the United States had taken the major initiative both in negotiating
the Non-Proliferation Treaty and in urging general adherence to it.

There are, of course, considerable differences in outlook, inter-
est, and sophistication among these non-nuclear countries. The more
advanced want some compensation for present U.S. commercial advantages
in peaceful nuclear technology, which, they often claim, originated
from prior U.S. nuclear weapons research programs--activities which
would now be prohibited to non-nuclear countries. They want the U.S.

*Earlier, at the Tenth Session of the Eighteen National Disarma-
ment Committee (ENDC) in 1966, Mr. Adrian Fisher of the U.S., in urging
international safeguards for the non-nuclear states, explained that the
United States did not propose a safeguards system for nuclear-weapons
states because this would place a great burden on the safeguards system
and serve no useful purpose.
to define explicitly its obligations under Article IV—and they have strong ideas concerning what these obligations should be.* Primarily, they would like commercial access to secret areas of U.S. nuclear power technology, such as enrichment technology, which were developed for military purposes but which have civilian application. Furthermore, they would like assurance that no restrictions will be placed on their own commercial nuclear power transactions, aside from the requirement of NPT safeguards.

The situation has not been ameliorated by the sweeping language of some U.S. pronouncements. President Johnson, in an address to the United Nations after the initial signing of the NPT, said:

...we shall, as the Treaty requires, facilitate the fullest possible exchange of equipment, materials, and scientific and technical information for the peaceful uses of nuclear energy. We shall give particular attention to the needs of the developing nations. We shall share our technical knowledge and experience in peaceful nuclear research fully, and we shall share it without reservation.**

It remains to be seen how these sentiments will be interpreted, particularly where the line is to be drawn on the many kinds of facilities and materials that can have both peaceful and military uses.

The less advanced countries want not so much removal of restrictions as outright assistance (in acquiring) nuclear facilities. These countries typically have only a vague notion of the commercial realities of nuclear power. They tend to imagine that it will somehow speed their attainment of advanced status.

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* These views were widely expressed at the 1968 Geneva Conference of Non-Nuclear-Weapon States. See especially References 5, 6 and 7. In the U.S. this conference has not received the attention it deserves, perhaps because of the diversion caused by the subsequent Soviet invasion of Czechoslovakia.

III. PURPOSES AND LIMITATIONS
OF INTERNATIONAL SAFEGUARDS SYSTEMS

The purpose of international safeguards on civilian nuclear programs should be to deter governments from clandestinely diverting resources from the civilian to the military sector. This it should do by giving reliable early warning of such diversion so that measures can be taken to defeat the objectives of the divertor government. If deterrence fails, prompt detection could help in starting countermeasures early.

Of course, this is not the only way in which diversion might occur. It could be perpetrated by sub-national groups. And international safeguards as presently envisioned—for example, the IAEA system—would also have a measure of responsibility for guarding against such non-governmental diversion. These additional responsibilities have the unfortunate tendency to bias IAEA efforts toward great concern with material accountability procedures for civilian nuclear programs and with detailed techniques for physical measurement. An international organization, to be sure, could play a useful role in training inspectors, educating government personnel in safeguards technology and techniques, and in developing and making available technical methods and special equipment, but it seems likely that for preventing nongovernmental diversion, a national safeguards system would be much more effective.

In the first place, national governments can be expected to be strongly motivated to guard against "unauthorized" diversion; national inspectors, familiar with the local situation, could freely use intelligence means unavailable to the IAEA. Furthermore, they could tolerate a much higher "false alarm" rate, with less likelihood that a small diversion would go undetected for long. Finally, national governments could rather freely impose severe sanctions and penalties, adopt more rigorous techniques and control measures, and utilize methods not envisioned by or acceptable to participants under an international inspection system.
The problems of nongovernmental diversion are therefore best left to a national safeguards system. Deep involvement of the IAEA in the largely mechanical procedures useful on the sub-national level is not only unnecessary but will seriously detract from the system's effectiveness in providing early warning of governmental diversion, a much more unpleasant possibility for the international system.

Unlike subgovernmental diversion, governmental diversion is not likely to be an isolated, random event, but would systematically involve the national decision-making apparatus, the military establishment expected to use the weapons, auxiliary research and development facilities, and so forth. Furthermore, a clandestine diversion program would need to make some political sense for the country involved. Consideration of political and psychological factors would thus seem essential in formulating the scope and extent of inspection systems. Unfortunately, from the point of view of the IAEA bureaucracy, a system for detecting diversion at the governmental level implies distrust of the very governmental group and individuals with whom the IAEA has to deal (and, incidentally, the same group which provides much of the data for evaluation to the IAEA). But this is unavoidable. Suspicion is inherently a part of any device for protecting oneself against others.

EARLY WARNING

"Early warning" of diversion, to make any sense, must mean definite evidence of actual or imminent diversion in time to permit some preventive action to be taken. We shall discuss what constitutes "definite evidence" and "preventive action" in a later section. The issue here is the time it takes for the following sequence of events to occur:

1. Collection of raw data from numerous sources;
2. Manipulation and evaluation of the raw data according to the standard materials accountability tests;
3. Determination that evidence of an irregularity exists;
4. Transmission of the nature of the evidence and the details to the appropriate supervisory bodies;
5. Decisions by the appropriate bodies as to what, if any, preventive actions shall be taken;
6. And, finally, the determination of the time required to implement preventive action and the time for that action to take effect.

The time factor, clearly of extreme importance, has received little attention in most safeguard studies. The usual approach is to make a statistical analysis of fuel-cycle sampling.* The results are intended to indicate the degree to which the fissile material content of a facility is known, say, to within 2 or 3 percent. While one may question the validity of these results,** it is clearly important to know how quickly a safeguard system can detect and evaluate irregularities. In particular, one needs to compare the time needed for detection and preventive action with the time needed to make some initial military or political use of the diverted nuclear material.

Individuals involved in detailed design of prospective safeguard systems have suggested that it would take from six months to a year to verify the materials balance of fissile material in a civilian nuclear fuel cycle. The hope is eventually to shorten this time to perhaps as little as a month. A safeguard system with a reaction time of six months or more may be completely unacceptable in the light of burgeoning peaceful nuclear programs. Nuclear technology for "peaceful purposes" is such that it may soon be able to provide a country with a military nuclear option that could be exercised before a safeguards system could detect and thwart it. Even discounting the possible hazards under this future technology, one may still question whether present criteria are capable of such precise definition and execution that one can arrive at an early and unambiguous determination that a diversion has occurred.

* See, for example, the report of the Karlsruhe group, W. Hafele et al., Safeguards System Studies and Fuel Cycle Analysis, KFK900, p. 4. The requirements of safeguards are met, if with x% confidence level the material balance is closed within y%." It should add "within z days."

CRITERIA

A safeguards system is commonly pictured as a careful and continuous watch for any signs of diversion over all of the activities of nuclear facilities. If any such signs are uncovered at any point, an alarm goes off, and the wrongdoer is promptly summoned before higher authorities for possible countermeasures. In practice, one can doubt both the ability to specify such clear-cut alarm criteria and the certainty of the process implied. A government engaged in a clandestine diversion effort is unlikely to exhibit unambiguous and preservable evidence of what it is doing. At best, whatever suspicious traces exist in permanent records may or may not be significant, because of the inevitable presence of random errors of measurement, inventory fluctuations, and various normal operating inaccuracies and process losses. It is thus necessary to establish criteria for activating the alarm.

One might at first suppose that any suspicious signal would do. After all, we are concerned with the manufacture of a device that can kill many thousands of people, and, at least according to popular opinion, could easily trigger large nuclear wars. Nevertheless, the number of false alarms which an international safeguards system can tolerate is undoubtedly small. One is therefore faced with a dilemma: To keep the false-alarm rate low, the threshold signal must be kept high; but a high threshold implies low effectiveness in detecting small diversions. Continuous low-level diversion is thus unlikely to trigger an alarm.**

*This is especially so when a new type of facility starts up. It may be a year before the losses characteristics of the facility are known. The losses have the unfortunate name "normal operating loss" (NOL).

**In the language of the statistician, one is testing the hypothesis that no diversion occurred. The false alarm rate corresponds to so-called Type I error, the probability that the statistical test will lead to a rejection of the hypothesis when it is true. For a given level of Type I error, one would generally like to choose a test that minimizes the Type II error, the probability that the test will lead to acceptance of the hypothesis when it is false. But for a given sample size, one cannot make Type I error as small as seems desirable.
Even when a test result has exceeded the set threshold, there is no certainty that a diversion has actually occurred. Given the possibility of error in measurement, one could only say, on the basis of a theoretical model of the nuclear facility in question, that, with some degree of confidence, some level of diversion had taken place. This information would then presumably be transmitted by inspectors to higher authorities.

What the higher authorities would do with such a report will depend very much on the circumstance. They could call for an explanation or more extensive and intensive on-the-spot investigation. This may or may not meet with cooperation and may or may not clarify or resolve the nature of the situation that triggered the alarm. It seems possible that all parties directly involved in the safeguards system would have a vested interest in trying to find an explanation that would smooth over the difficulty. Safeguards studies have not yet faced these critical problems of ambiguity.

Another essential element of an effective system is that it must respond quickly and decisively—otherwise it serves little purpose.

SANCTIONS

There is little point in having safeguards unless there are sanctions without incurring increasingly large Type II errors.

We are lumping all types of input together. In practice, there are many, possibly incommensurate, types of signals.

*If the degree of confidence, is, say, 95 percent, then 5 percent of results exceeding threshold are false alarms. Of course, one doesn't know which 5 percent are the false alarms.

**We might add here that apart from the low false-alarm rate acceptable for the system, there will generally be an even smaller false-alarm rate acceptable for an individual inspector. This will be especially true for resident inspectors who, after all, must live with the personnel of the nuclear facility. If some discretion in sounding alarms is granted him, he may be tempted to wait for more convincing evidence.

***There are many such situations for which it is extremely difficult to give a prescription for action. For example, suppose the existence of a large discrepancy is announced by the country involved. Everyone denies any wrong-doing, and the government says it will be happy if the inspector can find the missing fissile material. (Incidentally, such incidents have already occurred in the United States.) How does the system respond?
that can attempt either to head off a nuclear weapon program or to limit its potential consequences. Otherwise, one could dispense with safeguards and simply impose sanctions upon completion of development of nuclear weapons. The U.S. Government must at some point face the issue of what measures, if any, it is ready to take (unilaterally or with others) or support in order to uphold an international safeguards system.

The present IAEA safeguards system, of course, does contain certain provisions for "sanctions." Diversions and other forms of irregularity are treated as "noncompliance with the system." Under the IAEA Statute, the Inspector General reports any noncompliance to the Director General of the IAEA "who shall thereupon transmit the report to the Board of Governors." In turn the Board shall report the noncompliance to member states and to the Security Council and General Assembly of the United Nations. At the same time the Board shall call for a correction of the irregularity. In the event of further noncompliance, the Statute provides that the IAEA may suspend its own assistance to the noncomplying member and it may "call for" the return of the material and facilities involved. It may also suspend the noncomplying member "from the exercise of the privileges and rights of membership."** Thus the formal IAEA "sanctions" are scarcely sanctions at all.

Sanctions, of course, need not be a part of the international safeguards system. They could consist of retaliatory actions by other countries, such as military intervention by those who felt their security threatened. Perhaps more likely, those countries that felt endangered would exercise their own options for developing nuclear weapons. In this instance, proliferation by one country might lead to proliferation by others. Indeed, the possibilities inherent in such a situation may make the IAEA reluctant to aggravate the crisis by even raising the question of diversion. That is, in some sense, the thresholds for turning in an alarm may rise in parallel with the intensity of

*It is hard to imagine a case (aside from Israel, perhaps) where such deployment might be kept secret.
**IAEA Statute, Article XII.
the crisis, and thus to a lessening of everyone's confidence that the situation can be kept in hand.

**IS EFFECTIVENESS IMPORTANT?**

It is sometimes implied that considerations of effectiveness are not important. The significance of safeguards is said to be mainly political, that is, symbolic—what they actually accomplish is less important than what they appear to accomplish. There is, of course, some truth in this contention, especially because most countries have had no experience with safeguards. Thus, even ineffective safeguards are not without some force. But it is presumptuous to expect this blissful ignorance to continue indefinitely. Ultimately, the performance of safeguards systems will be carefully examined by all those concerned. Their usefulness for lessening suspicion will then depend on a critical assessment of their actual effectiveness in providing early warning of diversion.

*Some indications of skepticism on the part of foreign nationals towards the effectiveness of safeguards, as the functioning of the system in their country provides first hand evidence, may already be becoming apparent. See "IAEA Inspects Tokai Nuclear Station—First Safeguard Application of Japanese Commercial Reactor," *Atoms in Japan*, June 1968, pp. 10-11:

Going back to the accounting records, the IAEA inspectors found that all documents are in Japanese. Since this is an on-load charge reactor, there are fuel movements from cold storage to reactor and from reactor to pond practically every day. Movements are recorded on travelling instructions cards, which naturally are written in Japanese. Unless an IAEA inspector speaks and reads Japanese, he will have to accept the records as translated by the station staff. The JAPC staff warned them that they should not expect many English speaking senior staff members to accompany them each time, when inspections become routine and take several days. They said that they have to consider the station operation first and senior engineers are likely to be very much occupied with that job.

Although the first inspection did not go into these details, verification of monthly reports could lead to actual checking of the fuel history record. In Tokai, a computer program is used to keep track of fuel element numbers and their in-core positions, together with burn-up accumulation.
Thus, we are led to conclude that the application of the present IAEA safeguards system to the far larger task envisioned under the NPT would lead to all of the following:

1. In normal applications, it would constitute an irritant at the commercial operating level. Moreover, the irritation would be roughly proportional to the size of a country's nuclear program. Large industrial countries, having the most substantial programs and the least incentive for clandestine diversion, would suffer the most.

2. At the international level, the structure may initially generate a false sense of security; however, as experience is gained, the deficiencies of the international system should become much more apparent.

3. During a time of crisis, it is conceivable that the safeguards system itself would constitute an added source of tension.

and Pu (plutonium) formation information. Cell calculations of burn-up and isotope formation, power distribution in-core are all fairly complicated procedures even for the limited purpose of keeping fuel records. One can certainly foresee considerable complications when this is taken up as a part of the inspection procedure.

This first IAEA inspection was certainly a learning process both for the inspectors and the station. The station expressed their willingness to cooperate with the inspectors as much as possible, and said that the first experience provided an opportunity to gain some understanding of what IAEA safeguard requirements might be, so that they would be better prepared with the necessary documents etc. in readily available form. For Mr. McNight (Chief IAEA Inspector), this inspection trip seems to have brought home to him the practical difficulties of effective inspection. When one is not able to make a physical check of inventories of either cold or hot fuel elements, the auditing function of on-site inspection is already half jeopardized. When one is faced with twenty thousand or so fuel elements each weighing twenty kilograms floating in and out of the reactor core on day-to-day basis, what may appear in theory to be a plausible inspection procedure may prove to be an entirely impractical proposition.

Although both sides expressed satisfaction with the result of the first inspection, there was also a sense of realization (and dismay) that a good deal more has to be worked out before an effective routine can be established.
IV. CLANDESTINE NUCLEAR WEAPONS DEVELOPMENT?

The reasons for international safeguards on civilian nuclear activities in non-nuclear countries seem fairly clear. At presently projected rates of development, commercial nuclear industries in a number of these countries will be dealing, in the next decade, with thousands of kilograms of plutonium. In addition, a few of the most advanced countries may construct national uranium enrichment facilities for producing slightly enriched uranium to fuel nuclear power plants. These national facilities could also have a significant capacity for the production of highly enriched uranium.

It is beyond the scope of this paper to consider capabilities and intentions for individual national nuclear programs and governments, but it may be useful to summarize some information concerning projected fissile material production capacities in selected non-nuclear countries. This information is contained in Table 1. As a measure of the potential for diversion, such projections for the non-nuclear countries are useful. From the standpoint of the safeguards effort apparently required under the NPT, one would of course have to consider the size of the civil programs in the nuclear countries as well.

It is important to note that the plutonium production rates shown in Table 1 do not necessarily indicate the production rate of material useful for weapons. Because fuel is usually kept in a civilian power reactor for a relatively long time, the plutonium normally produced in these reactors is heavily contaminated with the isotope plutonium-240. Nuclear weapons made with such plutonium would generally be severely limited in performance. Since for practical purposes the contaminant


The prospects for construction of uranium enrichment facilities in non-nuclear countries are increasing. These facilities are now restricted to the nuclear states, but there are efforts underway in a number of industrial non-nuclear countries (especially the FRG, the Netherlands and Japan) to develop domestic enrichment technology, particularly gas centrifuge technology.
Table 1
ROUGH PROJECTIONS OF PLUTONIUM PRODUCTION CAPACITIES
IN SELECTED NON-NUCLEAR-WEAPON STATES
FOR THE YEARS 1975-1980

<table>
<thead>
<tr>
<th>Country</th>
<th>Estimated Installed Nuclear Capacity Mw 1975a-1980</th>
<th>Estimated Plutonium Production Capacityb kg per year 1975-1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRG</td>
<td>5,000 - 20,000</td>
<td>1,000 - 4,000</td>
</tr>
<tr>
<td>Japan</td>
<td>5,000 - 20,000</td>
<td>1,000 - 4,000</td>
</tr>
<tr>
<td>Canada</td>
<td>2,500 - 6,000</td>
<td>600 - 1,500</td>
</tr>
<tr>
<td>Sweden</td>
<td>2,500 - 4,000</td>
<td>500 - 800</td>
</tr>
<tr>
<td>Italy</td>
<td>1,400 - 5,000</td>
<td>300 - 1,000</td>
</tr>
<tr>
<td>Spain</td>
<td>2,000 - 5,000</td>
<td>400 - 1,000</td>
</tr>
<tr>
<td>Switzerland</td>
<td>1,000 - 3,000</td>
<td>200 - 600</td>
</tr>
<tr>
<td>India</td>
<td>1,200 - 2,000</td>
<td>300 - 500</td>
</tr>
<tr>
<td>Argentina</td>
<td>300 - 1,000</td>
<td>100 - 300</td>
</tr>
<tr>
<td>Israel</td>
<td>-</td>
<td>10 -</td>
</tr>
<tr>
<td>Other</td>
<td>5,000 - 15,000</td>
<td>1,000 - 3,000</td>
</tr>
<tr>
<td>Rounded Total for Non-Nuclear Countries</td>
<td>26,000 - 81,000</td>
<td>5,000 - 17,000</td>
</tr>
<tr>
<td>United States (for comparison)</td>
<td>50,000 - 120,000</td>
<td>10,000 - 25,000</td>
</tr>
</tbody>
</table>

bAdditional time must be allowed for extraction of plutonium.
cannot be removed, commercial plutonium is not well-suited for simple, predictable, efficient weapons.

Of course, civilian reactors can also be operated to produce plutonium with a fairly low plutonium-240 content—by replacing the fuel rods more frequently. This is easy with most natural uranium reactors, for they are generally designed to be refueled "on-power," without shutting down the reactor. In Table 2 we have listed all such reactors over 100 Mwe which have been installed, are under construction, or are on order in non-nuclear weapon states. For the near future, the number of these reactors will be small*, and of the countries listed in Table 2 only India has a fuel reprocessing facility and only Japan has definite plans for such a facility.

The case is quite different with light water reactors, which will account for most of the world's civilian nuclear power capacity for the next two decades, for they have to be shut down for weeks each time the fuel rods are replaced. These reactors therefore do not lend themselves easily to the production of plutonium for military purposes: power production is disrupted, the change in mode of operation is more difficult to conceal, and the plutonium production rate is lower.

A country might be willing instead to initiate a military program with unpredictable or inferior weapons. However, it is clearly necessary to keep this limitation in mind when drawing conclusions about the military usefulness of a particular stockpile of plutonium.

At any rate, the national production capacities for plutonium, together with the potential national production capacities for enriched uranium that we can expect in some of the non-nuclear countries, may more than satisfy the demands of a military nuclear weapons program.** It is thus likely that if these countries decide to produce nuclear

*Although there are reports that Canada and France may combine forces to sell natural uranium heavy water reactors. This could improve the prospects for such reactors. See "Canadians, French Team Up to Bid for Export Reactor Sales," Nucleonics Week, March 19, 1970, p. 5. Rumania, Australia, South Africa, Mexico, Turkey, Brazil, and Argentina were mentioned as possible customers.

**Recall that the nominal amounts of fissile material required per warhead are about 5 to 10 kilograms of plutonium or about 15 to 30 kilograms of highly enriched uranium.
Table 2

NATURAL URANIUM REACTORS OVER 100 Mwe
WITH ON-POWER REFueling CAPABILITIES INSTALLED,
UNDER CONSTRUCTION, OR ON ORDER
IN NON-NUCLEAR WEAPON STATES\textsuperscript{a, b}

<table>
<thead>
<tr>
<th>Country</th>
<th>Reactor</th>
<th>Power (Mwe)</th>
<th>Date On-Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>Atucha</td>
<td>320</td>
<td>1972</td>
</tr>
<tr>
<td>Canada</td>
<td>Douglas Point 1</td>
<td>200</td>
<td>1968</td>
</tr>
<tr>
<td></td>
<td>Gentilly</td>
<td>250</td>
<td>1971</td>
</tr>
<tr>
<td></td>
<td>Pickering 1,2,3,4</td>
<td>2000</td>
<td>1971-3</td>
</tr>
<tr>
<td></td>
<td>Bruce 2,3,4,5</td>
<td>3000</td>
<td>1976-9</td>
</tr>
<tr>
<td>Czechoslovakia</td>
<td>Bohunice</td>
<td>140</td>
<td>1969(?)</td>
</tr>
<tr>
<td>India\textsuperscript{c}</td>
<td>Rapp, 1,2</td>
<td>400</td>
<td>1970-2</td>
</tr>
<tr>
<td></td>
<td>Kalpakkam</td>
<td>400</td>
<td>1972</td>
</tr>
<tr>
<td>Italy</td>
<td>Latina</td>
<td>210</td>
<td>1964</td>
</tr>
<tr>
<td>Japan\textsuperscript{c}</td>
<td>Tokai</td>
<td>160</td>
<td>1966</td>
</tr>
<tr>
<td>Pakistan</td>
<td>Kanupp</td>
<td>125</td>
<td>1971</td>
</tr>
<tr>
<td>Spain</td>
<td>Vendellos</td>
<td>500</td>
<td>1972</td>
</tr>
</tbody>
</table>


\textsuperscript{b} Also of interest is the Israeli Dimona research reactor, critical since 1963. It is fueled with natural uranium and apparently has a power rating of about 25 thermal megawatts (equivalent to about 8 Mwe).

\textsuperscript{c} Reprocessing plant installed or under construction.
weapons, they will seek to shorten lead times by drawing on their civilian facilities and materials.

We have earlier indicated that the effectiveness of any practicable safeguard system is limited by both measurement and procedural shortcomings. Thus, covert diversion of some small percentage of a fissionable material stock or flow at any number of points is unlikely to be detected, and, even if suspicions should be aroused, the diverter may escape timely punitive action. By applying the same small percentage figure to various forecasts of the quantities of materials in nuclear programs, one could arrive at an estimate of the potentials for diversion.

The accuracy needed to arrive at a valid conclusion that no quantity of materials large enough to form a critical mass had been overlooked would of course be very considerable, especially for countries with large nuclear programs. The hopelessness of ever achieving this kind of accuracy has led many decision makers to conclude that the safeguards problem is insoluble; and that proliferation is therefore inevitable, safeguards or not. We shall endeavor to explain below why we feel that this view is both too pessimistic and counterproductive.

This procedure, of course, neglects the possibility that small systematic diversions might have a cumulative impact on the measurement system. Furthermore, as we have already indicated, fuel reprocessing facilities are needed to extract plutonium from fuel rods and are therefore prerequisite for governmental diversion of plutonium. But more fundamentally, this all-too-common analysis ignores the issue: To what extent is covert diversion of small amounts of fissile material an attractive real-world strategy for the development of an independent nuclear weapons capability?

Two important points are evident. First, the diversion of 5 to 10 kilograms of plutonium, while enough fissile material for a single nuclear explosive, is certainly not equivalent to the development of a militarily useful nuclear weapon, and is not remotely equivalent to the acquisition of a strategically meaningful nuclear force. A small number of primitive nuclear weapons would be of little value for confronting a capable nuclear-armed opponent. It is true that several such weapons could represent a serious danger in the Middle East and other parts of
the Third World. But apart from a conflict between militarily limited antagonists lacking great-power backing (or with such support neutralized), the strategic military potential of a few primitive nuclear weapons is likely to be small. The suggestion that the clandestine approach to a nuclear weapons capability represents a danger in a major industrialized nation such as West Germany or Japan borders on the ridiculous. The requirements either country would face in developing a meaningful strategic nuclear capability are enormous. A weapons acquisition plan based initially on the diversion of a few kilograms of nuclear material at a time seems absurd.

In short, when one considers the present strategic balance among the major industrialized countries, it seems evident that to develop a nuclear weapons capability, one would have to embark on a large nuclear materials production program, develop highly sophisticated delivery systems, miniaturized weapons, and extensive command-control, warning, and hardened force basing structures. Any country attempting to develop a nuclear deterrent against any one of the five present nuclear powers could hardly settle for less. Thus, clandestine theft of nuclear materials and development of weapons is, for the major industrial nations, an extremely unlikely threat at the national level.

Second, the risk of exposure of clandestine diversion would come largely from discoveries by foreign intelligence services, and from accidents, mishaps, and security leaks. Intelligence services have access to a much broader range of information than IAEA or other international inspectors, whose inspection rights are severely circumscribed, and can make many cross-checks among associated military and political activities. Indeed, as weapons production rates from a covert operation increase, so does the likelihood of discovery of its myriad supporting activities, such as the disappearance of key personnel from normal pursuits and the purchase of certain items from abroad. Thus, it is the size of the program commitment required of a major industrialized country that appears to militate against a clandestine weapons development program rather than the effectiveness of the safeguard system on civil nuclear programs.
The force of these arguments seems less clear-cut in the case of many of the less developed parts of the world. In many areas, a few relatively primitive nuclear warheads could be significant militarily. For one thing, the requirements for command, control and delivery system would be less severe. On the other hand, since the inventory of fissionable materials in the civilian program would normally be smaller than inventories in the major industrialized countries, the amount that would be diverted without detection would also be smaller. Furthermore, since weapons development efforts would take place at a much lower technological "noise" level, they would likely be more conspicuous and therefore subject to detection.

A more disturbing and dangerous possibility for a weapons development program in Third World areas is the acquisition and development of facilities, materials, and technology—all in strict compliance with the NPT safeguards provisions—until the lead time for production of weapons in quantity can be reduced to a matter of months. From then on, a weapons program could be undertaken at any time with some confidence that, by the time of discovery, a weapons stockpile would already be in hand.

When one considers a weapons program that would be largely completed before the safeguard system could react, it is clear that non-proliferation effort should aim at preventing the accumulation of critical materials, facilities, and technology—the preconditions—rather than at the existence of a weapons program, a discovery that may be made too late. The longer it takes to produce nuclear weapons, the less likely the decision to make them.
V. CONTROLLING THE SPREAD OF NUCLEAR TECHNOLOGY

We have concluded that antiproliferation efforts may be most effective when directed at inhibiting the preconditions for rapid development of nuclear weapons by limiting access, where possible, to critical facilities, materials, and technology associated with the production of fissile materials. For example, a small country with nuclear reactors, but lacking a fuel-reprocessing facility for separating out plutonium, is handicapped for the production of nuclear weapons. Of course, it could build such a facility, but that takes time. Or it could have its plutonium separated elsewhere and returned, but this limits its options, and might disclose valuable information as to quantity and quality.

Several advanced non-nuclear countries are now actively developing the gas centrifuge method of uranium enrichment. If its commercial development is successful, not only will there be alternative sources of enriched uranium, but it is likely that small enrichment plants will be offered for sale. Above a small scale, the economics of this enrichment process are rather insensitive to the scale of operation, as opposed to the U.S.-developed gaseous diffusion process. The gas centrifuge process is therefore suited for small national plants. It would also be especially suited for the production of highly enriched uranium useful for weapons, though initial purchase would probably be intended, or at least purported to be, for the production of low enrichment uranium for reactor fuel.*

Even this last point is uncertain, for highly enriched uranium, now seldom used in civilian nuclear power applications, may become an important fuel material. The High Temperature Gas-Cooled Reactor (HTGR), now being developed in the United States and Western Europe as a competitor to the common Light Water Reactor (LWR), is designed to use very highly enriched uranium fuel. A medium-sized power reactor of this type is now being constructed in Colorado. If it should prove

*For a more comprehensive discussion of these points see Gilinsky and Hoehn, RM-6123-ARPA, op.cit.
economical, HTGR sales may increase abroad, and consequently incentives may increase for the possession of small enrichment facilities to produce highly enriched uranium.

The technological possibilities are continually changing. The general advance of civilian nuclear power programs, together with a considerable increase in the extent of international transactions in nuclear materials and technology, serves to bring increasing numbers of countries to the nuclear weapons threshold, to the point where a political decision to proceed could be implemented rapidly. While this condition has been talked about for many years, it is now becoming a reality.

However, this situation is not inevitable, and we seek in this report to combat the hopeless view as much as the complacent one. The very fact that the process is just getting under way means it may still be possible to contain it or, failing that, to reduce its dangers.

It is desirable to be able to exert some influence over these and other developments. But the possibilities for unilateral U.S. control of the development of nuclear technology abroad are limited. The failures in the recent past of U.S. monopolizing attempts with respect to gaseous diffusion, the gas centrifuge, and chemical reprocessing technology should make this clear.

It is important to recognize that possibilities for control vary, depending strongly on the incentives and options of the major industrialized non-nuclear countries. Especially significant is the difference between the advanced and less developed countries in their capacity to utilize nuclear energy facilities and, where necessary, to develop nuclear technology. The most advanced non-nuclear countries are both producers and consumers of nuclear technology. Most less developed countries are merely potential consumers.

Commercial nuclear programs* of substantial physical and financial size are in progress in most of the Western European countries, Canada, and Japan. These countries have genuine economic interests in the

*By "commercial," we mean to imply substantial participation by utilities and industries in nuclear power plant manufacture or operation, rather than construction or operation of research or prototype facilities.
development of nuclear technology and in the acquisition of facilities associated with the production and processing of fissile materials.

Because they are motivated largely by economic considerations, many of these advanced countries would be open to multinational arrangements which reduce the costs and risks of advanced technology development and large capital investment projects. However, while most of these countries would benefit from multinational development of nuclear technology, in many cases their industrial and economic capabilities do not preclude independent development. The potential effectiveness of unilateral U.S. technology control measures is severely limited here. Indeed, U.S. unilateral measures in the past appear to have created incentives in those countries to pay a premium for independence in this area.

There is, therefore, little that can be done directly to slow the development of nuclear technology in the advanced countries. However, it can be channeled to some extent through cooperative U.S. actions. The U.S. through its tremendous R & D efforts greatly affects both the present and potential economics of nuclear power. We should like to see the civilian nuclear programs in the advanced countries closely interdependent and based in critical areas on multinational facilities so as to reduce opportunities for transfer of civilian nuclear materials and facilities to military purposes. Such transfers generally require a self-contained nuclear program. Interdependence, or specialization, will take place only under appropriate commercial conditions. It cannot be brought about by obvious manipulations--these will surely backfire and lead to nationally oriented independent nuclear programs under strong governmental sponsorship. In short, if U.S. non-proliferation actions are to be successful, they cannot be to the gross commercial disadvantage of the advanced non-nuclear countries.

The less developed countries, by contrast, have few domestic options in this area. Their access to nuclear facilities can probably

*In contrast, in the less developed countries the utilization of nuclear energy is at far from commercial levels; it is sponsored largely by governmental bodies, and supported by a variety of internal and external subsidization mechanisms.
be limited by agreement among the several exporters of nuclear technology. It is not entirely unreasonable to expect the exporters to be able to cooperate to this end because the entire nuclear market among the underdeveloped countries is small, and the market for the most critical technologies is smaller yet. If the problem were purely commercial, it would not be difficult or expensive for U.S. concessions to make up for the loss of this trade.

However, there are many difficulties in the way of a more restrictive common policy toward technology transfers to the less developed countries. The less developed countries have largely taken the attitude that the NPT asks much of them but offers little in return. Their insistence on this score led to the inclusion of a paragraph in Article IV, in which the developed countries pledged to contribute assistance "to the maximum extent possible." The degree to which this pledge is redeemable is open to question, of course. But it should be noted that a straightforward interpretation of this provision and the similar provisions in Articles IV and V calls for intensification and diversification of the peaceful use of atomic energy. Taken together, these provisions clearly could be used to justify unfettered commercial transactions in nuclear materials, facilities, and technology. To the extent that the industrialized countries make sophisticated nuclear facilities and technology available to less capable (and more volatile) underdeveloped countries on a routine commercial basis, subject only to NPT-IAEA safeguards, the NPT could foster rather than inhibit the spread of nuclear weapons.

These unfortunate transactions might arise not simply as a by-product of pervasive "why worry" attitudes among NPT signatories, but as a consequence of deliberate impositions of a strict IAEA version of NPT safeguards on technologically sophisticated allies. Because sophisticated technological capabilities have been developed or are in prospect in a number of nonweapons industrialized countries, the U.S. can no longer anticipate absolute control over the dissemination (or the recipients) of nuclear technology. Any further limitations will have to be on a voluntary basis among the several potential suppliers. U.S. efforts must rely on gaining mutual support from other
supplier nations, not on U.S. unilateral decisions. However, an elaborate and cumbersome inspection system imposed on large civilian nuclear programs is likely to lead more in the direction of increased friction.*

Aside from antagonizing the other non-nuclear supplier nations, an extensive IAEA safeguards system would increase the size and importance of the IAEA. Since a principal function of the IAEA other than safeguards is to further the peaceful application of nuclear energy, there would be a clear tendency for the size of the Agency's promotional activities to expand along with its safeguard efforts. The IAEA in past years has devoted a substantially smaller fraction of its annual budget to the development and implementation of safeguards systems than to what may be broadly characterized as "promotional" activities—international conferences, studies of nuclear applications in various countries, publications of handbooks for estimating costs and benefits of nuclear power and water desalting plants, etc.

Promotional activities and safeguards systems implementation per se are not incompatible. Indeed, the history of bureaucratic organizations clearly suggests that the IAEA would find these to be reinforcing activities. More promotional activities leads to more nuclear materials and facilities, which leads to more safeguards and inspection activities, which leads to larger budgets and staffs, and so forth. The bureaucratic incentive structure becomes subject to internal stresses only if "more safeguards system activities" is replaced by "less potential for the spread of nuclear weapons to additional countries." United States policy makers would presumably prefer the latter objective to the former, but it is not evident that the bureaucratic structure of the IAEA will give them much satisfaction. The promotional activities of the IAEA have been oriented largely toward less developed nations, both because

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*The IAEA inspection experienced in the U.S., on which the official position that safeguards are not "intrusive" or "abrasive" rests, was limited both in scope (some half-dozen facilities, mostly small ones) and in intensiveness. See, for example, W. E. Hoehn, Clandestine Diversion and Safeguards in Nuclear Power Reactors (U), The Rand Corporation, RM-4998-PR/ISA, October 1966 (Secret), and A Technical Analysis of Some Possibilities for Diversion of Fissionable Material from Light-Water Reactors (U), The Rand Corporation, RM-4999-PR/ISA, October 1966 (Secret) (Restricted Data).
promotional activities by commercial enterprises have largely preempted the market in industrialized countries consuming large blocks of electric power, and because membership on the IAEA is heavily weighted toward less developed countries. In short, promotional efforts on behalf of the less developed nations are unlikely to be lessened, especially given the reinforcement of the "nuclear assistance" provisions in Articles IV and V of the Non-Proliferation Treaty.

The preceding considerations raise the prospect of essentially unrestricted transactions in nuclear materials and facilities, with only the existence of safeguards and the NPT pledges to deter military application. Once the NPT safeguards are operative, the U.S. in effect, will have transferred major responsibility for nonproliferation efforts to the IAEA. Its ability to influence the prospects for further proliferation will thus be substantially reduced. One can presume that U.S. policy makers will want to evaluate carefully the extent to which the IAEA might be disposed to limiting the widespread availability of nuclear materials and facilities and to restricting the development of "latent" weapons capabilities.

As we have noted above, the avowed purpose of safeguards is to detect diversions of materials at a sufficiently early point in a clandestine weapons program so that sanctions can be brought to bear. The development of latent weapons capabilities, which can be carried out in full compliance with safeguards provisions, is a more worrisome problem not adequately covered by present or prospective safeguards systems. It would seem best controlled by restricting the spread of at least those nuclear facilities that cannot be justified on economic grounds. This is a task for which the IAEA appears particularly ill-suited. If it can be carried out at all, a restrictive policy can only be arranged through tacit understanding by the major nuclear equipment manufacturing nations—the very countries that are most concerned about the interpretation of safeguards systems to be established under Article III of the NPT.
VI. PRACTICABLE INTERNATIONAL SAFEGUARDS

In supporting a blanket acceptance of IAEA safeguards, the United States has worked itself into something of a dilemma. On the one hand, it has assured the major industrialized non-nuclear countries that the safeguard system to be employed under the NPT will be neither intrusive nor burdensome. Furthermore, the United States has offered to place all of its commercial nuclear facilities, whose number will probably exceed the total for all non-nuclear countries, under the same set of international safeguards. Although the offer, originally made by President Johnson, has recently been reiterated by AEC Chairman Seaborg,* there were some earlier suggestions that the United States did not expect international safeguards to be fully applied to its civilian facilities,** and the precise nature of the offer remains unclear.

At any rate, many countries are, or profess to be, anticipating that the system to be imposed upon the United States will be the same in kind and degree as that which they are expected to accept. They feel that the United States could be persuaded to lend its backing to proposals for modifying the safeguard system only if the system turned out to be more burdensome and intrusive to the United States than is presently expected. Thus, U.S. policy makers may have to decide whether to accept a massive safeguard effort imposed on the U.S. civilian nuclear economy, in return for any equivalently weighty safeguard system in the United States, while insisting that the major non-nuclear countries have as comprehensive a system as the regulations would envision. In the latter case, the prospects for agreement with other

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* See Nuclear Industry, April 1970, p. 57. Dr. Seaborg is quoted as saying to a Japanese audience, "I can assure you here today that this offer remains in full force and that the U.S. will not only allow but will insist on its vigorous implementation.

** See Congressional Record—Senate, S2387, March 7, 1969. Senator Aiken asked the State Department several questions about the NPT. From the answers, which were prepared by the AEC, it is clear that the estimate of the cost of IAEA safeguards in the U.S. is based on the expectation that the IAEA will eventually safeguard only one-fourth of U.S. facilities eligible for inspection.
advanced countries to the spread of nuclear technology to secondary
countries would be essentially nil.

We have already noted that even an intensive safeguard system
constitutes only a marginal deterrent to a major industrialized nation's
decision to embark on a weapons program. Thus, in order to get a small
tail of rigorous safeguards applied in a great many countries of rela-
tively modest potential capabilities, it is necessary to envision the
purchase of a very large animal. We believe there are better alterna-
tives.

Although a detailed examination of alternative international safe-
guards systems is beyond the scope of this report—our purpose is prin-
cipally to question a number of widely held assumptions in this area—
we should like to outline one such alternative which we regard as de-
sirable and practicable. Its scope is considerably reduced from what
is presently envisioned for the IAEA system, without, we think, sacri-
ficing much in the way of assurance that safeguards should provide.
In fact, because a reduction in scope would permit smoother and speed-
ier operation, such a system might conceivably be more effective—in
any case, it is clearly more cost-effective.

The basis of the proposed safeguards system would be IAEA monitor-
ing of IAEA-approved national or multinational safeguards systems. There
have been many such proposals, and they all suffer from the fact that
extensive reliance upon national or multinational safeguard systems may
be unacceptable to the Soviet Union. A principal Soviet interest in
safeguards has been to assure that the FRG is subjected to IAEA safe-
guards. It may be, therefore, that our proposed system departs too far
from the present IAEA system to meet with Soviet approval. It is our
view, however, that Soviet insistence on this point does not enhance
antiproliferation, but rather detracts from it and, while Soviet approv-
al may be essential, it should be clear that, to the extent that the
S.U. insists on rigorous IAEA inspection, such approval must be traded
for a reduction in overall antiproliferation effectiveness of the NPT.

To return to the proposed system: The IAEA would first set stand-
ards and procedures for national inspection systems. Countries or mul-
tinational groupings (for the moment, Euratom) that met the standards
would then inspect themselves. This would insure against "unauthorized diversion" by other than the governments concerned. We shall deal later with the problem of governmental diversion.

We envision a system whereby the principal industrial countries, mainly Euratom and Japan and of course the U.S. and U.K. would, after some initial ceremony, immediately acquire certification. This should meet the principal objections of Euratom; the concern of Japan that it will be at a disadvantage compared with Euratom countries; and the problem of equalizing inspection between the U.S. and U.K. and the other non-nuclear countries, a point particularly emphasized by Japan.* The limited nature of direct IAEA involvement should also meet the objections, coming mainly from advanced countries, to the intrusiveness of existing IAEA safeguards.

The few advanced countries mentioned above, with one or two additions, are still the only non-nuclear countries that have or will have sizable civilian nuclear programs in the next decade. For the other countries, many of which will have reactors but not fuel reprocessing and fabrication facilities, it would be feasible and practical to adopt a substantial degree of IAEA inspection with the proviso that when the country had gained sufficient experience and met IAEA inspection standards it could graduate to the inspection status of the advanced countries. Or it could join with several other countries to form a multinational inspection system, similar to Euratom's, subject only to IAEA monitoring.

Since the less advanced countries have few nuclear facilities, inspecting them would not unduly tax IAEA resources. As the number of facilities grew, so would the number of countries that graduate to advanced status requiring only IAEA monitoring. The size and cost of the IAEA inspectorate can therefore be expected to remain relatively stable; at any rate, it would not grow at the rate that installed nuclear capacity grows.

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All governments will want to guard against diversion by sub-
governmental groups and are therefore likely to cooperate to this end. 
The IAEA could act as an exchange for new techniques and possibly po-
lice information. Occasional detailed IAEA checks would be made to 
ascertain whether a national inspection system was functioning properly. 
This might even be welcomed by most governments—it is similar to the 
role played by an outside accounting firm engaged to audit a company's 
books.*

We must now deal with the effectiveness of the proposed system 
with respect to governmental diversion—a point on which we criticized 
the presently envisioned IAEA system. Frankly, we do not propose that 
for the present great reliance be placed on the proposed safeguard sys-
tem, as opposed to national intelligence, for providing prompt warning 
of governmental diversion. However, we think it would be as effective 
as the present IAEA system, and at far lower cost. Of course, one can 
imagine an international inspection system that provides reliable prompt 
warning of any form of diversion. Its cost, however, and its degree of 
intrusiveness make it completely unacceptable, not only to the indus-
trial non-nuclear states, but also to the nuclear industry in the United 
States. Certainly, it would be far more uncompromising than the pres-
ent IAEA system, and there is no prospect whatever that such a super-
system could be adopted.

In scaling down the level of inspection, we should like to retain 
certain features of the presently discussed systems:

(1) We believe it is particularly important to retain the right 
of an inspector to inspect any part of a facility at any 
time, though the number of such inspections will in practice 
be strictly limited. This is very much preferable to a 
greater number of inspections whose scope is severely lim-
ited.

(2) Provision should be made for automated sampling at strategic 
points. We do not have much faith in methods using "black

*An analogy used by R. Lumb and D. George, International Safeguards 
Draft Paper prepared for Charlottesville Conference on Civil Nuclear 
boxes," but neither can we exclude the possibility of substantial advances in remote measurement technology. There should be a way to incorporate such devices once developed so as to improve the safeguards systems.

(3) Inspection should be strongly weighted toward facilities that employ fissile materials in relatively pure form, or that could rapidly produce such materials. Where alternative methods are available, one could use heavy inspections to "tax" the more dangerous alternative.

(4) Uniform bookkeeping should be instituted so that national systems are readily monitored.

(5) The number of IAEA inspections, which will necessarily be limited, should not be apportioned according to installed nuclear capacity in each country but should be decided upon by the IAEA.

We believe such a reduced system, though it departs in several ways from current plans, is nevertheless compatible with present IAEA guidelines * and therefore needs only agreement between the signatories to the NPT and the IAEA. Hopefully, the system, by reducing the more onerous aspects of international inspections, will meet less resistance. We should like to emphasize that even a slight degree of international inspection is much better than none because it permits peaceful states to demonstrate the innocence of their activities without the embarrassment that bilateral inspections may occasion. Problems arising from misunderstanding can thus be resolved.

Those arising from hostility are a different matter. In this regard there is little that the system can accomplish aside from the deterrent effect of occasional, randomized but unannounced inspections, though even these can be frustrated fairly easily. The main point is that early adoption of a reduced system would conserve political capital which could be used to attempt control of the more dangerous aspects of nuclear technology.

* Information Circular #66, Revision #2, 1968.
We would like to comment on another alternative, advocated mainly by the FRG, which has received a great deal of attention. This is the so-called strategic points system, which involves measuring the flow of fissile material at a finite number of strategic points—the only points to which inspectors shall have access. It is also generally implied that, even at strategic points, measurement can eventually be carried out by remote instruments, thus largely dispensing with inspectors.

The strategic points would include entrances and exits to the entire facility and, in principle, as many interior points as are necessary to reduce uncertainty about the internal flow of material. When the number of strategic points becomes large, there is little to distinguish this approach from the standard one. The object is clearly to minimize the number of strategic points. But then the system is heavily dependent on the associated notion of 'containment,' that is, the sealing off of the civilian nuclear fuel cycle.

Of course, any well-designed safeguards system will find it convenient to make measurements at certain points in the fuel cycle, and the civilian nuclear facilities should be guarded as well as possible. But we are unconvinced, and in fact find it implausible, that this approach by itself can prevent governmental diversion—by the operators of the facilities. We believe it is essential to retain complete freedom for inspection, though the number of inspections may have to be small and randomized.

In addition to the difficulty mentioned earlier, any safeguards proposal which emphasizes national safeguards together with some measures for the control of nuclear technology export, in effect a discriminating antiproliferation policy, would necessitate a continuing and sustained diplomatic and technical collaboration among the various technology-exporting countries. Such a policy would oblige the present U.S. administration to coordinate nonproliferation policy-making within

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*See, for example, W. Gmelin, D. Gupta, and W. Hafele, On a Modern Safeguard in the Field of Peaceful Application of Nuclear Energy, KFG 800, May 1968.
the U.S. government to a far greater degree than prevailed in previous administrations.

While this makes the proposal less attractive, the alternatives are also unattractive. The authors are convinced that it is futile to rely on international safeguards to protect us from the consequences of unrestricted sale of nuclear technology and nuclear facilities. A partial success in controlling technology would, we think, be much more useful in controlling proliferation even at the price of watering down the safeguard system.

We believe, furthermore, that one presently proposed system, featuring IAEA safeguards operating in parallel with national safeguards, will ultimately be unacceptable to many countries that have signed the NPT, and that the coming negotiations will result in some kind of reduced system involving IAEA verification of national records with a minor degree of on-the-spot IAEA inspection. Little more is likely to emerge, given the problems of Euratom inspection vs. IAEA inspection; equality of inspection between Euratom countries and other industrial states, especially Japan; equality of inspection between non-nuclear countries and the United States and the U.K., which have agreed to accept inspection over their civilian facilities on an equal basis; and the general reluctance of all states to accept costly intrusive safeguards. Rather than be driven back to a reduced system by grudging compromises, it would seem preferable to adopt a position early in the negotiations that will insure the maintenance of certain desirable features. If such a position is taken at the outset, it may ease the way for other types of control agreements. Of course, the worst position would be to set such great store by safeguards that the United States continues to make technological concessions to gain them, and then only to find them ineffective and troublesome.